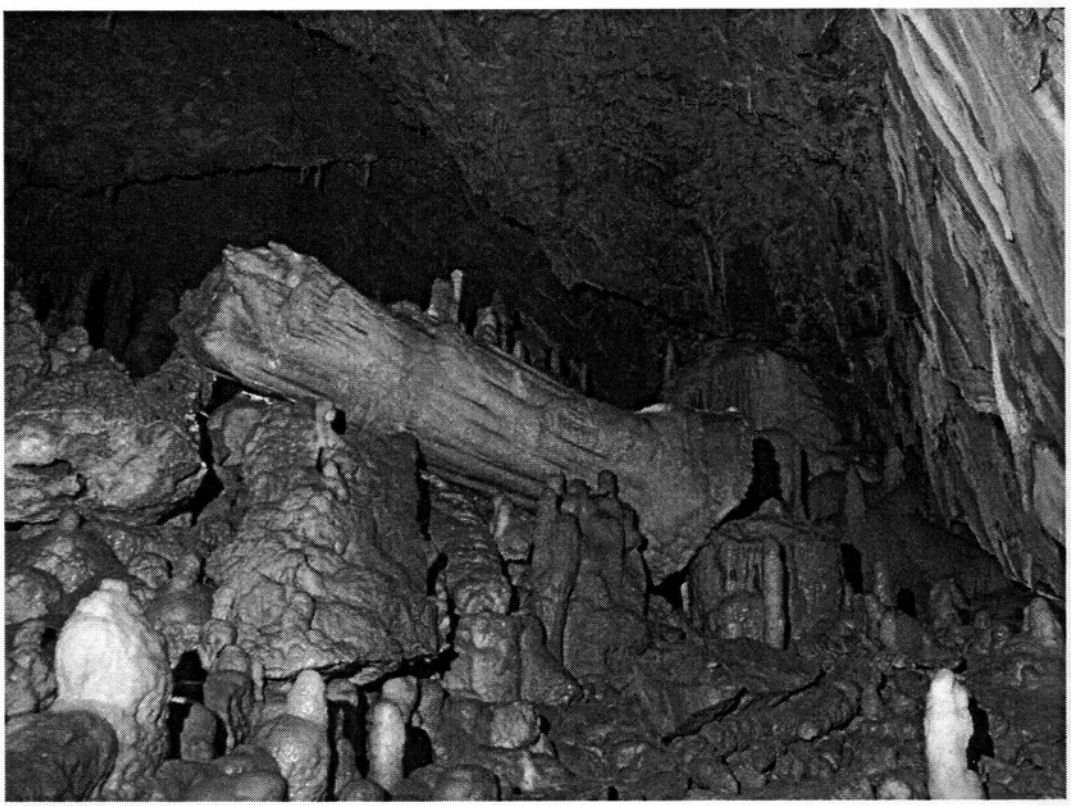
KARST RESEARCH INSTITUTE ZRC SAZU

Speleological Association of Slovenia
Slovenian National Commission for UNESCO
Karst Commission IGU
International Speleological Union UIS

16th INTERNATIONAL KARSTOLOGICAL SCHOOL "CLASSICAL KARST"

KARST SEDIMENTS



GUIDE BOOK & ABSTRACTS

Postojna, 2008

Editors
Nadja Zupan Hajna & Andrej Mihevc

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Marie Curie Conferences and Training Courses
SMART-KARST (MSCF-2005-029674)

Contents

Financed by the European Union
Marie Curie Conferences and Training Courses
(http://europa.eu.int/mariecurie-actions)

Project **SMART-KARST**
(MSCF-2005-029674)

Within the frame of the 6th FP Action Marie Curie Conferences & Training Courses the Karst Research Institute SRC SASA is leading the project SMART-KARST: International Karstological school "Sustainable management of natural resources on karst". The project supports five events organized in the period of 2006 to 2009. Four of them are our regular International Karstological Schools "Classical Karst" held each year in June, and the fifth one is the Symposium on Time in Karst organized in March 2007. An important objective of the project is to bring together researchers of karst from different disciplines, and especially to facilitate and disseminate knowledge from experienced to early-stage researchers. Therefore at each event 45 participants in the early stage of their research career receive a grant which covers travel costs, living allowance, and registration fee. Organisation of each event is partly supported by the project.

According to the rules of the Marie Curie programme all participants are invited to complete the Assessment Questionnaire, which is designed to give the EU Commission feedback on the overall impact of the event. As our SMART-KARST project is thoroughly monitored by the European Commission, we would be very thankful to you if you could take some time and complete the questionnaire after the end of the School.

A web based application has been developed to allow the online submission of questionnaires. It is available at http://webgate.cec.eu.int/sesam

First you should click **MCA Questionnaires** in the left upper corner.
Then you choose: Instrument: MCA-Marie Curie Actions
Project type: SCF-Series of Events
Then click the button: Edit Questionnaire
Project ID is: 029674
Then click the button: Validate

In this way you reach a short questionnaire, which you can complete in few minutes. All information provided to the European Commission will remain anonymous and confidential.

General information

Lectures and poster presentations

Lectures will be held in the lecture room at the Cultural centre of Postojna (Kulturni dom Postojna, Prešernova ulica 1, Postojna). Presentation of posters will be held in the hall of the Karst Research Institute ZRC SAZU (Titov trg 2, Postojna). See schedule for details.

Excursions

Do not forget to **register your participation at excursions at the registration desk!** Seats on buses are limited. Suitable clothes, shoes and light for the fieldwork are required. For registered accompanying persons each half-day excursion costs 5 EUR, and whole-day excursion 10 EUR.

PARTICIPATION AT THE EXCURSIONS IS AT YOUR OWN RISK!!!

Departures for the excursions

Buses leave for the excursions from:

- parking place in front of PTC Primorka (Business Centre Primorka, see map) – Postojna Centre,
- parking place in front of Hotel Jama (if interest also in front of the Epicenter Hotel).

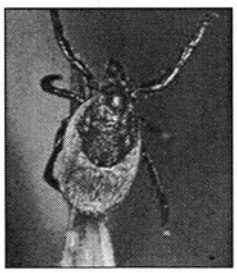
PLEASE BE ON TIME!

Beverages and food on the excursions

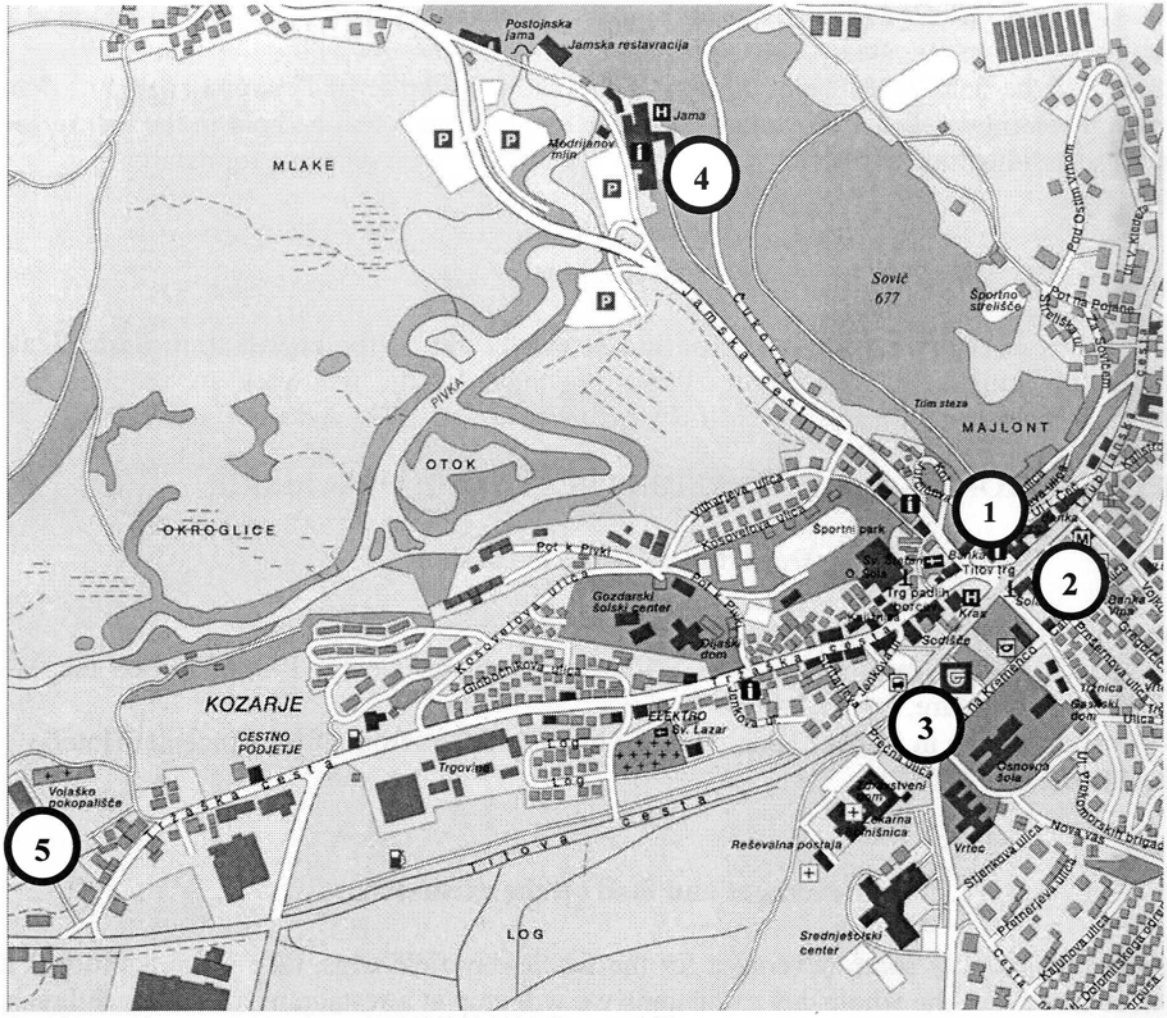
Organizer will supply some beverages for the whole-day field-trips, take some additional if you need more. For the whole day excursions we will stop at a restaurant for the lunch break. **You have to pay your lunch at the registration for the excursion – organized meal at restaurant (7 EUR on Thursday, 6 EUR on Friday)!** Do not forget to notify at the registration desk!

Important notice for the excursions

Ticks are excellent vectors for disease transmission and they populate the areas of field trips. Before going to the field trip **USE INSECT REPELLENT!** Do not forget to check yourself carefully for the presence of ticks after the excursions.



Map of Postojna (www.postojna.si)



1 – Karst Research Institute ZRC SAZU (Titov trg 2)
2 – Cultural Centre of Postojna (Kulturni dom, Prešernova ulica 1)
3 – Parking place for excursions (PTC Primorka, Novi trg 6)
4 – Hotel Jama
5 – TPT Epicenter (Tržaška cesta 82)

Programme

MONDAY, 16. 6. 2008

7.30-13.00 **Registration of participants**/ Cultural centre of Postojna

OPENING SESSION (Cultural centre of Postojna)

8.30-9.00 Opening
9.00-10.00 **Keynote lecturer Ira D. Sasowsky:** Cave sediments - uses, processes, and stories

SESSION 1: FLOWSTONES

10.00-10.30 **Invited lecturer Charles Self:** How speleothems grow
10.30-11.00 **Invited lecturer Bogdan P. Onac:** Crystallization processes and spatial distribution of speleothems

11.00-11.15 Coffee break

11.15-12.15 **Keynote lecturer Wolfgang Dreybrodt & D. Romanov:** Regular stalagmites: the theory behind their shape
12.15-12.30 **A. Martín-Pérez & A. M. Alonso-Zarza:** Huntite, dolomite, magnesite and sepiolite in moonmilk deposits: Castañar Cave, Spain
12.30-12.45 **A. Summers Engel et al.:** Implications of bacterial diversity and activity in carbonate deposits, Bus de la Foos Cave, Italy
12.45-13.00 **R. Aubrecht et al.:** Microbial origin of opal speleothems in Venezuelan Quartzite caves (Roraima Group, Guyana Highlands)

13.00-14.30 Lunch break

SESSION 2: CAVE SEDIMENTS (Cultural centre of Postojna)

14.30-14.45 **L. Rosales Lagarde et al.:** Characteristics of caves at the Villaluz Park, Tabasco, Southern Mexico
14.45-15.00 **A. Persoiu:** Ice in caves: a peculiar type of sediment in low-altitude caves in the temperate region
15.00-15.15 **B. Sadier:** Contribution to the knowledge of the racking process 3d visualisation assets in dynamic studies of realignment of the endokarstics fills in the Aven d'Orgnac Cave; France

POSTER SESSION (at the Karst Research Institute ZRC SAZU, Titov trg 2, Postojna)

15.30 Coffee break

15.45-17.30 **Poster presentations** (2 minutes/poster)
Cave sediments, Cave minerals, Flowstone, Anthropogenic sediments, Dating & Isotopes & Climate, Caves, Cave fauna, Karst, Karst morphology, Palaeokarst, Modelling, GIS, Conservation, Karst hydrogeology, …

17.30-19.00 Dinner break

19.00-22.00(23.00) **Excursion 1:** to non-tourist part of the Postojna cave; easy walk: **boots or walking shoes and light are required!** Meeting point: the entrance to Postojna cave, at 19 o'clock sharp - train is leaving on time. Leaders: Nadja Zupan Hajna & Andrej Mihevc.

TUESDAY, 17. 6. 2008

SESSION 3: CAVE CLASTIC SEDIMENTS (Cultural centre of Postojna)

8.30- 9.30 **Keynote lecturer Peter Bull:** Clastic sediments from inner cave facies
9.30-10.00 **Invited lecturer Pavel Bosak:** Entrance facies of cave sediments
10.00-10.30 **Invited lecturer Armstrong Osborne:** Cave turbidites

10.30-10.45 Coffee break

10.45-11.15 **Invited lecturer Bernard Sigé**: Paleogene karstic fillings of Southern France; geological data and time constraints
11.15-11.30 **Invited lecturer Bogdan Ridush:** Cave taphonomy
11.30-11.45 **P. Häuselmann:** Sediments, morphology, datings, different caves - all in one?!
11.45-12.00 **J. Ginés et al.:** Present-day sedimentary facies into the coastal karst caves of Mallorca Island (Western Mediterranean)
12.00-12.15 **V. K. Jena:** Trends of environmental change and geochemical study of sedimentary records in Mediterranean rockshelters and caves
12.15-12.30 **G.L. Harley et al.:** An analysis of cave sediments from Jennings Cave, Marion County, Florida: geomorphic implications
12.30-12.45 **A. Mihevc:** Sedimentary structures and movements of the cave entrance sediments, examples from caves in Slovenia
12.45-13.00 **E. Maitre & Bernard Sigé:** Bat study contribution to the chronology of the Paleogene karstic fillings in Western Europe

13.00-14.30 Lunch break

14.30-21.00 **Excursion 2**: to Matarsko Podolje and Dimnice cave (bus & walk; light and walking shoes are recommended). Leaders: Nadja Zupan Hajna & Andrej Mihevc.

WEDNESDAY, 18. 6. 2008

SESSION 4: SURFACE KARST SEDIMENTS & VARIOUS

8.30- 9.30 **Keynote lecturer Jean-Noel Salomon:** Connection between karst surface sediments and climate
9.30-10.00 **Invited lecturer Kazuko Urushibara:** The comparison of red soil formed from calcareous rock under the different climatic condition
10.00-10.30 **Invited lecturer Tihomir Marjanac & L. Marjanac:** Glacial sediments in Dinaric karst

10.30-10.45 Coffee break

10.45-11.15 **Invited lecturer Nada Horvatinčić:** Tufa as a karst phenomena: environmental and palaeoclimate conditions of tufa formation
11.15-11.45 **Invited lecturer Paolo Forti:** Chemical deposits in caves
11.45-12.00 **P. Audra**: Presentation of the typical sediments associated to hypogenic caves
12.00-12.15 **C.M. Fadem et al.:** Polje soils: unique karst sediments?
12.15-12.30 **U. Sauro et al.:** A multi-disciplinary study of filling deposits of dolines in Faverghera Plateau, Belluno, Italy
12.30-12.45 **De Waele & D.E. Granger:** Sediments in caves of the Taquisara Valley: karstic evolution, palaeoclimatological and palaeogeographical implications: a preliminary report

13.00-14.30 Lunch break

14.30-21.00 **Excursion 3**: Cave sediments at Škocjanske jame and surface karst above caves (bus & walk; light and walking shoes are recommended). Leaders: Nadja Zupan Hajna, Andrej Mihevc& Andrej Kranjc.

THURSDAY, 19. 6. 2008

8.00-19.30 **Excursion 4**: Karst sediments of Kras plateau (bus & walk; caves, light and walking shoes are recommended, organized lunch (additional payment for lunch / 7 EUR)). Leaders: Nadja Zupan Hajna & Andrej Mihevc.

20.30 **Reception** at the Karst Research Institute ZRC SAZU, Titov trg 2, Postojna

FRIDAY, 20. 6. 2008

8.30-20.00 **Excursion 5**: Classical Karst (Karst of the underground Ljubljanica river, poljes of Cerknica and Planina, Rakov Škocjan natural bridges, springs, ponors…; bus & walk, organized lunch (additional payment for lunch)). Leaders: Nadja Zupan Hajna & Andrej Mihevc.

SATURDAY, 21. 6. 2008

Optional: tourist visit to Postojna cave with a free ticket (register at the reception desk!) at 9.00 o'clock.

LIST OF POSTER PRESENTATIONS

1. Samer Al Hachem: A PROPOSED METHOD FOR MODELING THE EROSIONAL COASTAL PROCESSES OF ROCKY COASTS WITH THE USE OF REMOTE SENSING AND GIS: A CASE STUDY ALONG THE LEBANESE KARSTIC COASTLINE
2. Jadranka Barešić, Nada Horvatinčić, Ines Krajcar Bronić, Andreja Sironić, Bogomil Obelić, Polona Vreča: GEOCHEMICAL AND ISOTOPIC RESEARCH AT PLITVICE LAKES SYSTEM
3. Neven Bočić, Sanja Faivre & Marijan Kovačić: UNDERGROUND KARST FEATURES AND GLACIAL SEDIMENTS – EXAMPLE FROM "SNJEŽNICA U ŠTIROVAČI" CAVE ON THE VELEBIT MT. (CROATIA)
4. Ognjen Bonacci & Ivo Andrić: HYDROLOGY OF THE KARST RIVERS LIKA AND GACKA
5. Rosana Cerkvenik: ANTHROPOGENIC SEDIMENTS IN THE CAVES ON KRAS
6. Megan D. Curry & Penelope J. Boston: BIOGENETIC POTENTIAL OF MOONMILK DEPOSITS: SPIDER CAVE AND PAHOEHOE CAVE, NEW MEXICO; THURSDAY MORNING CAVE, COLORADO; THRUSH CAVE AND CATARACT CAVE, ALASKA
7. Nikola Čadjenović: PALEOKARST FORM IN THE LATE TRIASSIC ROCKS OF MT.RUMIJA, SOUTHERN MONTENEGRO
8. Jelena Ćalić, Tamas Telbisz & Laszlo Mari: OLD THEORIES AND NEW INSIGHTS ON THE MORPHOGENESIS OF THE DANUBE'S KAZAN GORGE – THE ROLE OF KARST PROCESSES"
9. Veronica Dârmiceanu, Bogdan P. Onac, Tudor Tămaş & Jonathan Sumrall: MINERALOGY OF CAVE DEPOSITS ALONG CERNA VALLEY, ROMANIA
10. Neda Dević, Dragan Radojević, Milan Radulović & Milica Blecić: GEOCHEMICAL CHARACTERISTICS OF THE MORACA RIVER BASIN-UPSTREAM FROM THE CONFLUENCE WITH THE ZETA RIVER
11. Radosław Dobrowolski, Lucjan Gazda & Przemysław Mroczek : PALAEOKARST CLAY CORTEX FROM THE LUBLIN-VOLHYNIA REGION (SE POLAND, NW UKRAINE) – GENETIC AND PALAEOGEOGRAPHICAL CONTEXT
12. Domínguez-Villar D.; Vázquez-Navarro J.A., Razola L. & Edwards R.L.: RECONSTRUCTION OF HUMID CONDITIONS DURING THE LAST INTERGLACIAL (MIS 5E) INFERRED FROM TUFA DEPOSITS IN TRABAQUE CANYON, CENTRAL SPAIN.
13. Abdolah Fazeli Farsani & Gholamali Bagheri: KARST FEATURES IN CHAHARMAHAL VA BAKHTIARI PROVINCE(SW OF I.R. OF IRAN)
14. João Forte: THE GEOMORPHOLOGICAL HERITAGE (KARST) OF THE TERRITORIAL UNIT OF ALVAIÁZERE: FROM ITS INVENTORY TO A PROPOSAL OF VALUING IT
15. Sapana Gupta: ASSESSMENT OF GEOLOGICAL RISK AND ENVIRONMENTAL FACTORS OF THE AREA SURROUNDING CAVES: A PROPOSED NATURAL RISK INDEX AND SAFETY FACTOR
16. Anamaria Haeuselmann: DEPOSITION OF THE SEDIMENTS IN CICLOVINA CAVE (SUREANU MTS., ROMANIA)
17. Brian Ham, Yuan Doaxian, Luo Jianxin, Yang Pingheng, Jiang Yongjun & Chris Groves: US/CHINESE COOPERATION AND TRAINING IN KARST WATER RESOURCE INVESTIGATION IN FOLDED CARBONATE STRATA, QING MUGUAN KARST GROUNDWATER BASIN, CHONGQING, CHINA

18. Harley G.L., Reeder P. & Polk J.S.: AN ANALYSIS OF CAVE SEDIMENTS FROM JENNINGS CAVE, MARION COUNTY, FLORIDA: GEOMORPHIC IMPLICATIONS
19. Nikola Jurková, Pavel Bosák, Maryna Komar & Petr Pruner: IN-SITU FLOWSTONE OUTCROPS AT MACHNÍN – THE FIRST INDICATION OF UNROOFED CAVE IN THE CZECH REPUBLIC
20. Kapralova Ekaterina: APPLICATION OF REMOTE SENSING METHODS FOR INVESTIGATION OF KARST PROCESSES
21. Kapralova V.N.: USE OF MATHEMATICAL MORPHOLOGY OF LANDSCAPE TO STUDY KARST PROCESSES
22. Kiefer E., Loisy C. & Cerepi A.: PALAEOKARSTIC RECORDS AS A PART OF DIAGENETIC EXPRESSIONS OF THE MIDDLE PALAEOCENE SUBAERIAL EXPOSURE ON THE PYRENEAN CARBONATED PLATFORM (NORTHERN ARAGON, SPAIN)
23. Klaudia Kiss & János Móga: COMPARISON OF TWO LOESS COVERED KARST REGIONS IN HUNGARY: THE TÉSI-PLATEAU (BAKONY MOUNTAINS) AND THE ABALIGET – ORFŰ KARST (MECSEK MOUNTAINS)
24. M. Kosina, D. Poulová, M. Laichmanová, I. Sedláček & J. Štelcl: CALCITE MOONMILK: MICROBIOLOGICAL AND GEOLOGICAL ASPECTS
25. Jure Košutnik: CONTRIBUTION TO CONTACT KARST MORPHOLOGY: A CASE STUDY OF NOVOKRAČINE (SW SLOVENIA)
26. Martin Kucera: GENERATIONS OF TECTONIC EVENTS AND THEIR INFLUENCE ON GENESIS OF THE CAVES (SLOVAK REPUBLIC, HIGH TATRA MTS., UPLAZ MASSIF)
27. Lončar N., Perica D., Husnjak S., Krklec K. & Andačić N.: CAVE SEDIMENTS IN SV. ROK CAVERN (CROATIA)
28. Ivo Lučić: INVISIBLE BUT POWERFUL KARST SEDIMENTS
29. Ljerka Marjanac, Kristina Krklec, Tihomir Mrjanac & Valentina Hajek Tadesse: PALEOKARST AND ASSOCIATED SEDIMENTS AT DUBCI GEOSITE IN DALMATIA, SOUTHERN CROATIA
30. R. Martín-García, A.M. Alonso-Zarza & A. Martín-Pérez: EXAMPLE OF RECENT SUBAERIAL DIAGENESIS
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33. Magdalena Năpăruş & Marius Mocuţa: SIGNIFICANCE OF THE TOPOGRAPHICAL MEASUREMENTS PERFORMED BETWEEN 2006 AND 2007 FOR ANALYSING THE MORPHOLOGY OF THE COLLAPSE SINKHOLE ESTABLISHED ON THE ANTHROPIC SALT KARST FROM OCNELE MARI, ROMANIA
34. Tamer Nassar & Adham Refae SEDIMENTOLOGICAL CHARACTERIZATION OF THE CAVE DEPOSITS IN THE GABAL CRYSTAL, EGYPT
35. Leslie North: INTERREGIONAL COMPARISON OF KARST DISTURBANCE: WEST-CENTRAL FLORIDA AND SOUTHEAST ITALY
36. Andreea Oarga: SPECIES RICHNESS IN SEDIMENT-FILLED POOLS AND DRIPS IN CAVES
37. Dalibor Paar, Darko Bakšić, Damir Lacković, Magdalena Ujević & Ana Čop: PHYSICAL AND CHEMICAL RESEARCH IN VELEBITA PIT (CROATIA)
38. Persoiu Ioana & Persoiu Aurel: SEDIMENTS VARIABILITY ALONG THE ACTIVE PASSAGE OF VANTULUI CAVE, ROMANIA

39. Branislav Petrović: PROTECTION OF LISINE WATERFALL (BELJANICA MT, EASTERN SERBIA)
40. Lukas Plan, Marco Filipponi, Michael Behm & Robert Seebacher: ANALYSIS OF PLANAR FEATURES IN CAVE GENESIS – EXAMPLES FROM THE TOTES GEBIRGE (NORTHERN CALCAREOUS ALPS, AUSTRIA)
41. Jason S. Polk & Philip van Beynen: A MULTI-PROXY APPROACH TO USING CAVE SEDIMENT CARBON ISOTOPES FOR LATE HOLOCENE PALEOENVIRONMENTAL RECONSTRUCTION IN FLORIDA
42. Petr Pruner, Nadja Zupan Hajna, Andrej Mihevc, Daniela Venhodová, Petr Schnabl, Stanislav Šlechta & Pavel Bosák: PALAEOMAGNETIC RESEARCH OF CAVE SEDIMENTS IN SLOVENIA IN 2007
43. Puşcaş Montana PHOSPHATE MINERALS FROM LILIECILOR CAVE, TRASCAU MOUNTAINS, ROMANIA - A PRELIMINARY STUDY
44. Mohamed Rouai: RELATIONSHIP BETWEEN KARST AND FRACTURING IN THE MIDDLE ATLAS CARBONATE AQUIFER (MOROCCO): A FRACTAL APPROACH
45. Rusjan S., Mikoš M., Brilly M., Padežnik M. & Vidmar A.: HYDROLOGICAL CHARACTERISTICS OF THE PADEŽ STREAM AND THE REKA RIVER CATCHMENTS
46. Saeed Noor: THE IDENTIFICATION OF LAND SPONGES FOR FLOOD RISK REDUCTION IN UK (GLOBAL ENVIRONMENTAL ISSUE)
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48. Julie E. Schenck Brown & Dr. Stephen T. Kenworthy: TRANSPORT OF THE PESTICIDE ATRAZINE WITHIN THE LOGSDON RIVER, MAMMOTH CAVE, KENTUCKY
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50. Lucinda Silva & João Forte: THE RELATIONSHIP BETWEEN CAVES IN KARST AREAS AND RELIGION – THE PORTUGUESE CASE
51. Stemberk Josef, Briestenský Miloš, Jurková Nikola & Altová Viola: FRESH SPELEOTHEMES DAMAGES VERSUS ACTIVE FAULT MOVEMENTS IN SELECTED CAVES OF THE BOHEMIAN MASSIF AND WESTERN CARPATHIANS
52. Uroš Stepišnik: ELECTRICAL RESISTIVITY IMAGING OF COLLAPSE DOLINE FLOORS: THE KRAS PLATEAU, SLOVENIA
53. Uroš Stepišnik, Mateja Ferk, Petra Gostinčar & Luka Černuta: HOLOCENE HIGH FLOODS OF THE PLANINSKO POLJE, DINARIC KARST, SLOVENIA
54. Stepišnik Uroš & Mihevc Andrej: ELECTRICAL RESISTIVITY IMAGING OF DIVAŠKA JAMA CAVE
55. Jonathan Sumrall & Bogdan P. Onac: MINERALOGY OF CAVE DEPOSITS ON SAN SALVADOR ISLAND, BAHAMAS
56. Branislav Šmída, Lukáš Vlček, Charles Brewer-Carías, Marek Audy & Federico Mayoral: CAVES OF MACIZÓ CHIMANTÁ AND RORAIMA TEPUY IN LA GRAN SABANA AREA (ESTADO BOLÍVAR, VENEZUELA)
57. Tudor Tămaş & Ferenc Kristaly: THE MINERALOGY OF A WEATHERING DEPOSIT
58. (IZA CAVE, RODNEI MOUNTAINS, NORTHERN ROMANIA)
59. Tassy Aurélie, Mocochain Ludovic, Bellier Olivier, Braucher Régis, Bourlès Didier, Gattacceca Jérome & Rochette Pierre: DATING CAVE LEVELS IN RHONE VALLEY USING COSMONUCLEIDE 10BE AND 26AL, PALEOMAGNETISM AND BIOSTRATIGRAPHY: IMPLICATIONS FOR REGIONAL GEODYNAMIC FOR THE LAST 6 MY

60. Brandon L. Taylor, Mark W. Tracy, Arthur N. Palmer & Margaret V. Palmer: MAJOR PASSAGE ELEVATIONS AND PALEO-WATER LEVELS AS INDICATORS OF RELATIVE SPELEOGENETIC CHRONOLOGY IN THE GUADALUPE MOUNTAINS, NEW MEXICO, USA
61. Emir Temimović: KARST SEDIMENTS IN OF THE SANA RIVER DRAINAGE BASIN
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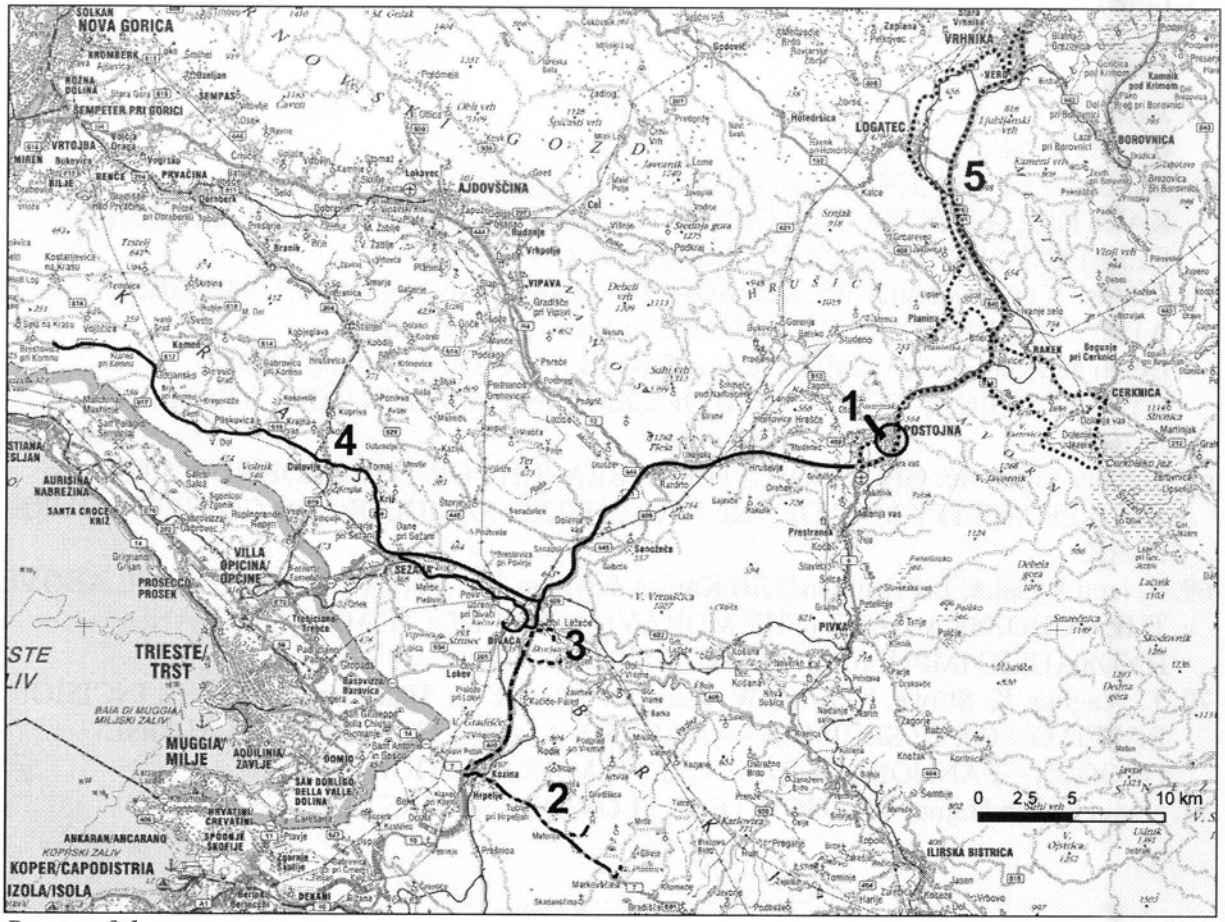
64. Janez Turk: PALAEOTEMPERATURE RECORD IN THE UPPER PLEISTOCENE CLASTIC SEDIMENTS AT DIVJE BABE 1 CAVE
65. Wolfgang Ufrecht: EVALUATING LANDSCAPE DEVELOPMENT AND KARSTIFICATION OF THE CENTRAL SCHWÄBISCHE ALB (SOUTHWEST GERMANY) BY FOSSIL RECORD OF KARST FILLINGS
66. Santosh Kumar Verma: WATER SOLUBLE INORGANIC CONTENT IN URBON ATMOSPHERE OF CENTRAL EASTERN PARTO OF INDIA
67. Dejan Milenić, Ana Vranješ, Nevena Savić &Djuro Milanković: KARSTIC HYDROLOGICAL ECOSYSTEM OF CEMERNICA MOUNTAIN, WESTERN SERBIA
68. Tatjana Vujnović: GROUNDWATER RESEARCH FOR THE GROUNDWATER VULNERABILITY MAP OF THE "ŽUMBERAK-SAMOBORSKO GORJE" NATURE PARK
69. Helena Vysoká, Jiří Bruthans, Jiří Kamas & Milan Jež: UNSATURATED ZONE ABOVE THE OCHOZSKA CAVE (THE MORAVIAN KARST): TRACER TEST AND HYDRAULIC IMPULSE PROPAGATION
70. T. Wagner, K. Stüwe, H. Fritz, W. Kurz, D. Fabel & Ph. Häuselmann: RIVER INCISION BASED ON CAVE SEDIMENT ANALYSIS ALONG THE EASTERN ALPINE OROGEN – PANNONIAN BASIN SYSTEM TRANSITION ZONE
71. Nadja Zupan Hajna: ARAGONITE IN SLOVENIAN KARST CAVES

EXCURSIONS

Nadja Zupan Hajna & Andrej Mihevc



Routs of the excursions:
Excursion 1 *(Monday evening): Postojna cave;*
Excursion 2 *(Tuesday afternoon): Matarsko podolje & Dimnice cave;*
Excursion 3 *(Wednesday afternoon): Škocjanske jame & surface;*
Ecursion 4 *(Thursday whole-day): Kras plateau;*
Ecursion 5 *(Friday whole-day): Clasical Karst.*

EVENING EXCURSION (1), 16 June 2008

SEDIMENTS IN PISANI ROV (POSTOJNSKA JAMA)

Postojnska jama

Postojnska jama (Reg. No. 747; 45°46′57.79″N; 14°12′13.18″E) developed in Postojnski kras where the surface is at about 600 to 650 m a.s.l. The evolution of the Pivka basin (flysch rocks) is defined by the altitudes of the ponors of the Pivka river that drains into this cave. The gentle fluvial surface of the basin itself stands out in sharp contrast to the karst lands above the cave and to other higher karst plateaus, where there are no traces of fluvial valleys or other elements of the early fluvial relief today. These surfaces are dissected with numerous dolines. Sixteen large collapse dolines developed above some parts of Postojnska jama, blocking certain passages. The thickness of bedrock overburden above the cave is 60 to 120 m. The cave was formed by the Pivka river. Its modern ponor is at 511 m a.s.l. and the terminal sump in Pivka jama is at 477 m a.s.l. There are still more than 2,200 m of unexplored galleries until the river re-appears in Planinska jama at 460 m a.s.l.

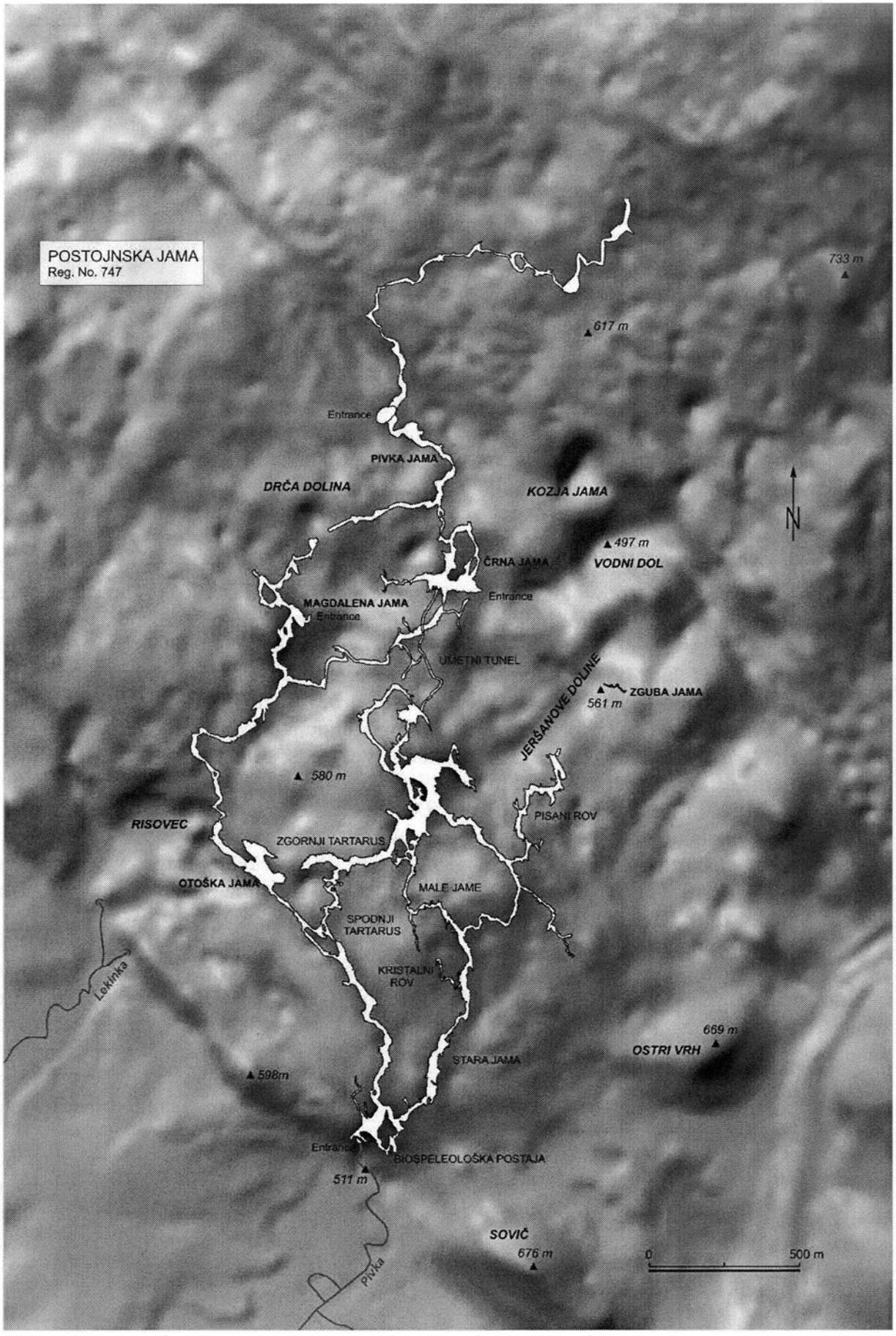
The historical entrance at 529 m a.s.l. is located above the modern ponor. Other entrances and parts of the system, i.e. Otoška jama, Magdalena jama, Črna jama and Pivka jama, are scattered on the surface above the cave. All these caves are interconnected and form a cave system 20.5 km in length, the longest in Slovenia.

The entrance to Postojnska jama is situated near the contact between the Eocene flysch and the Upper Cretaceous limestones (Buser, Grad & Pleničar 1967). The entire cave system is developed in an 800 m thick sequence of the Upper Cenomanian and Turonian to Senonian limestones. The Turonian limestone contains radiolitid fauna. The lower part of Senonian consists of thick-bedded limestone with numerous *Keramospherina tergestina*. The youngest beds belong to Maastrichtian, with some *Hippurites giordanni Pirona*.

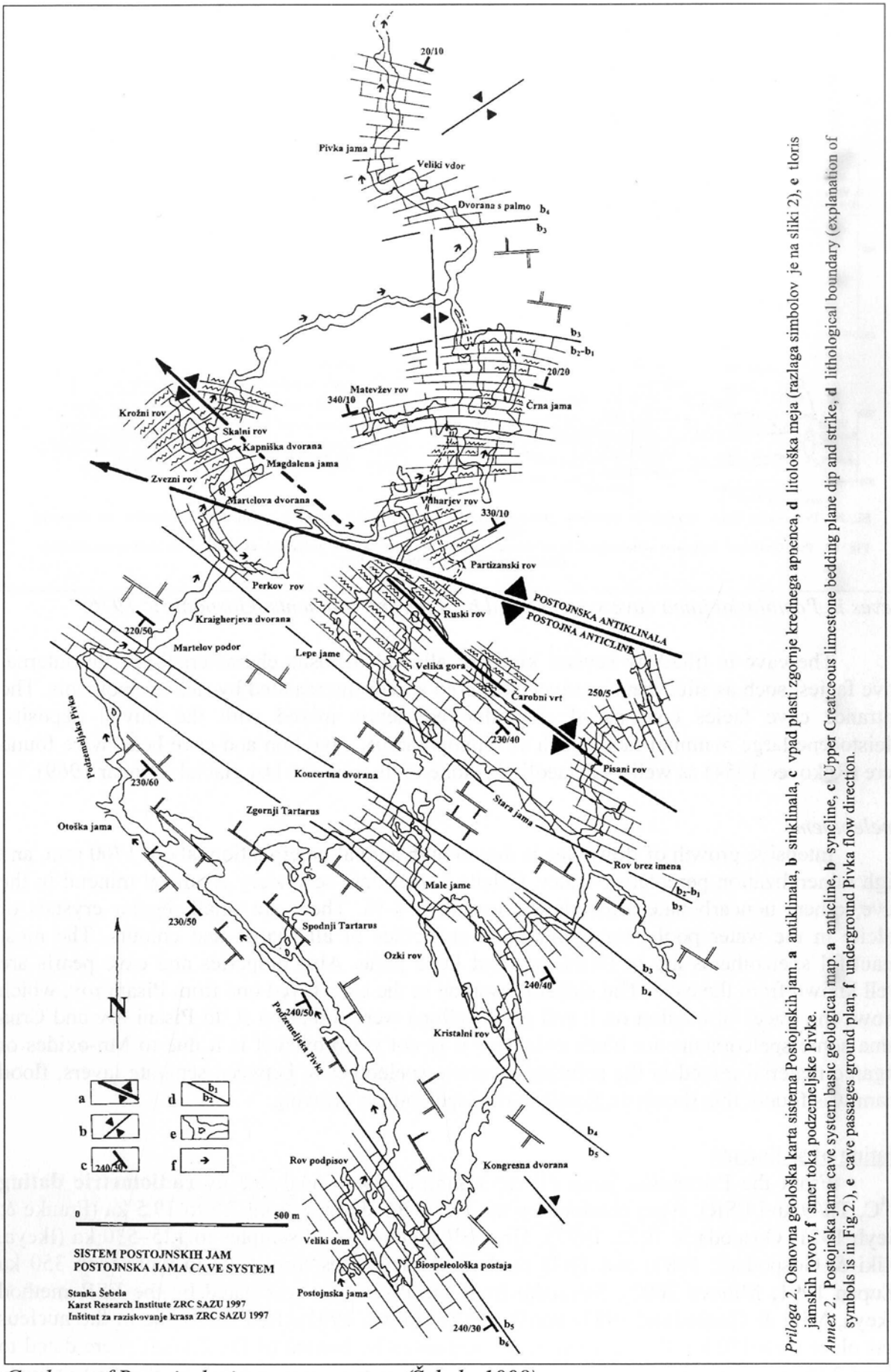
The cave passages are formed in the Postojna anticline, which is oriented NW–SE (Gospodarič 1976), most of channels being in its steeper south-western flank. The cave system is in the tectonic block confined by two distinctive dextral strike-slip fault zones in the Dinaric trend, the Idrija and Predjama faults (Buser, Grad & Pleničar 1967; Placer 1996). Habič (1982a) explained different features, such as collapses and sumps in the cave, as the results of neotectonic movements. A geological survey of the cave passages was made by Gospodarič (1964, 1976) and Šebela (1994, 1998a, b) added structural mapping in detail. The cave and the Pivka underground river have a general N–S trend.

The known passages were formed at two main levels. The upper level is between 529 m a.s.l., at the main entrance to the cave and 520 m a.s.l. in the Črna jama. This level is composed of large passages, generally up to 10 m high and wide. Their profiles are more rounded and show also traces of paragenesis (levelled ceilings, side notches on the walls and scallops on the walls and ceiling). There are also remnants of cave fills indicating repeated fillings of the cave and successive erosion of the sediments. Speleothems were deposited in different phases above clastic sediments. The natural floor of the cave was modified for the construction of a railway during opening for tourists.

The second level is about 18 m below the upper one, where the modern underground Pivka river flows from its entrance. The river bed has a low gradient and, except for some collapses and sumps, there are no natural barriers. It leaves the system through a terminal sump. The active river passages are mostly smaller than the higher ones. The river bed is composed mostly of gravels derived from the Eocene flysch. The mean annual discharge of the river is 5.2 m^3s^{-1}. The water level can rise for 10 m during floods.



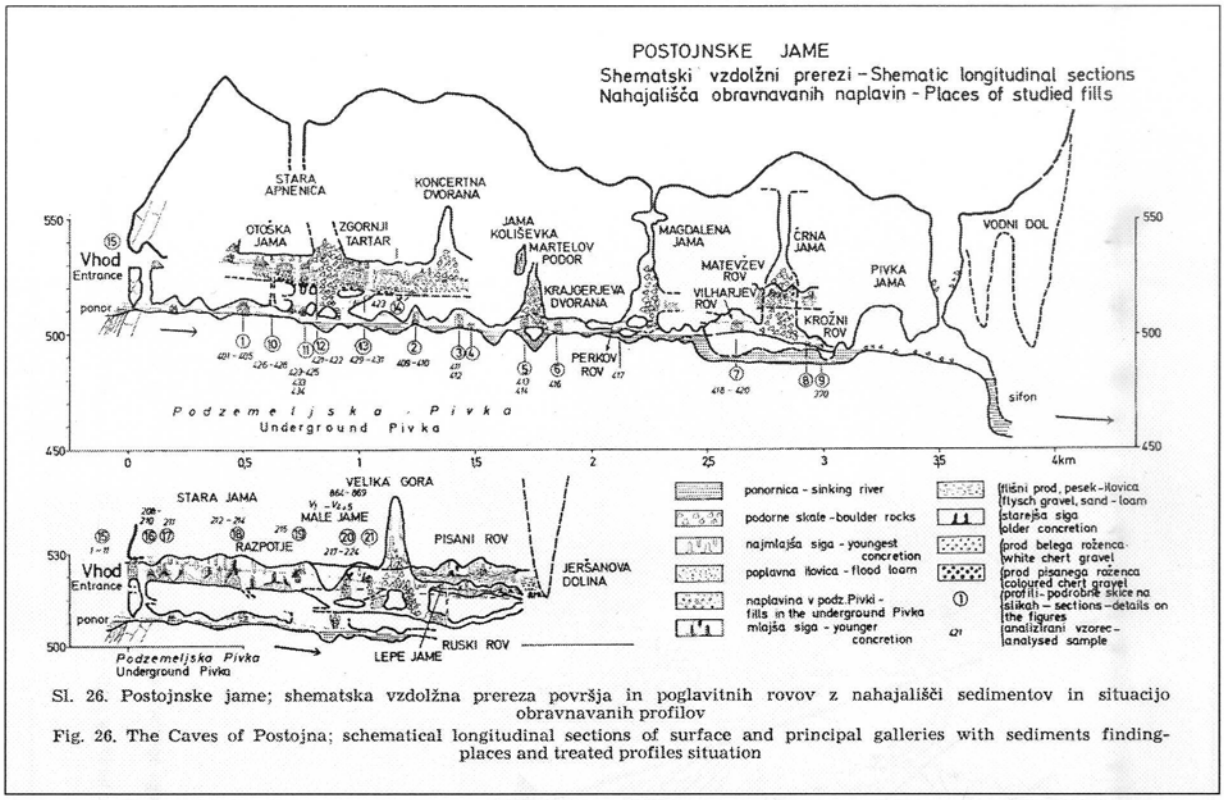
Plan of Postojnska jama cave system with the surface above the cave.



Priloga 2. Osnovna geološka karta sistema Postojnskih jam. **a** antiklinala, **b** sinklinala, **c** vpad plasti zgornje krednega apnenca, **d** litološka meja (razlaga simbolov je na sliki 2), **e** tloris jamskih rovov, **f** smer toka podzemeljske Pivke.

Annex 2. Postojnska jama cave system basic geological map. **a** anticline, **b** syncline, **c** Upper Creatceous limestone bedding plane dip and strike, **d** lithological boundary (explanation of symbols is in Fig.2.), **e** cave passages ground plan, **f** underground Pivka flow direction.

Geology of Postojnska jama cave system (Šebela 1998)



Sl. 26. Postojnske jame; shematska vzdolžna prereza površja in poglavitnih rovov z nahajališči sedimentov in situacijo obravnavanih profilov

Fig. 26. The Caves of Postojna; schematical longitudinal sections of surface and principal galleries with sediments finding-places and treated profiles situation

Leves in Postojnska jama cave system filled by different sediments (Gospodarič 1976)

The cave is filled by several kinds of alluvial deposits characteristic of the internal cave facies, such as silts, sands, gravels, covered and/or intercalated by rich speleothems. The entrance cave facies consists of slope-derived debris mixed with the fluvial deposits. Pleistocene large mammal fauna such as hippopotamus, cave lion and cave bear, were found here (Rakovec 1954) as well as Palaeolithic stone tools from the last glacial (Brodar 1969).

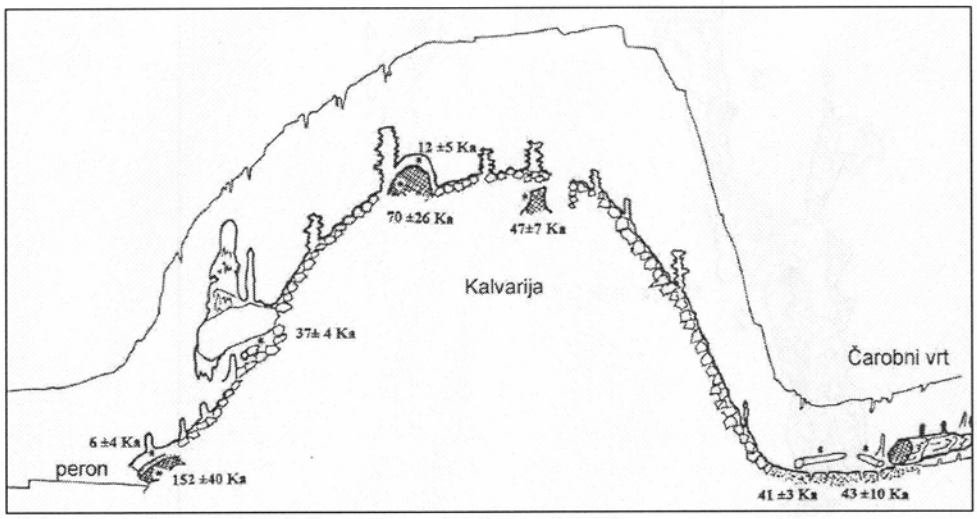
Speleothems

Intensive growth of flowstone is due to high annual precipitation, about 1700 mm, and high mineralization percolating water. Calcite is the main secondary chemical mineral in the cave, others noncarbonate minerals are less than 1 %. There are small regular crystals of calcite in the water pools, stalagmites and stalactites of all shapes and colours. The most beautiful speleothems are in Pisani rov and Lepe jame. Also draperies and cave pearls are well known from the cave. The oldest flowstone in the cave is red one from Pisani rov, which shows the traces of erosion on it and also scallops were found on it. In Pisani rov and Črna jama some speleothems are black coloured; it is not yet proved if is it due to Mn-oxides or organic material mixed in the solution. In some speleothems, between separate layers, flood loam was found; this shows on floods during speleothem growing.

Dating of sediments

From the Postojnska jama different samples were analysed by **radiometric dating** (^{14}C, Th/U and ESR). Ages obtained by the ^{14}C method range from 7.5 to 39.5 ka (Franke & Geyh 1971; Gospodarič 1972, 1977). The ESR method dated samples to 125–530 ka (Ikeya, Miki & Gospodarič 1983) and Th/U method yielded dates from 6 ka to more than 350 ka (Zupan 1991; Mihevc 2002). Stalactite from the Pisani rov was dated by the ESR method (Ikeya, Miki & Gospodarič 1983) and by Th/U (Zupan 1991). Red flowstone in the nucleus was older than 350 ka; the next two rings, separated by lamina of flood loam, were dated to about 270 ka and to about 75 ka, respectively. Two other samples from the Podorna dvorana

in Pisani rov were dated by the Th/U method. The base of a stalactite under a collapse block yielded age of about 75 ka and the base of a stalagmite which grew on the block was established to be about 20 ka old. Mihevc (2002) recorded three periods of flowstone growth on the Velika gora and in the Pisani rov (excluding recent flowstones). The oldest flowstone was dated at the foot of collapse at the railway station. Flowstone was deposited above collapse boulders at 152 ±40 ka. A flowstone dome at the top of the Kalvarija was 70 ± 26 ka old. An important growth period of flowstone was documented in five samples from Pisani rov. The sampled stalagmites here fell because clayey substratum was washed away and afterwards they were covered by big boulders or they were found broken and covered with scree. The stalagmites were growing on clays (41 ±3 ka, 43 ±10 ka), on collapse boulders (37 ±7 ka) and on rubble (47 ±7 ka). The youngest phase of flowstone deposition is recorded in samples of grey crystalline flowstone and stalagmite (12 ±5 ka and 6 ±4 ka) covering all collapse blocks. The intensity of rock fall is low under the present conditions. These data, in spite of some errors, helped to distinguish some clear phases of collapse alternating with flowstone deposition. Collapses have been usually connected with colder climate, flowstone deposition with the warmer one.

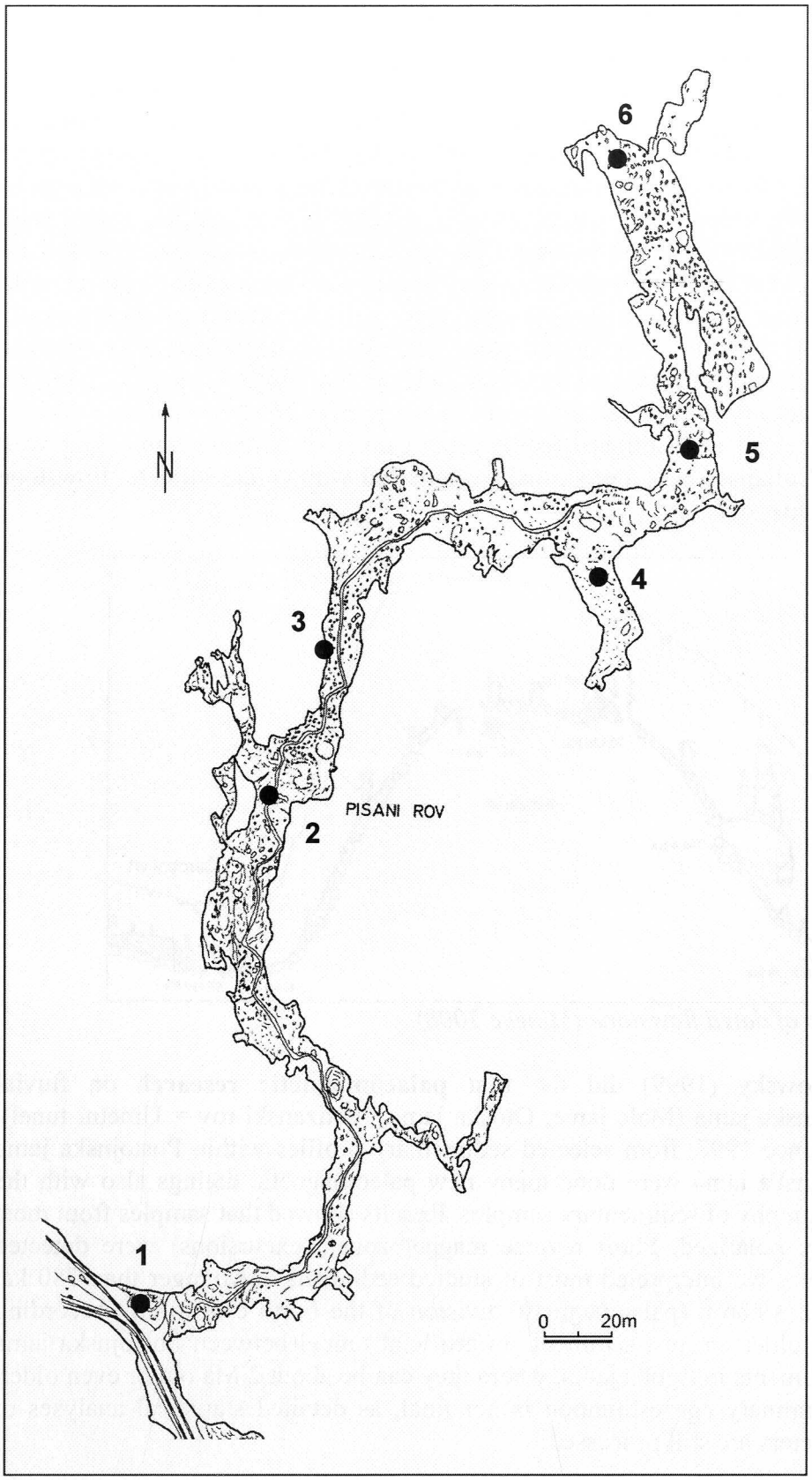


Position of the samples of dated flowstone (Mihevc 2008)

Šebela & Sasowsky (1999) did the first **palaeomagnetic research** on fluvial sediments from Postojnska jama (Male jame, Otoška jama, Partizanski rov = Umetni tunel). In the last ten years, since 1997, from selected sedimentary profiles within Postojnska jama Zguba jama and Planinska jama were done many new paleomagnetic datings also with the study of magnetostratigraphy of sedimentary samples. Results showed that samples from most profiles were normally polarized. Short reverse magnetozones (excursions) were detected only in places. Therefore we interpreted most of studied sediments as younger than 780 ka, belonging to the Brunhes chron (paleomagnetic division of the Earth evolution). According till now obtained data older are just sediments in artificial tunnel between Postojnska jama and Črna jama and sediments in Zguba jama, where they can be about 2 Ma old or even older. Nevertheless this preliminary age estimation is not final, as detailed statistical analyses of palaeomagnetic parameters are still processed.

Stara jama

Stara jama is the main passage of the upper level of the cave, gently dipping to the north. It is developed in the thick-bedded rudist Turonian limestone, with strata dip south-west. The passage was formed in epiphreatic conditions and there are traces of paragenesis on the ceiling.



Map of Pisani rov; Legend: 1 – entrance to Pisani rov, 2 – corrosional trickles, 3 - speleothems with alternating dense and porous laminations, 4 – course grained stalagmites, 5 – broken speleothems (here excursion stops), 6 – location of the profile for the paleomagnetic analyses.

Relicts of the sedimentary fill are still preserved in some parts protected by flowstones or collapse. Our profile of the sediments is located in Stara jama at Križ (in front of the Kristalni rov; 528 m a.s.l.). It was exposed by quarrying for sand during the construction of tourist pathways.

The approximately 220 cm profile was sampled in the left portion of the outcrop, where it was covered by flowstone. Grey clayey-sandy gravels with sub-angular to sub-rounded flat pebbles up to 3 cm in size, with some bands and lenses of clayey-silty fine-grained sand, constituted the lower 118 cm of the profile. They were overlain by greyish light brown silty clays; finely light micaceous, with laminae and bands with sandy admixture (6 cm). A total of 26 samples were investigated from the Stara jama profile. Mean palaeomagnetic directions of N polarized C-components for this profile are D = 19° and I = 65°. Fragments of bones (probably *Ursus spelaeus*; det. I. Horáček 2007) were found in silty clays between sands in the right part of the outcrop. As far as can be said, the palaeomagnetic results indicate the age of sediments to be younger than 0.78 Ma in the Stara jama profile. This interpretation is also supported by Pleistocene bear bones occurring on the top of the profile. The top part of the profile showing flaky disintegration could be disturbed by freezing, as this kind of texture is typical of cryoturbation processes.

Pisani rov

Pisani rov is the passage which deviates to the north from the main passage of the Stara jama. It terminates below the slopes of the collapse doline of Velika Jeršanova where the bottom is filled by sediments at 535 m a.s.l. The passage was formed in the thick-bedded Turonian limestones with the stratal dip towards west along bedding planes (Gospodarič 1962).

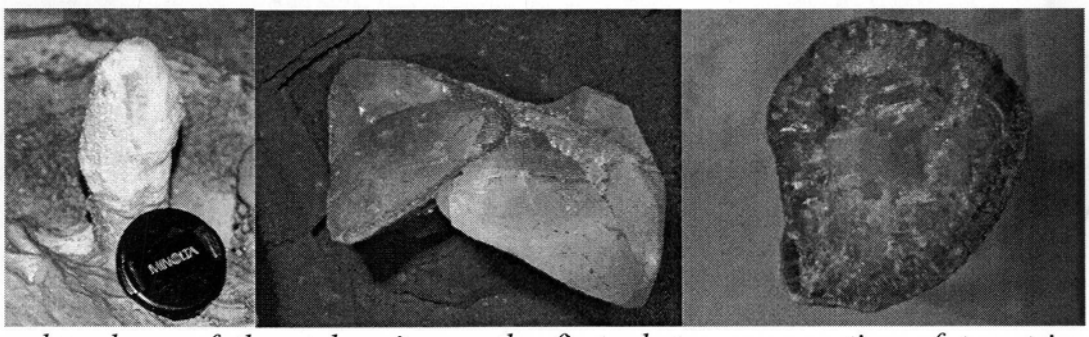
In Pisani rov tectonically broken zones are in different directions those of N-W are the most frequent. Dinaric (NW-SE) and cross Dinaric (NE-SW) directions are a bit less common (Šebela 1992, 1998).

Speleothems in Pisani rov

Pisani rov (Coloured Passage) is known by different speleothems of various colours and forms. The evidence of floods above already existing speleothems is indicated by clay layers between dense calcite (sinter) layers and in porous layers (the best is seen in broken stalactites with alternating dense and porous laminations at point 3 on Pisani rov map).

The oldest flowstone in the passage is red in colour, in some places covers passage walls and it is also presented as nucleus of many stalactites and stalagmites. Red flowstone was eroded in many places and also scallops may be found on it.

There are also recrystalised (coarse-crystals) speleothems (yellowish to brownish in colour). A lot of stalagmites is already so much recrystalised (growing of monocrystal) that also the outer shape of them are deformed/transformed to triangular form.



Triangular shape of the stalagmite on the first photo; cross-section of two triangular stalagmites on the second photo and recrystalisation of the stalagmite on the third photo

Monocrystaline speleothems are usually stalactites and helictite which are growing as mono crystal (Hill & Forti 1997), stalagmites are rare. That kind of speleothems may be found in calm (closed) part of the caves; conditions: low saturation, high humidity and CO_2 levels, and low wind.

In Slovenia we have a lot of caves with triangular stalagmites. In almost all of them macrocrystalline growth can be detected in the base the stalagmites in which already overgrowth of single crystals can be detected. But the research is still in progress.

In the passage all different kinds of stalagmites and stalactites are presented and also draperies, small shields, turnips and helictites may be found. In places black coating over the speleothems can be seen, and at the other places red (orange) coloured layers cover the youngest white speleothems.

A lot of speleothems are broken and fallen; Gospodarič (1962) explained it with subsiding of the sediments. There are also a lot of broken points of stalactites.

The oldest dated flowstone in Slovenia is the red nucleus of the stalactite from Pisani rov, being about 530.000 years old (Zupan 1991). In this channel several stalactites about 1 m long grow, some of them have fallen off, but their bases are left on the roof. Red flowstone in their nucleus was precipitated during one of Mindel Interglacials and it was also eroded in Mindel already. The next two rings, between them is a layer of flood loam, were dated to Mindel-Riss Interglacial, about 270.000 years old, and to Riss-Würm Interglacial, about 75.000 years old. The same type of stalactite has given the very similar data using ESR and U/Th dating method.

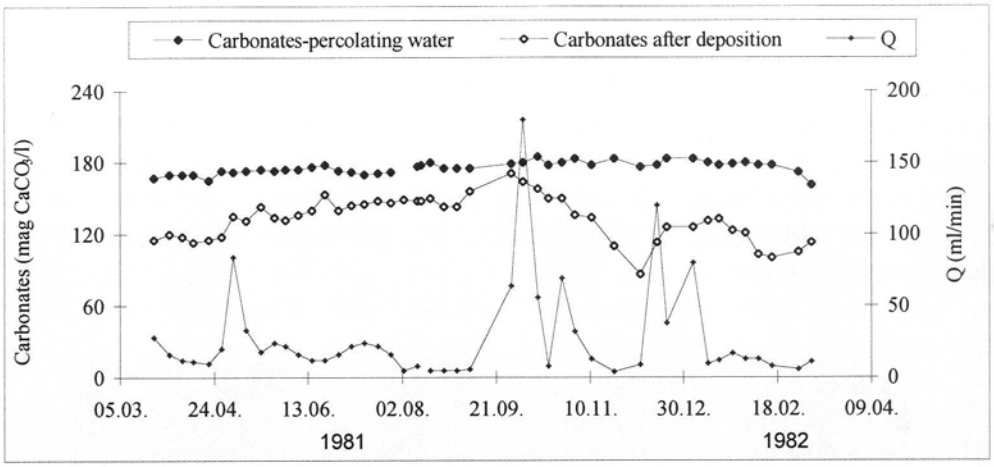
From Podorna dvorana in Pisani rov another sample was analysed. The base of stalagmite which continues to grow on the collapsed rocky block was established to be about 20.000 years. Thus it follows that the collapse occurred in Late or Middle Würm probably and that stalagmite started its growth on the collapsed block in some Würm Interglacial.

Flowstone deposition in Pisani rov (by Janja Kogovšek)

In a largely decorated Pisani rov tiny drippings with low discharges and relatively low variations prevail. After the rain this percolation water forms a gentle water pulse with very slow decrease and bigger or smaller retardations confirming strong retardation of precipitation influence through the cave ceiling. This is reflected also in a relatively small hardness oscillation of percolation water during the year. An important role is played by the ceiling that retains and directs the percolation water. One can conclude that in Pisani rov calm drippings prevail without abrupt or quick changes. Some larger trickles are connected with faults, their discharges oscillate and during dry period they also dry up. They resemble the trickles in Planinska jama by fast reaction to rain and by forming expressive water pulses that show distribution and precipitation quantity.

It is clear that the structure of the ceiling has the greatest impact on the discharge regime; bigger differences among neighbour trickles can be explained by different system of inflow and different percolation as sometimes it is connected with joints and fractures. So one can also explain the different types of trickles located in immediate vicinity, one with saturated percolation water, depositing flowstone and the other one aggressive, corroding rocks and old speleothems.

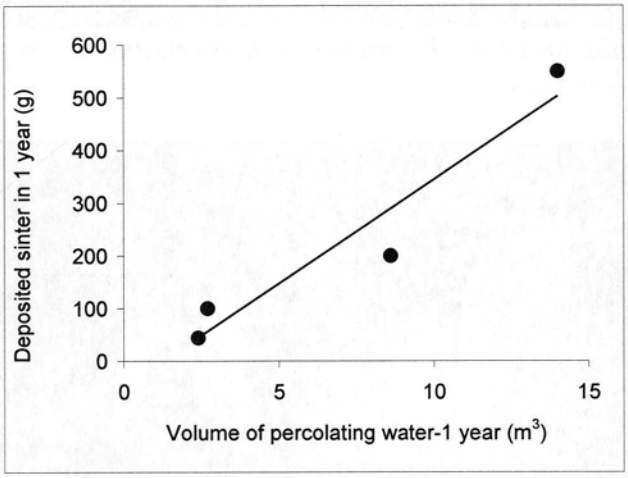
Nicely coloured speleothems in Pisani rov reflect diversified deposition of flowstone in the past. Today this passage is climatically very steady. Most of percolations water has high carbonate hardness (190 – 240 mg HCO^-_3) and deposits flowstone.



Sinter deposition at Point 23 in Pisani rov.

Discharge and carbonate hardness measurements every week cleared up the way of flowstone deposition during the whole year. They enabled a rough calculation of deposited carbonates at observed points giving us that permanent drippings would yield 0.5 mm flowstone per year. During the low discharge the deposition of carbonates increases but we have stated that the quantity of deposited carbonates in a defined time (the discharge rarely exceeds 100 ml min^{-1}) mostly depends on the quantity of percolation water.

Evidently it is important how water flows on a speleothem; there are many asymmetrically grown speleothems as the flowstone deposition can change during a year even if other conditions are quite constant. Extremely steady conditions in Pisani rov show that the flowstone is deposited constantly during the whole year thus completing the old speleothems.



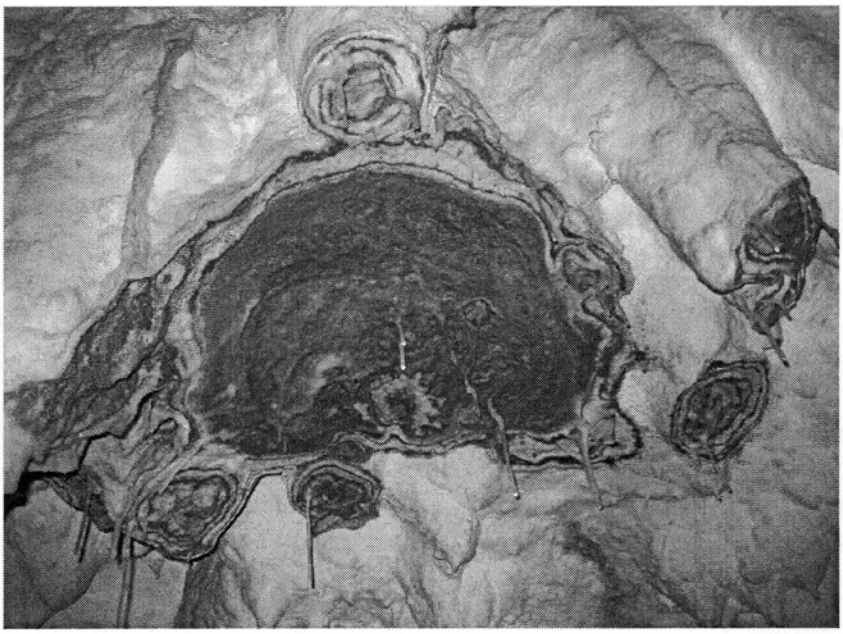
Mass of deposited sinter in dependence of water volume.

Profile of fluvial sediments at the end of the passage

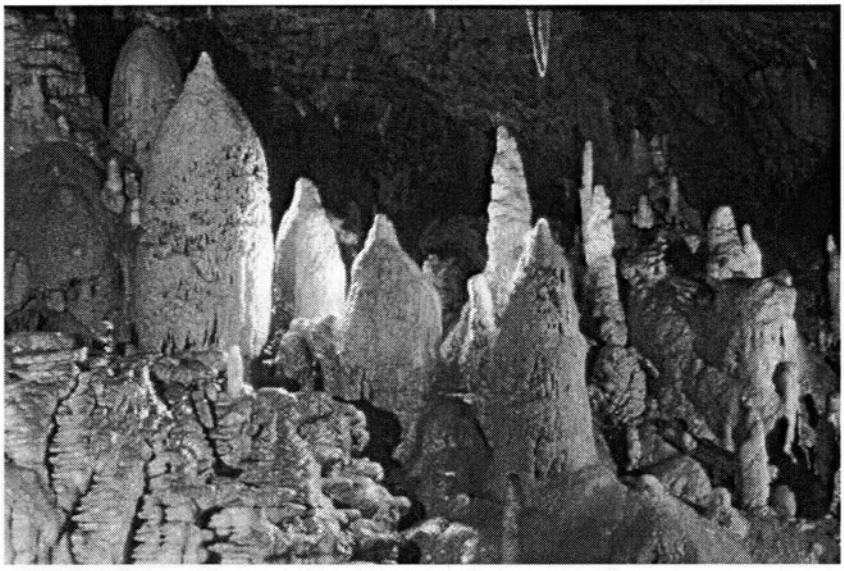
Along whole the passage grey loam originated from weathered flysch rocks can be find, on the bottom, between flowstone layers, incorporated into the stalagmites and stalactites, on walls and ceiling. The profile of fluvial sediments situated at the end of the Pisani rov (529 m a.s.l.), was studied. Fine-grained sediment covers the collapse boulders and massive flowstone. The roughly 145 cm thick Pisani rov profile was composed of yellowish brown silts to clays with dark stains and schlieren, with an olive-green horizon in the lower third, finely laminated in the lower part. The upper part of lutites showed cubic to columnar disintegration with Fe stains on the fractures. The profile is covered by two layers of

flowstone. The lower one contained broken stalagmite, which remain was lying on flowstone surface. The second layer was developed only in places and was covered by limestone clasts. Samples of flowstone were delivered for Th/U dating to Warsaw (Poland).

A total of 65 samples have been investigated for their palaeomagnetic properties. Mean palaeomagnetic directions of N polarized C-components for this profile are D = 6° and I = 64°. The profile showed only N polarized magnetization and a palaeomagnetic direction very close to the present magnetic field; therefore we assume that deposition occurred within the Brunhes chron (<780 ka).



Cross-section of the stalactites from Pisani rov with alternating dense and porous laminations and layers of caly between them



Stalagmites in Pisani rov

AFTERNOON EXCURSION (2), 17 June 2008

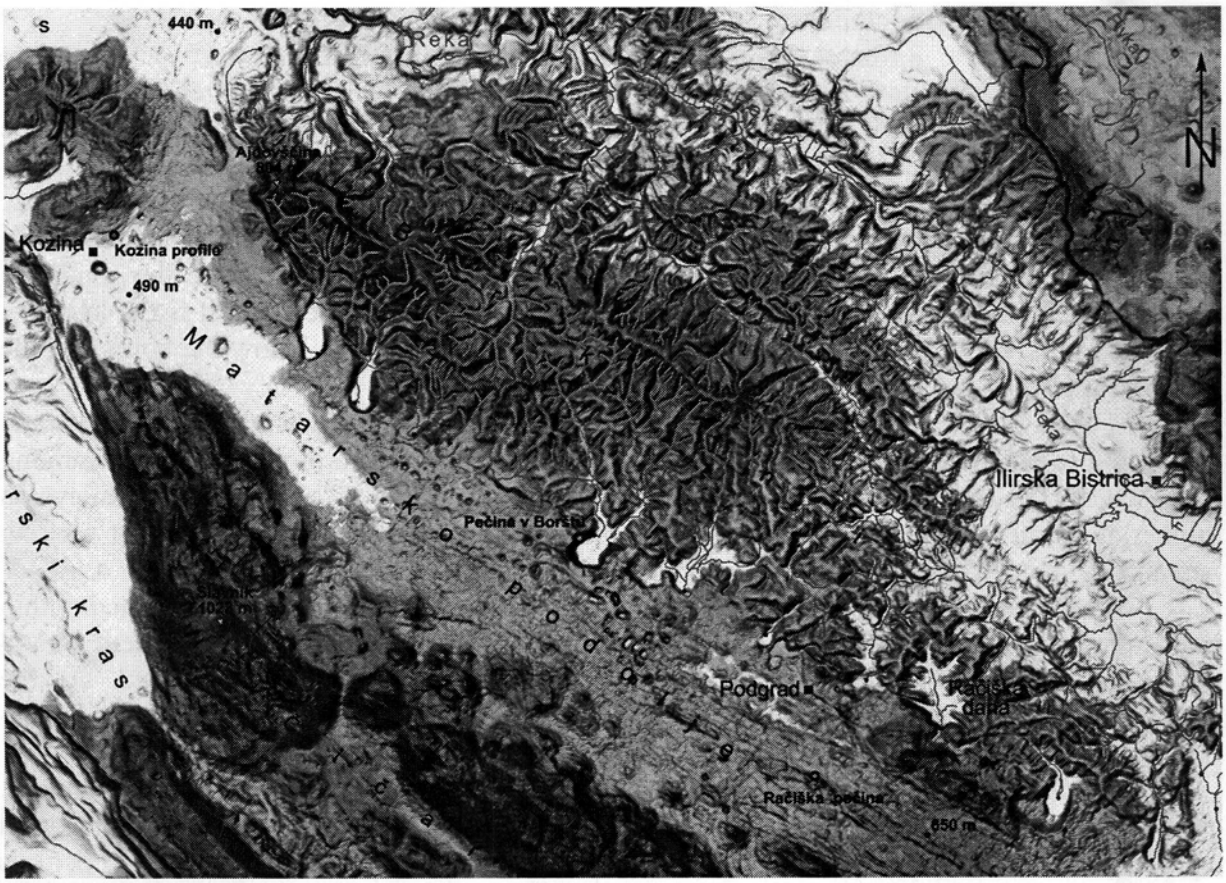
SEDIMENTS OF CONTACT KARST

Karst of Matarsko podolje

Karst formed by the influence of the allogenic rivers: large quantity of water, and sediment inflow, could be designated by the term of contact karst. The term grows familiar in Dinaric karst where are several such areas, which sharply contrast the karst without such influence. In the international karstological literature such forms and phenomena are treated as karst influenced by allogenic flow.

The contact karst of Matarsko podolje at the foot of Brkini hills was explained within the frame of cyclic and later climatic geomorphologic theory.

Now we understand the contact karst features as a type of interaction of two systems of drainage, fluvial and karstic and that has also geomorphic expression. Allogenic sediments are very important for the formation.



Digital elevation model of Matarsko Podolje with well expressed blind valleys

The Matarsko podolje is 20 km long and 2-5 km wide levelled karst surface south of Brkini hills. From there 17 brooks flow to the karst and sink at its edge. The allogenic discharge into the karst is responsible for creation of several large blind valleys and caves and lot of allogenic sediments deposited on the surface and underground (Mihevc 1993).

Surface of the Matarsko podolje probably developed as a base-levelled plain, later it was dissected by the dolines and blind valleys. Stronger tectonic uplift in SE part upraised the lowered surface and due to stronger uplift incomparable deep blind valleys developed there (Mihevc 1993).The deepening and the contemporaneous widening of the valleys followed the

lowering of the karst water to the altitudes about 500 m. Because the bottoms of the blind valleys practically remain on the same altitude were probably controlled by the piezometric level. The blind valleys started to cut into the corrosion plain with small transverse and longitudinal gradient as in the contrary case the fluvial valleys should develop in them. They should be preserved on karst as dry valleys.

Bad permeability (low gradient?) of the karst caused the deposition of the sediments on the edge of the karst in front of ponors and the deposits affected the planation and corrosion of the bottom of the blind valleys. The sedimentation was especially intensive in the cold periods of the Quaternary and these deposits are preserved on the bottom of most of the blind valleys. Due to lack of sediments the sequence of the events could not be temporally defined.

In actual conditions the karst water table stays deep under the altitude of the blind valley bottoms. The bottoms of the blind valleys are out of reach of the floods of the sinking streams in front of ponors and the gradient in the karst is so big that the old deposits from the surface are washed off into the karst by the suffosion processes.

Matarsko podolje blind valleys

Characteristic forms at the edge of podolje are contact karst features developed at sinking brooks which flow from Brkini hills. The term contact karst marks relief formed by the influence of the allogenic flow essentially and which differs from the karst which surface was formed without such influence.

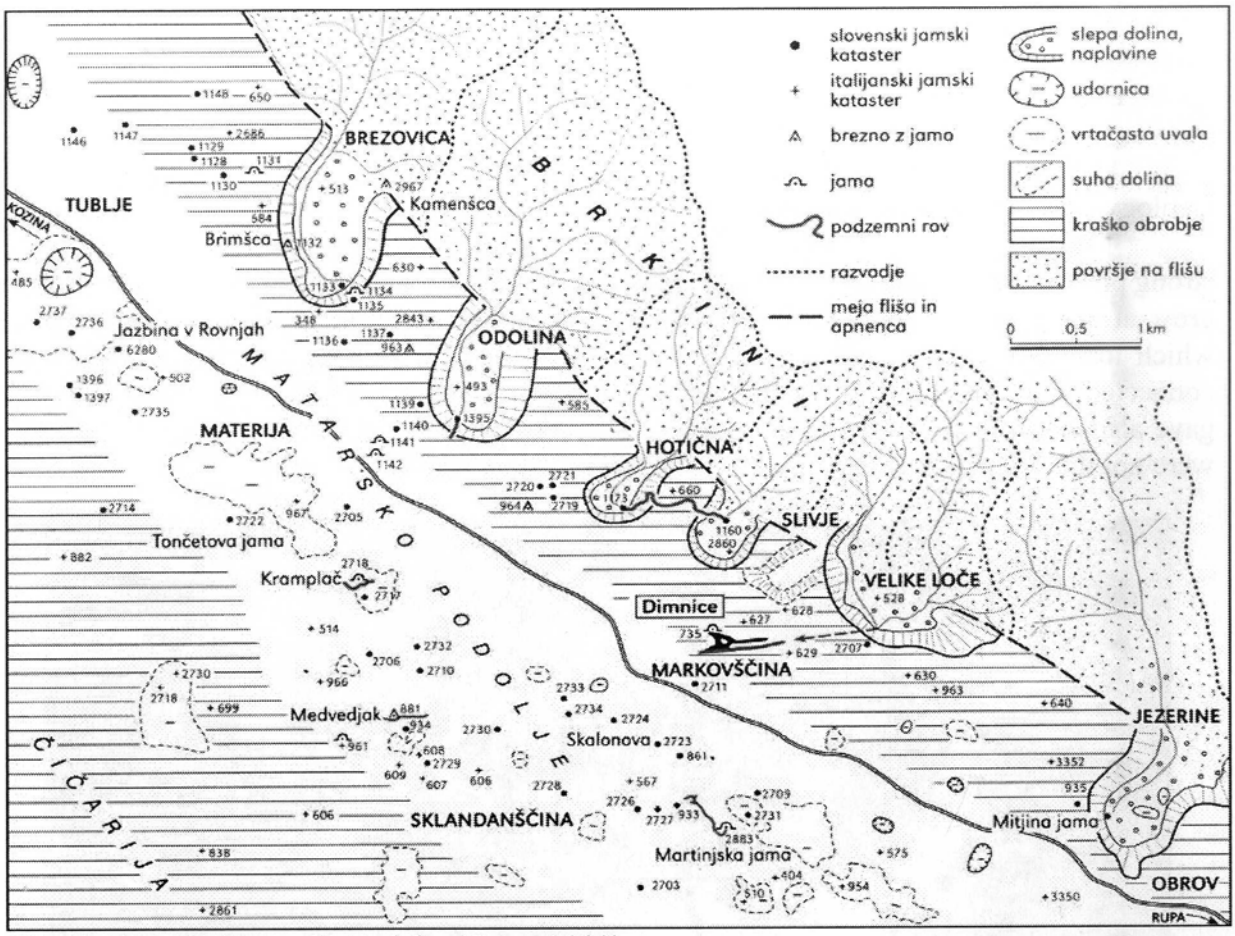
Most of the brooks namely developed blind valleys with corrosion widened bottom. The bottoms of these valleys are situated between 490 to 510 m. As the valleys are incised in the border of the karst, uplifted towards SE, the blind valleys lying more to the south are deeper. The first deepened blind valley is cut for 50 m only while the deepest is the last one, deepened into border limestones for 250 m and its bottom lies 120 m below the bottom of the lowered surface.

Fossil blind valleys developed in upper SE part of the lowered surface only and according to altitude, preservation of sediments or size they are no more comparable among themselves. The characteristic of this contact where are the most of the fossil blind valleys on higher position in comparison to impermeable flysch where the water basins of sinking streams developed and sink in the blind valleys.

The contact karst of Matarsko podolje at the foot of Brkini hills was explained within the frame of cyclic geomorphologic theory. The period of fluvial relief development should be followed by the karstification when the impermeable cover was removed. At the karstification beginning the superficial streams shortened and the last remains of this pre-karstic phase should be the blind valleys (Melik 1955).

Various forms of the blind valleys were later attributed to the climatic changes. Widened and levelled by corrosion bottom of the blind valleys and also bigger planation spread all over the Dinaric karst should be the result of the warm climate mostly. Cold periods in the Pleistocene accelerated the incision of the valleys, erosion and denudation in the water basins of the superficial rivers. Planation was feasible in the areas only where the sediments were deposited on the karst.

The Matarsko podolje was more likely formed as karst corrosional plain. The water flowing on it had modest gradient in karst and was capable of the planation of the surface only.



Blind valleys in Matarsko podolje (Gams 2003)

The deepening and the contemporaneous widening of the valleys followed the lowering of the karst water to the altitudes about 500 m. Stronger tectonic uplift in SE part upraised the lowered surface and due to stronger uplift incomparable deep blind valleys developed there (Mihevc 1993). Bad permeability of the karst caused the deposition of the sediments in front of ponors and the deposits affected the planation and corrosion of the bottom of the blind valleys. The sedimentation was extremely intensive in the cold periods of the Quaternary and these deposits are preserved on the bottom of most of the blind valleys.

The blind valleys started to cut into the corrosional plain with small transverse and longitudinal gradient as in the contrary case the fluvial valleys should develop in them. They should be preserved on karst as dry valleys. Because the bottoms of the blind valleys practically remain on the same altitude they were probably controlled by the piezometric level.

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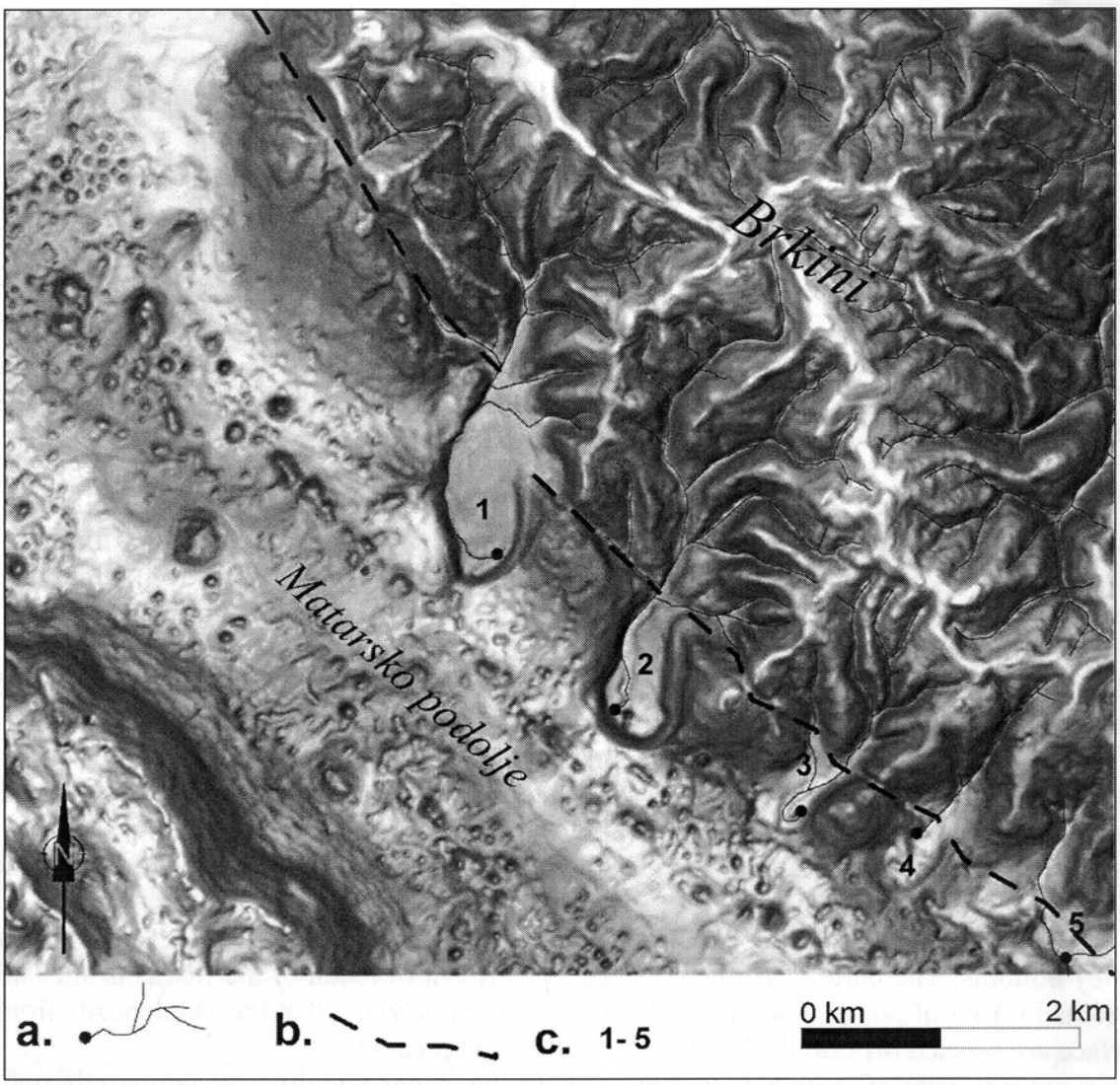
Due to lack of sediments the sequence of the events could not be temporally defined. The destruction of the levelled surface and development of the blind valleys in elevation of about 500 m probably occurred due to differentiated tectonic uplift in the Pliocene. Quick lower of the piezometric level in the entire area of this karst which was not followed by the deepening of the blind valley bottoms thus happened before, in the middle of the Quaternary probably.

Caves in blind valleys have been often filled with allogenic sediments, originating from the impermeable surroundings. Some of them have been later reactivated, making the speleomorphological interpretations difficult. On the sediments of last infill stalagmites are growing, and some of them have been dated.

Speleothem dating was conducted through collaboration between Department of Geology, University of Bergen and Institute of Karst Research, ZRC SAZU.

The sampling was concentrated on the tall stalagmites, which have grown after the strong phase of infilling of the blind valleys and caves of the contact karst. Stalagmites start to grow at about 16 ka and show in their lower part numerous strongly expressed hiatuses in which loam and quartz sands are also deposited. The growth of speleothems is apparently connected with the end of sedimentation phase in blind valleys, but the same age of growth gave also stalagmites from caves not affected by floods. Here limiting factor for the growth were not the floods or deposition of pebbles but probably aridity.



DEM of the Blind valleys in Matarsko podolje. Legend: ***a****. river,* ***b.*** *contact line: limestone on SW, flysch on NE,* ***c.*** *blind valleys: 1. Brezovica, 2. Odolina, 3. Hotična, 4. Slivarske ponikve, 5. Velike loče.*

Odolina blind valley

The blind valley was formed by the sinking stream draining 4.3 km^2 large water basin. The average discharge of the brook is about 15 l/s, but oscillations due to precipitation regime

are frequent. The floods are rare and reach the narrow belt along the brook only. Periodical water hardness measurements indicated 111 mg of dissolved carbonates originating from the flysch marls.

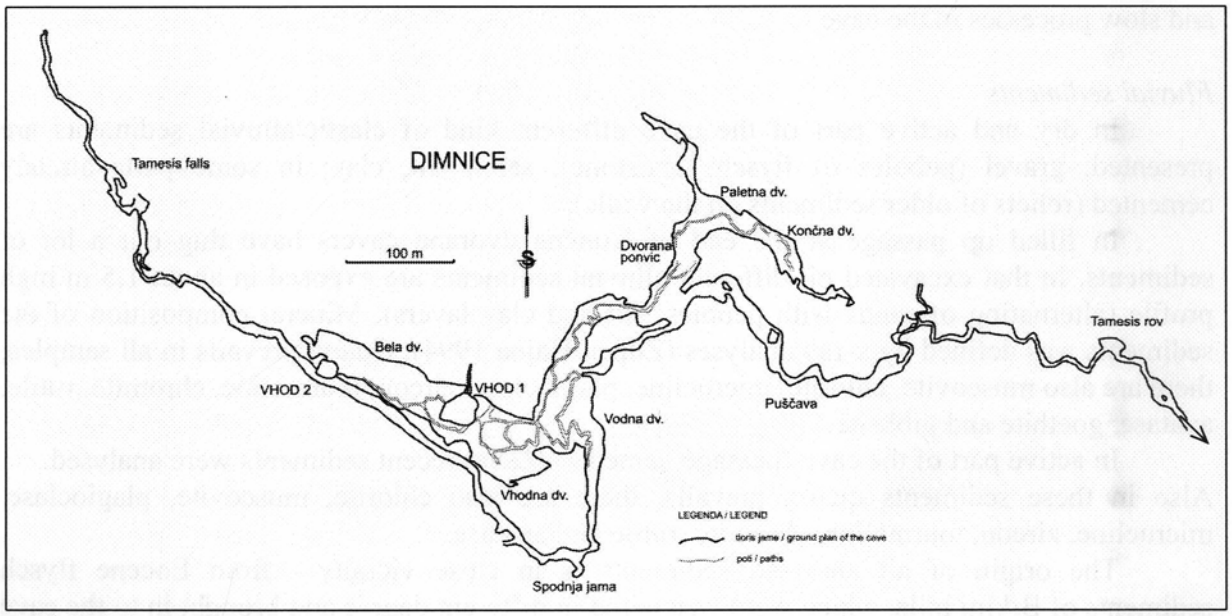
Close to the brook's passage to the limestone the narrow fluvial valley widens. A valley, 1 km long and 300 m wide, developed on the limestone, on the southern end it is deepened into the karst plain for 60 m.

During the normal water level the brook sinks in the riverbed immediately after the passage to the limestone, during higher water level it flows into 117 m deep ponor cave composed by potholes and shorter channels. The cave is basically phreatic with strong traces of vadose transformation. It ends by the siphon of captured water on 370 m a.s.l.

The valley's bottom is covered by the sediments, large poorly rounded gravels and sands of the Quaternary age. This age indicates that after 12 ka in a cave in Jezerina blind valleys no important sedimentation was recorded and on the allogenic sediments flowstone start to grow (Mihevc 2001).

Alluvial cone of sediments is now cut by erosion ob the brook and the piping or subsidence of the sediments into the karst. Up to 25 m deep alluvial dolines and sinkholes and deep riverbed of the brook have been formed. In the alluvial dolines, sinks and in the riverbed the limestone is exposed showing uneven rock surface relief below the sediments.

According to shape, sediment on the bottom and the depth of the accessible caves other blind valleys situated along the contact of flysch hills and Matarsko podolje are alike Odolina blind valley.



Plan of the Dimnice cave; arrow indicate the cave continuation; VHOD = entrance (Cave Register if IZRK ZRC SAZU and JZS).

Dimnice cave

Dimnice are 6020 m long and 134 m deep cave. According to the Basic Geological Map 1: 100 000, Sheet Ilirska Bistrica, (Šikić et al. 1972). Dimnice cave formed in well stratified Turonian limestone (K_2^2) with general dip of strata to NE. The two vertical, 40 m deep shafts form the entrance to the cave at the elevation of 567 m.

Upper, dry part of the cave represents a large passage which is up to 20 m wide and high. The continuation of the passage is blocked by sand fill, collapse and flowstone. The bottom of this passage covers collapse boulders, fluvial sediments and flowstone. In the passage is clearly seen the influence of the yearly oscillations of the temperature, which in the

entrance parts can be below 0 °C in winter. Such temperatures are destroying the flowstone and also causing the cryoturbation of the sediments.

Below the main passage there are several connections with today active water channel, through which a small brook flows. The brook flows in a cave from a ponor in blind valley Velike Loče. The active passage is smaller than the older one and there are several sumps in it. The brook is transporting clay, sand and well rounded pebbles through the cave, but in some places the banks of pebbles are rather inactive, since there are already scallops developed on the pebbles.

Speleothems

Different kind of speleothem may be found in Dimnice cave. The most common are cypress-like stalagmites and other stalagmites, stalactites; there are also a lot of turnips – stalactite with bulb with soda-straw. In one part of the cave triangular stalagmites are presented; the growing of single calcite crystal reshapes original stalagmite form and the cross-section of stalagmites become triangle.

Several samples of flowstone were dated in the cave, but due to low U content and pollution by detritic Th results are not very reliable (Mihevc 2001).

On the large boulder in entrance part of the cave there are several small stalactites. If the boulder moves they stop to grow. One of them showed the displacement of the boulder that moved at about 180.65 +48 -36 ka. The second dating was performed on the sample from the triangular, possibly recrystallised stalagmite that grows on the collapse in a cave. Stalagmite starts to grow at 98.25 +8 -7 ka. Both dating, show large age of the cave collapse and slow processes in the cave.

Fluvial sediments

In dry and active part of the cave different kind of clastic/alluvial sediments are presented: gravel (pebbles of flysch sandstone), sand, silt, clay; in some parts already cemented (relicts of older sediments on the walls).

In filled up passage at the end of Končna dvorana cavers have dug out a lot of sediments. In that excavated pit different alluvial sediments are exposed in about 1.5 m high profile (alternating of sands with pebbles, silt and clay layers). Mineral composition of the sediments was defined by x-ray analyses (Zupan Hajna 1994). Quartz prevails in all samples; there are also muscovite, chlorite, microcline, plagioclase, zircon, tourmaline, chromite, rutile, anatase, goethite and gibbsite.

In active part of the cave (passage named Puščava) recent sediments were analysed. Also in these sediments quartz prevails, there are also chlorite, muscovite, plagioclase, microcline, zircon, tourmaline, chromite, rutile and anatase.

The origin of all analysed sediments is in close vicinity - from Eocene flysch sediments of Brkini hills, which were weathered in different degree and brought in to the cave by sinking stream in Velike and Male Loče blind valleys.

AFTERNOON EXCURSION (3), 18 June 2008

RECENT AND RELICT SEDIMENTS OF THE REKA RIVER

Divaški kras

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

In the area there are known 64 caves with the total passages length of 18,500 m. The largest caves of the area are 12 km long and 275 m deep Kačna jama and 5800 m long and 250 m deep Škocjanske jame. Both caves were formed by the sinking Reka river.

The relief is levelled with numerous dolines and collapse dolines as the dominant surface relief form. In an area of 31 km^2 there are 761 dolines and 15 collapse dolines. In some parts of the area, on Paleogene limestone and slopes, their density is low. Higher densities, up to 240 dolines/km^2 and with an average of 25 dolines/km^2, occur on Cretaceous limestone.

The total area covered by dolines and collapse dolines represents 11 % of the total area: 761 dolines make up 7 % and 15 collapse dolines make up 4 % of the total area. Unroofed caves are an important part of the surface morphology of Divaški kras where 2.900 m of the unroofed caves were mapped. In such features flowstone, allochtonous sediments and morphology are testifying their cave origin. The proportion of denuded caves is small in area (only approximately 0.16 % of the total area). Most of the area (88 %) is levelled and smooth.

The ratio between the volumes of depression forms presents a different picture (Mihevc 2001). The total volume of the selected 15 collapse caves is 38,000,000 m^3, while the total volume of dolines is 6,000,000-10,000,000 m^3.

A comparison of the proportion of area of smooth relief and the area covered with dolines and collapse dolines shows that levelling is a dominant geomorphologic process in this part of the Karst. The proportional area of dolines is low, despite the great vertical gradient in karst. In comparison with doline surfaces, the speleological elements (collapse dolines, unroofed caves and cave entrances) are an important part of the relief. Even more important is the proportion of speleological elements in karstic relief if we compare volumes of ordinary dolines and collapse dolines. Even though the areas of the dolines are only twice those of collapse dolines, the volumes of collapse dolines are five times larger than those of collapse dolines.

Reka river

The Reka gathers the water from more than 350 km^2 of the surface, from it 214 km^2 (60%) from impermeable flysch while the karst background is not precisely defined.

The Reka has a sub-mediterranean pluvio-nival river regime with influence of karst retention. The minimal Reka discharge is 0.16 m^3/s, the medium 8.95 and the highest above 387 m^3/s. The relation between low and high discharge is 1: 2.400 evidencing its torrential character. At the highest discharges the water is dammed in the underground and floods occur in Škocjanske jame (Rojšek, 1989)

The Reka starts to loose its waters into karst as soon as it reaches the limestone. First ponors are in the river bed or river bank; they have capacity of about 1 m^3/s, but were in past regularly filled by millers, which were trying to keep water on the surface as long as possible. However, the main quantity of the water sinks into Škocjanske jame at 314 m a.s.l.

The Reka river was known by pollution of its waters from the Ilirska Bistrica town downwards. The river was degraded by communal and industrial waste waters. After 1991 quality of the water improved, and is now in 2nd class.

Reka reappears after 41 km of underground flow as a Timavo river at the sea level near S. Giovanni di Duino in the northern part of Trieste bay. The ground water velocities, which are calculated by tracing techniques, are generally high (over 100 m/h). Tracing tests from Škocjanske jame cave and Trebiciano cave have determined that during floods flow velocity exceeds 300 m/h at discharge about 90 m^3/s. At mean-water (32 - 37 m^3/s) the velocity is reduced to about 100 m/h). During low waters velocities about 90 m/h have been assessed.

The main Timavo spring group, at 2.4 m a.s.l., comprises several resurgences with average discharge 30.2 m^3/s (1972-83) with Qmin 9.1 m^3/s, Qmax 127 m^3/s. There are three main springs and several smaller. Besides water of theReka, an important infiltration derives from rains over the Kras plateau (1633 mm/year) and through recharge from the Vipava and Soča rivers (some m^3/s) through alluvium on the northern edge of the Kras.

Škocjanske jame

Škocjanske jame, 5800 m long and 250 m deep cave was formed by the Reka sinking river in Palaeocene and Upper Cretaceous limestone. After reaching carbonate terrain from Eocene flysch the Reka river (8.9 m^3 mean discharge) incises in a 2 km long canyon and disappears underground into Škocjanske jame. The river enters the cave at an altitude of 317 m and leaves it in a sump at about 190 m a.s.l.

The Reka's discharge during the lowest water table level is around 50 l/s. An increase in flow rate will be reflected in the rise of the water table level after individual obstacles, mostly less than 10 m. Floods usually reach up to 30 m. The largest known flood in the previous century raised the water table level to 346 m above sea level (i.e. by 132 m in the Martel room).

Škocjanske jame are composed of phreatic tunnels, and gravitational or paragenetic reshaped galleries. The proto-channels developed in phreatic conditions, formed along tectonised bedding-planes. Between the two, water also followed other tectonic structures, vertical fractures in fissured zones running mostly north to south. The water flow demanded a high degree of phreatic rising and falling between individual bedding-planes which is in Šumeča jama approximately 175 m. Thus, phreatic shafts developed next to the fissure zones. Meanwhile, rubble was transported through water table caves, today found higher, for instance in the denuded cave in Lipove doline at an altitude of around 450 m.

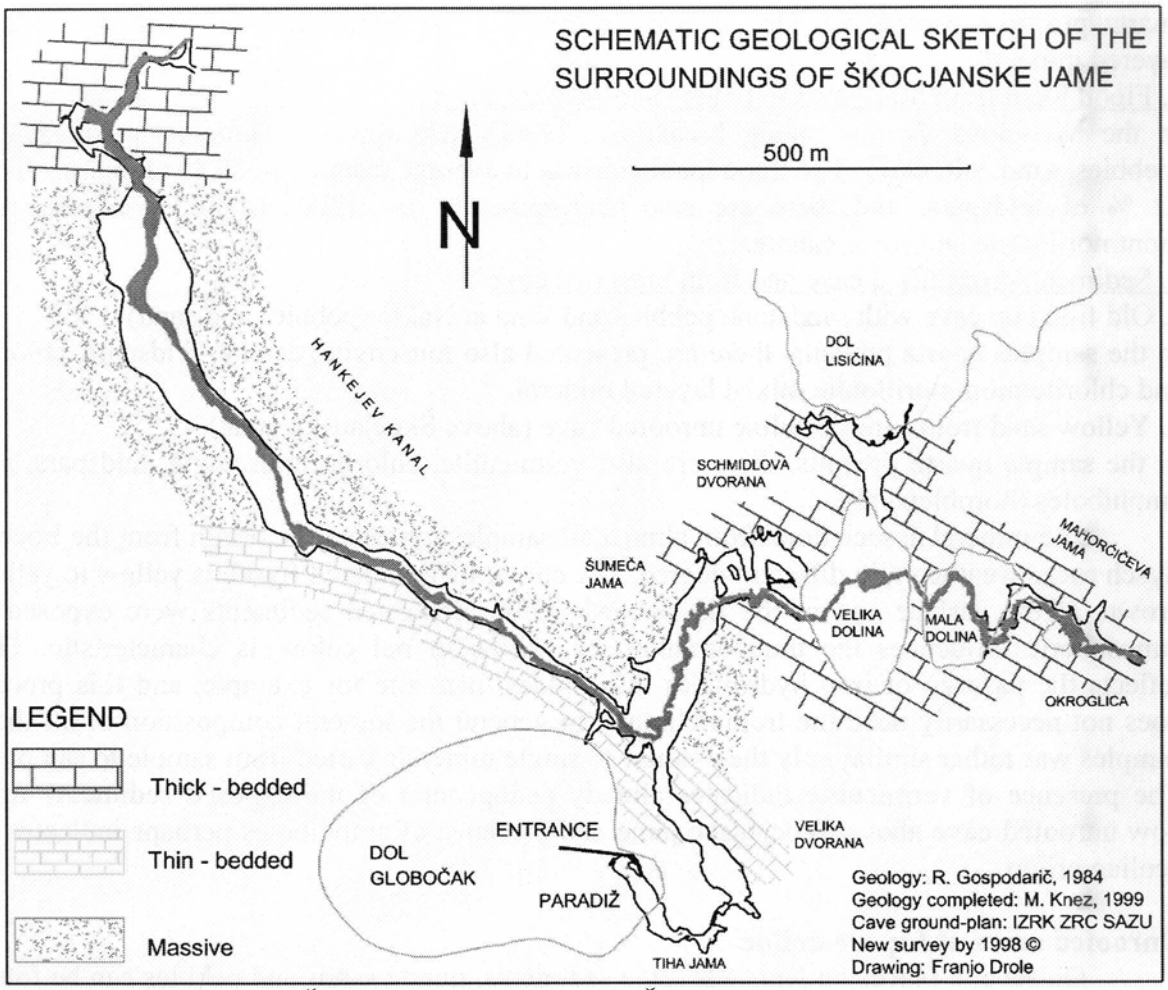
We can conclude from the shapes of cave tunnels that a long period followed when the piezometric water table was 340-300 m above sea level and the gradient was in a south-west direction. The Reka adapted to these conditions, forming new large tunnels by paragenesis, bypassing and entrenchment. The Reka's gradient in these tunnels was low, which is why the flow deposited sediment and levelled the ceiling above it by paragenesis.

In the further development of Škocjanske jame, potent cutting prevailed, the reason for it lying outside of the caves. Cutting occurred first in the chamber Martelova dvorana, then in the canyon Hankejev channel, where it cut to 80 m; the other parts of the cave followed too. The least cutting took place in the eastern part of the cave. In some locations, the Reka formed bypasses and reshaped old phreatic tunnels.

Vast rooms are a special characteristic of Škocjanske jame. They probably developed when the Reka cut into the zone of phreatic jumps. This occurred in fissure zones, where water enlarged a number of parallel fractures. The largest are the Martelova dvorana, with a volume of 2,100,000 m^3, and Šumeča jama (870,000 m^3).

Understanding the development of the collapse dolines Velika and Mala dolina is difficult - only a few short tunnels are preserved in that area. But we can presume that there were at work conditions similar to those in which large rooms formed.

Investigation of the genesis of Škocjanske jame must take into account the remnants of denuded caves. To understand the development of the caves, it is necessary to study the 1800 m long denuded cave in Lipove doline north-east of Škocjanske jame. Evidence that this was a cave through which a large submerged river once flowed is provided by a trench formed of a series of dolines (clearly visible in relief and up to 20 m wide), flowstone and fluvial sediments. The denuded cave is located where the same tectonised bedding-planes as in Škocjanske jame cross with the surface plane.



Map and stratigraphy of Škocjanske jame (Knez & Šebela 2004)

Fluvial sediments

Cave sediments in Škocjanske jame were described by Gospodarič (1984). He distinguished between recent sediments in water channel and fossil allochthonous and autochthonous sediments from dry galleries at the levels of 310 and 330 m. According to Gospodarič the Holocene loamy deposits are preserved in the level 300-310 m (Tominčeva jama, Schmidlova dvorana). In upper part of the sediments there were Bronze and Iron Age findings presented. In Černigojeva dvorana 15 m thick deposit in completely filled channel was studied by Gospodarič. He described different pebbles of the gravel (chert, sandstone, limestone). In the other parts of the cave bigger accumulations of sand and loams are presented with up to 10% of carbonate particles in them. Recent alluvial gravels were studied

by Kranjc (1986, 1989), he found out that in entrance part of the cave sandstone pebbles prevail and at the end of the cave limestone pebbles. Sandstone pebbles, which originated from Eocene flysch sandstone, , are crushed to sand and silt size particles the transport through the cave.

Mineral composition of fluvial sediments along the Reka river (results of x-ray analyses; by Nadja Zupan Hajna)

1. Recent sediments from the streams in the Reka river catchment area:

a. Sediments from Kobljak brook (at Zemon, stream sediment; sandy silt): quartz prevails; there are also muscovite, chlorite, feldspars and calcite.

b. Canyon Sušica (stream sediment from riverbed, sand & pebbles (flysch sandstone)): quartz prevails; present are also muscovite, feldspars and chlorite/montmorillonite mixed layered mineral.

2. Flood loam from Martelova dvorana (Škocjanske jame)

In the Martelova dvorana along breakdown blocks also fluvial sediments are presented (pebbles, sand, silt, clay). The flood loam consists in average from up to 80 % of quartz, about 12 % of feldspars, and there are also clay minerals like illite, kaolinite, chlorite and montmorillonite and some calcite.

3. Sediments from filled cave and from unroofed cave

a. Old filled up cave with sandstone pebbles and sand at Naklo (pebbles and sand)

In the samples quartz prevails, there are presented also muscovite, calcite, feldspars, chlorite and chlorite/montmorillonite mixed layered mineral.

b. Yellow sand from Lipove doline unroofed cave (above Škocjanske jame)

In the sample quartz prevails, there are also vermiculite, chlorite, muscovite, feldspars, and amphiboles (hornblende?).

The mineral associations from almost all samples represent the origin from the Eocene flysch rocks weathered in different degree. The colour of weathered flysch is yellow to yellow brown, at the surface and in the fissures where the deposited sediments were exposed to atmospheric influences the transformation of yellow to red colour is characteristic. This reflects the passage of iron hydroxides into oxides, hematite for example, and this process does not necessarily need the tropic climate. In general the mineral composition of all these samples was rather similar only the amount of single minerals varied from sample to sample. The presence of vermiculite indicates already pedogenesis of the exposed sediments from now unroofed cave above Škocjanske jame and presence of amphiboles perhaps indicates its aeolian origin.

Unroofed caves at Lipove doline

On several places on Kras allogenic sediments, quartz sands and pebbles can be found on the surface. Their appearance was explained as remained fluvial deposits of surface rivers. These sediments were the basis for the presumption of prekarstification period and several karst forms were described as remains from that period (Radinja 1969; Melik 1962).

New interpretation of these localities together with geomorphologic and sedimentary studies reveals (Mihevc 1996; Mihevc & Zupan Hajna 1996; Mihevc 2001) that these are the cave sediments exposed to the surface because the denudation removed the rock above the caves.

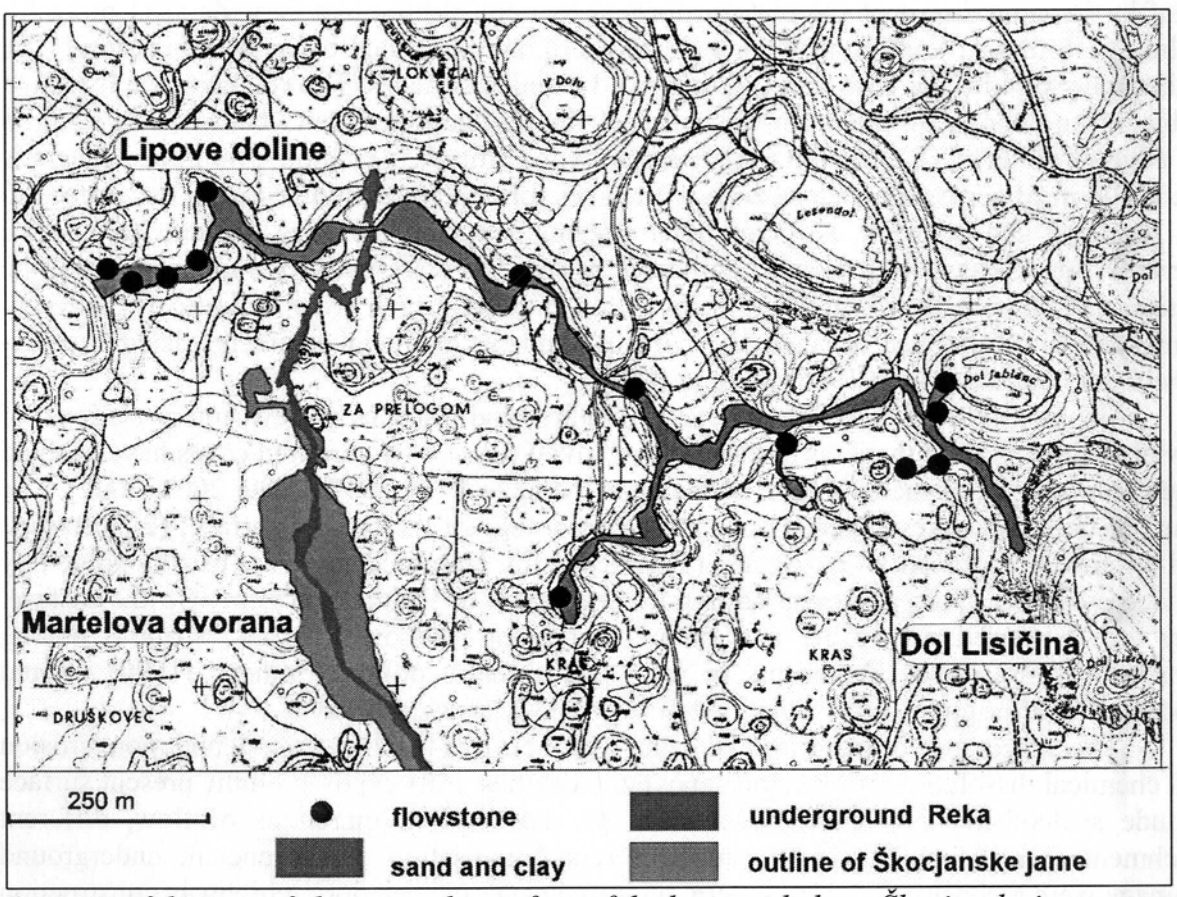
The largest such a denuded or unroofed cave in the Divača karst is located on the surface northeast of Škocjanske jame, named after great number of dolines Lipove doline. The mapping of the surface showed 1800 m long series of dolines and elongated doline-like depressions 450 m above sea level and interconnected without higher thresholds. The bottoms of the dolines are 5 m to 10 m below the level of the rest of the surface; the depressions are 20

m to 30 m wide. Chert rubble, yellow-red sandy loam and massive flowstone were found at the bottom of the dolines. The denuded cave passage forks in a number of places. These side tunnels also contain flowstone and allochtonous fluvial sediments.

In the western part of this roofless cave, in one of the Lipove doline, quartz sand was extracted, during which a large amount of flowstone and a large stalactite were exposed. The stalagmite and the sediments were described by Pleničar (1954), who also described the cave as being formerly small and located near the surface, with a collapsed roof.

The unroofed cave in Lipove doline is similar to Škocjanske jame in its dimensions, as the width of the tunnel was in some places likely to be more than 20 m. Judging by the massive stalagmite and flowstone, the ceiling was a least 10 m thick and at least 500 m above sea level during the time flowstone was deposited in the cave. Deposited flowstone was then covered by allogenic fluvial sediments. A rough estimate would be that there are still approximately 45,000 m^3 of cave sediments preserved in the unroofed cave.

A larger part of the denuded cave in Lipove doline lies north-east of Škocjanske jame. This part even crosses above the northern part of cave, where the Reka flows at 214 m above sea level. Despite this, there are no visible effects of lower-lying cave galleries on the surface. There are sediments in the denuded cave and there are no hollows indicating strong washing of the sediments into the parts of passages below.



Position of the unroofed cave on the surface of the karst and above Škocjanske jame

WHOLE DAY EXCURSION (4), 19 June 2008

SEDIMENTS ON KRAS

Kras

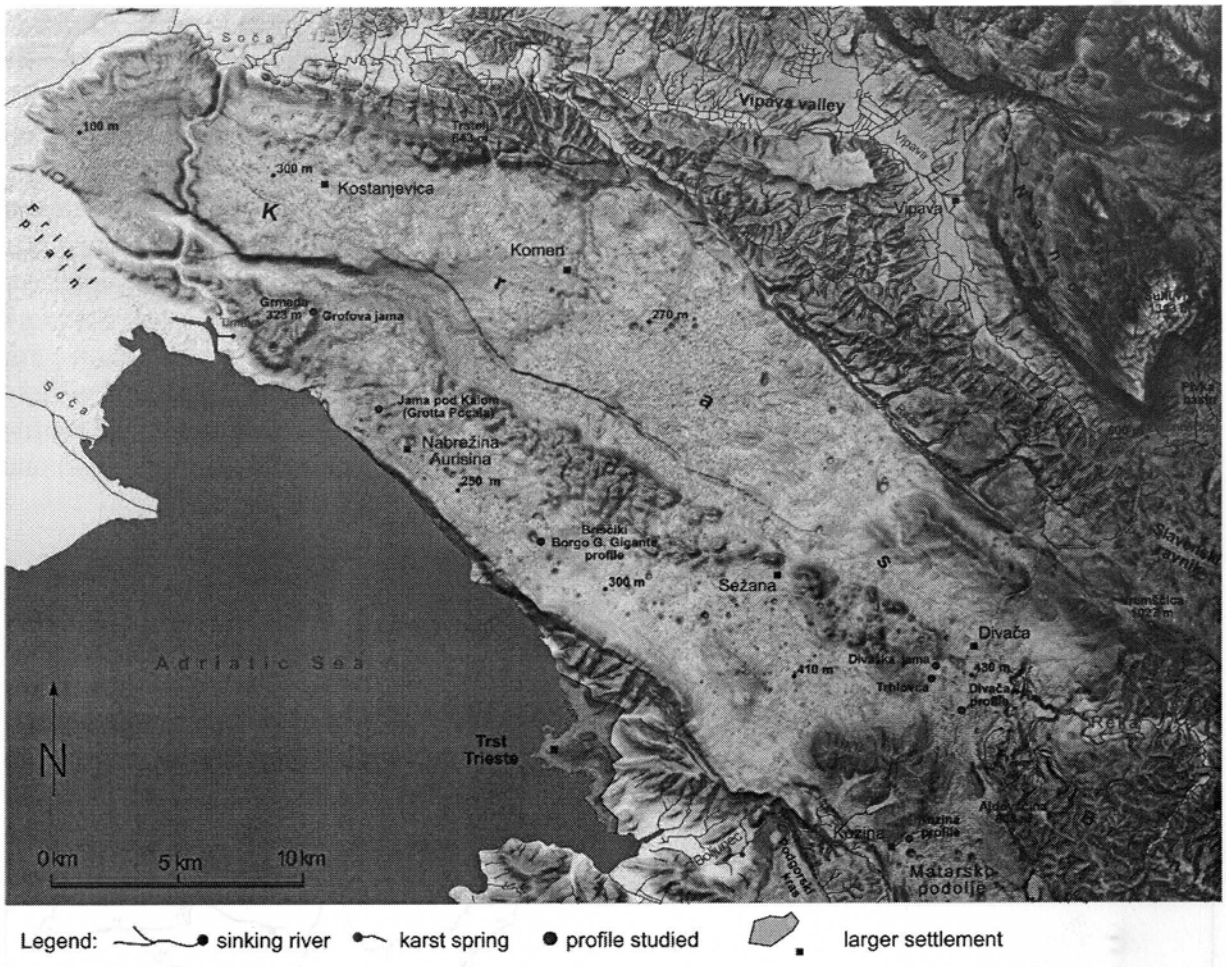
The Kras is a low NW–SE-trending limestone plateau lying between Trieste Bay, the northernmost part of the Adriatic Sea, Vipava valley in north-east, and Friuli–Venezia Giulia lowlands and the Soča river in north-west. The 45°45´´N and 14°00´´E lines of latitude and longitude cross the Kras near Divača village. Climate is sub-Mediterranean with warm dry summers. Cold winters, with most of the precipitation, show strong influence of the continent.

The Kras belongs to Adriatic–Dinaric Carbonate Platform of the External Dinarides composed of shallow marine fossil-bearing Cretaceous and Palaeogene carbonates. Eocene flysch rocks encircle the carbonate plateau. Kras and Matarsko podolje tectonically belong to Komen thrust sheet (Placer 1999), which is thrust over Eocene flysch and Palaeocene/Eocene limestone of the Podgorski kras, a part of Kras imbricated structure (before known as Čičarija imbricated structure; Placer 2007). The whole structure is sub-thrust by the Istria unit.

The main part of the plateau is essentially levelled, inclined slightly towards the north-west, with numerous dolines, caves and other karst features. There is a belt of slightly higher relief in the central part of the plateau, formed by conical hills like Grmada (324 m a.s.l.), Volnik (545 m a.s.l.) and Stari tabor (603 m a.s.l.), and dissected by large depressions. The higher relief divides the Kras into two separated levelled surfaces. The southern one is named Nabrežinsko podolje. In the north-western part, the plateau descends to below 50 m a.s.l. on the edge of the Friuli Plain; on its south-eastern edge altitudes are about 500 m a.s.l There is about 300 m of accessible vadose zone with caves formed at all altitudes from the surface to the sea level and below it. No superficial streams occur on the Kras surface, because all rainwater immediately infiltrates to carbonate rocks. There are two dry valleys crossing the plateau and some NW–SE-trending belts of lower relief which were believed to represent primary river valleys also because they contain remnants of fluvial sediments dated to a pre-karstification phase (Melik 1955; Radinja 1986).

Geomorphologic and speleogenetic studies and especially new interpretations of fluvial sediments from the Kras surface as the fluvial fill of now unroofed caves have enabled a new explanation of the evolution of the Kras (Mihevc 1996, 1998, 1999, 2001, 2007). The shape of unroofed caves depends on (1) the morphology of the present surface; (2) size, type and original arrangement of caves, and (3) the cave fill. Unroofed caves are usually altered by surface processes. They represent an important element of the epikarst zone. On the surface, they are expressed as narrow and often meandering shallow trenches, shallow oblong depressions, and doline-like forms in rows and collapse dolines. Mihevc (1999) offered models of their origin and their relation to the presently accessible caves.

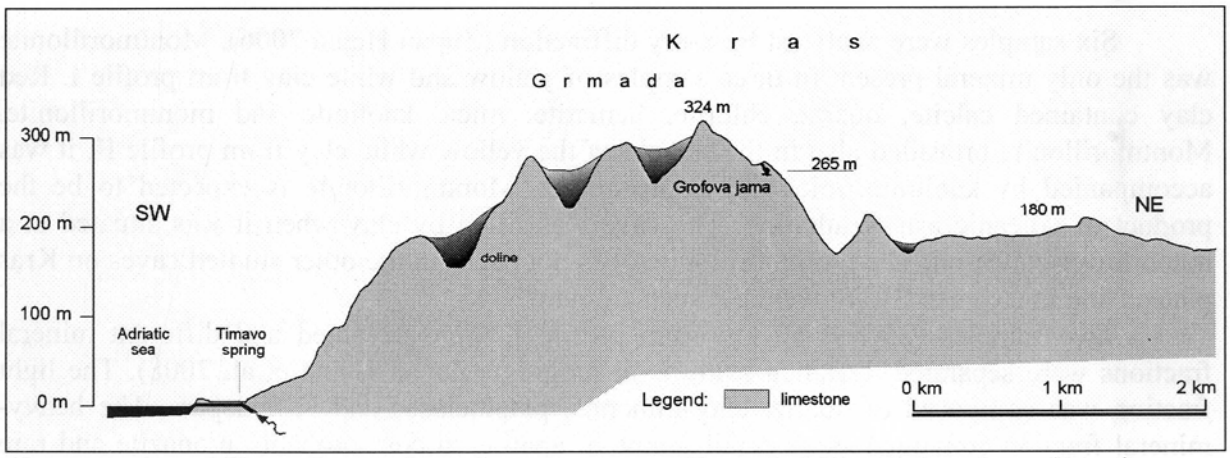
The appearance of old unroofed caves and their fills resulted from denudation, erosion and chemical dissolution of limestone above the cavities. Fills exposed on the present surface include speleothems and cave fluvial deposits. The ancient directions of flow, different catchment areas of sinking rivers and different organisation of the ancient underground drainage were reconstructed from several unroofed caves opened during highway construction in the Divaški kras (Mihevc 1996; Mihevc & Zupan Hajna 1996). The thickness of rock overburden removed above cavities was established to have been 50–100 m. The age of cave fills was calculated from denudation rates and the expected thickness of missing overburden to 0.7–5 Ma (Mihevc 1996, 2001). This large time range resulted from the expected minimum (20 $m.Ma^{-1}$) and maximum denudation rates (50 $m.Ma^{-1}$) calculated or measured in the area (Gams 1962; Cucchi, Forti & Ulcigrai 1994).



DEM of the Kras plateau

Grofova jama

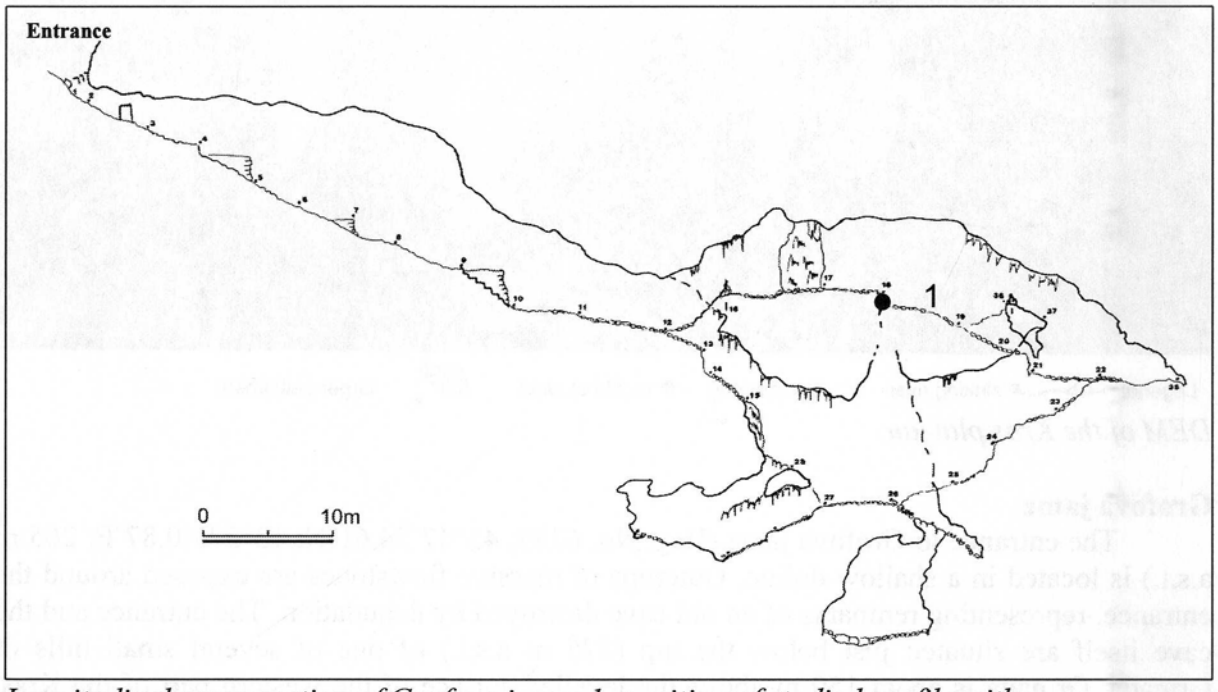
The entrance to Grofova jama (Reg. No. 6289; 45°47′54.61″N; 13°37′40.87″E; 265 m a.s.l.) is located in a shallow doline. Outcrops of massive flowstones are exposed around the entrance, representing remnants of an old cave destroyed by denudation. The entrance and the cave itself are situated just below the top (275 m a.s.l.) of one of several small hills of Grmada. Grmada is about 150 m above the levelled surface of the western part of the Kras. The cave is only 4 km from the springs of Timavo on the coast of the Adriatic Sea.



Cross section of Kras plateau from the coast across Grmada hill with location of Grofova jama

The cave was formed in Lower Cretaceous limestone and dolomite (Buser, Pavlovec & Pleničar 1968), which alternate with rare limestone and dolomite breccia of the Brje Formation (Barremian–Aptian; Jurkovšek et al. 1996). It is about 300 m long and 46 m deep. Narrow passages from three entrances join at a depth of about 10 m into one larger, inclined passage up to 10 m wide and high and with phreatic forms. The cave was once completely filled by yellow clay-sized sediment as indicated by fill in niches on the walls. Speleothems of recent vadose percolation origin are not abundant. The entrance of the cave and the main passage were much reworked during the World War I, when the cave served as a shelter for soldiers.

Clay sediments were documented and analysed by Zupan Hajna et al. (2008) for paleomagnetic analyses. There are two profiles in the sediments. One was exposed by military works and another was preserved on the wall in the bottom part of the cave. The first profile was situated on the side of an artificially levelled floor at survey point 18 (245 m a.s.l.) and the second in lower part of the cave.

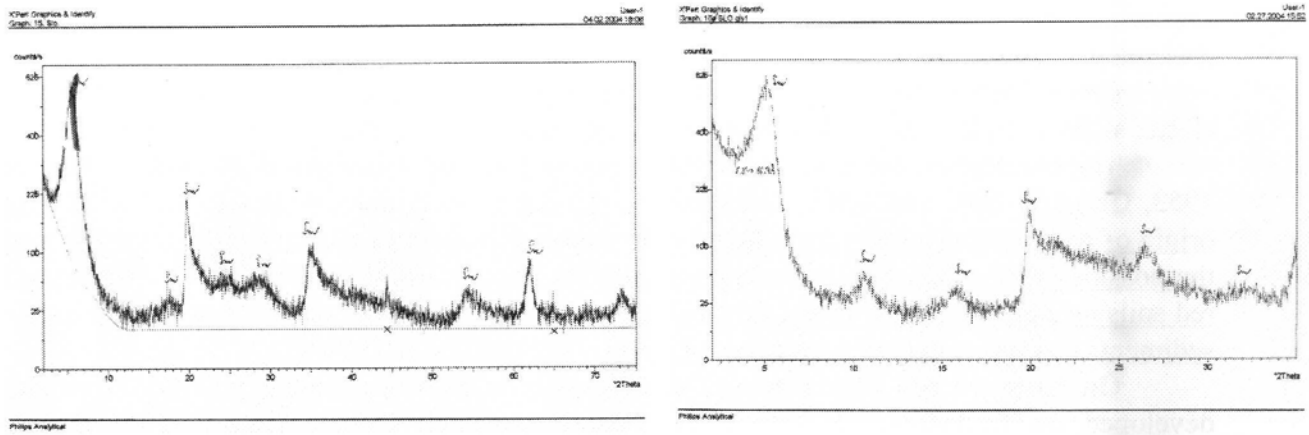


Longitudinal cross-section of Grofova jama; 1- position of studied profile with montmorillonite clay

Six samples were analysed by x-ray diffraction (Zupan Hajna 2006). Montmorillonite was the only mineral present in three samples of yellow and white clay from profile I. Red clay contained calcite, quartz, chlorite, hematite, mica, kaolinite and montmorillonite. Montmorillonite prevailed also in the sample of the yellow white clay from profile II; it was accompanied by kaolinite, mica and some quartz. Montmorillonite is expected to be the product of volcanic ash weathering. The cave was filled by clay when it was situated at a much lower elevation. The montmorillonite does not occur in the other studied caves on Kras plateau and in caves in SW Slovenia in such amounts.

Two samples (25 and 60 kg) from profile II were decanted and different mineral fractions were separated. Detailed study is in progress (Zupan Hajna et al. 2008). The light fraction was composed of quartz, clay minerals, plagioclases and K-feldspars. The heavy-mineral fraction contained some small grains of apatite, zircon, probably monazite and rare opaque ore minerals. Ferruginized clay minerals were common.

a. b.



X-ray from yellow clay: montmorillonite (Sm- smectite); a. non-oriented sample, b.glycolised sample (Zupan Hajna 2006)

From the results of the analyses we (Zupan Hajna et al. 2008) have anticipated that according to the morphology of the walls and passages of Grofova jama, the cave was formed in phreatic conditions. At one stage the entire cave was filled with montmorillonite clay. This sediment was later partly washed out and covered with red clay. Complete transition to the vadose zone is reflected in another erosion of nearly all sedimentary fill. There is modest flowstone deposition in the cave, but abundant flowstone remains occur when the part of the cave that was already destroyed by the denudation is considered. The position of the cave at top of Grmada hill can be explained (1) by tectonic uplift of a small block above the general levelled surface of the Kras, or (2) the Grmada represents the residual hill. The second possibility is less probable since there is evidence of active tectonic movements in the area. Montmorillonite is expected to be the product of volcanic ash weathering. The cave was filled by clay when it was situated at a much lower elevation. The character and composition of cave fill clearly demonstrates that: (1) the yellow and white pure montmorillonitic clays represent weathering products or relatively pure and fine-grained volcaniclastic material (ash) in humid and warm climates of the tropical type. Such material should be product of intensive weathering of a quite thick volcaniclastic pile which completely covered the bedrock ; and (2) the red clays with frequent clastic impurities and mixture with iron compounds represent weathering products of flysch rocks (weathering on the surface in warm and periodically dry and wet climate) mixed with remains of the volcaniclastic material. Red clays were deposited only after the underlying montmorillonite clays were substantially eroded from the cave. The montmorillonitic fill can represent either (1) *in situ* weathered volcanic ash or (2) weathering products of volcaniclastic rocks transported over the Kras. The principal problem with the second mechanism is the long distance between the source and the cave, and the grain size and purity of deposited material within the cave. If montmorillonite represents more or less *in situ* weathering products of volcanic ash deposited over limestone, the source should be found in some of the volcanic centres around the Mediterranean (Becalluva, Bianchini & Wilson 2007 and Lustrino & Wilson 2007).

Considering the alternative possibility of air transport of volcaniclastics is from the northeast. The nearest volcanism was in the Smrekovec, in the area of Periadriatic fault (Oligocene and Miocene andesites and andesitic tuffs), now situated about 100 km from our site.

Soils and clastic sediments on the Kras

Red soils

One of the characteristics of the Kras is red soil, which is developed on different clastic sediments, limestones, limestone with chert and on dolomite.

The researchers were very interested in red soil, its composition and origin (Hrovat 1953, Gregorič 1967 and 1969) and their accumulation in dolines (Gams et al. 1971). The origin of red soil was mostly contributed to insoluble remains of limestone with chert and also the possibility of eolian origin was not excluded (Gregorič 1967; Šušteršič 1987), but not all red soils on Kras have that origin, they can develope from weathered remains of flysch clastic sediments re-transported into the caves or dolines (Zupan Hajna 1998).

On Kras red soil ("terra rossa" in Italian) is in Slovenia named **jerovica**. It is soil developed on Cretaceous limestone with chert, so-called Komen limestone of Sežana Formation and Tomaj limestone of Lipica Formation (Jurkovšek et al. 1996). This jerovica differs in its characteristic from other red soils on Kras and grapevine grows especially well on it.

In general is not a lot of soil on the Kras; there are accumulations of it in dolines or connected to the mentioned bedrock. There jerovica or rendzina are presented. Jerovica tends to appear in the Kras in two different variations: as ilovka, without quartz fragments, developed on Cretaceous grey and dark grey limestone; and as kremenica, with chert fragments, developed on platy and laminated limestone with chert (Culiberg et al. 1997). After Gams (2003) kremenica in B-horizon consist of 56–75 % SiO_2 and ilovka of 49–57 % SiO_2. Ilovka consists of a lot of clay, especially in the middle and lower layers of the profile, where its amount can transcend 60 % (Culiberg et al. 1997); small sand grains are less common. Kremenica consists of more fine sand and also coarse sand is more common. Jerovica includes a lot of free $CaCO_3$; the reaction is acid and contains very little organic matter.

Dutovlje

Typical **thick red soils with chert** (jerovica – kremenica) are developed on limestone with chert in the area of Komen, Tomaj and Dutovlje. There are presented thin-bedded platy and laminated black limestones with chert, which appears in the form of thinner lenses. This limestone is the best for developing jerovica. In all other parts of the area the accumulation of the soil are in the bottom of the dolines. In some dolines quartz pebbles can be found.

Pliskovica

West of Pliskovica village there are some excavated pits of red soils along road. Soil is overlaying weathered dolomite. It consists of quartz, chlorite, feldspars and goethite. There are no chert fragments in it.

Beside jerovica, **rendzina** is most common soil on Kras. In rendzina humus horizon is to 40 cm deep, red or brown. There is also brown chromic cambisol presented, which is to 90 cm deep with many horizons. Both of them are connected to limestone and dolomites (Culiberg et al. 1997).

The thickness of red soil may be controlled by development in conditions of tropical climate when the rock weathering and soil formation were accelerated. Bauxite minerals, that some of them contain, in here described samples gibbsite, show that some of red coloured sediments and red soil on Kras passed through a period of tropical climate. Different soils are product of different factors; climate, relief and parent rocks are very important. As parent rocks on Kras are important different Cretaceous and Paleocene limestone and dolomites and Eocene flysch rocks (Buser et al. 1968; Šikić et al. 1972; Jurkovšek et al. 1996). Their

weathered remains can stay insitu and pedogenetic processes transform them, or they can be transported along the surface and into the caves.

Red soils differ in respect of mineral composition and thus also by its origin and time of development. In some places red soil is transported into the caves and presents red layers in the yellow cave sediments.

Clastic sediments (caves & surface)

Clastic karst sediments are divided on surface sediments and cave sediments, their origin can be autochthonous or allochtonous and they are recent or old. Clastic sediments on the surface and in the caves are different in size (from clay, silt, sand to gravel) and in origin. Mineral composition of clastic sediments from Kras surface and caves was studied by Zupan Hajna (1992, 1998, 1999, 2000). For analyses clastic sediments were distinguished according to theirs granularity and colour. The sediment colours involve all the varieties from yellow to red. Mineralogical analyses were made of sand, silt and clay by x-ray powder diffraction method. Samples were analysed at the Geological Institute of NTF, Ljubljana by Philips x-ray powder diffractometer. In almost all samples of sediments from caves, unroofed caves and bottom of dolines from SW part of Slovenia relatively equal mineral composition prevailed, indicating the main source from Eocene flysch sediments, which were weathered in different degree. In mentioned studies was found out that in general the mineral composition of analysed samples contained the minerals which are typical of Eocene flysch rocks and they don't contain amphiboles that are typical of loess sediments in Istria (Durn & Aljinović 1995) and thus their eolian origin can be excluded. In some cases the surface soils contain just insoluble residue of limestone, but many times, they are mixed by sediments, which originated from weathered flysch.

These sediments are yellow or red. Yellow sediments, which have been in contact with percolating water from the surface, have changed colour during diagenesis in oxidation zone to red. It is interesting that Habič (1992) defined the colour of unconsolidated clastic sediments on Kras by climate; according to him the yellow colour reflects the sedimentation in cold climate, and red colour in tropical climate. In sediments from caves and from now roofless caves we didn't find minerals, which are characteristic for material with loess origin, it looks like that caves have already been filled up by sediments when loess deposition in Istria started. For example flysch sandstone from Velike Loče (blind valley near Dimnice cave) consists from light minerals: quartz, muscovite, chlorite, microcline and plagioclase and heavy minerals: rutile, zircon, anatase, tourmaline, chromite and goethite. All these light and heavy minerals could be found in cave sediments along Kras. Mineral gibbsite in red loam indicate formation of red soil on the karst surface in some period of warm climate before re-deposition to the caves.

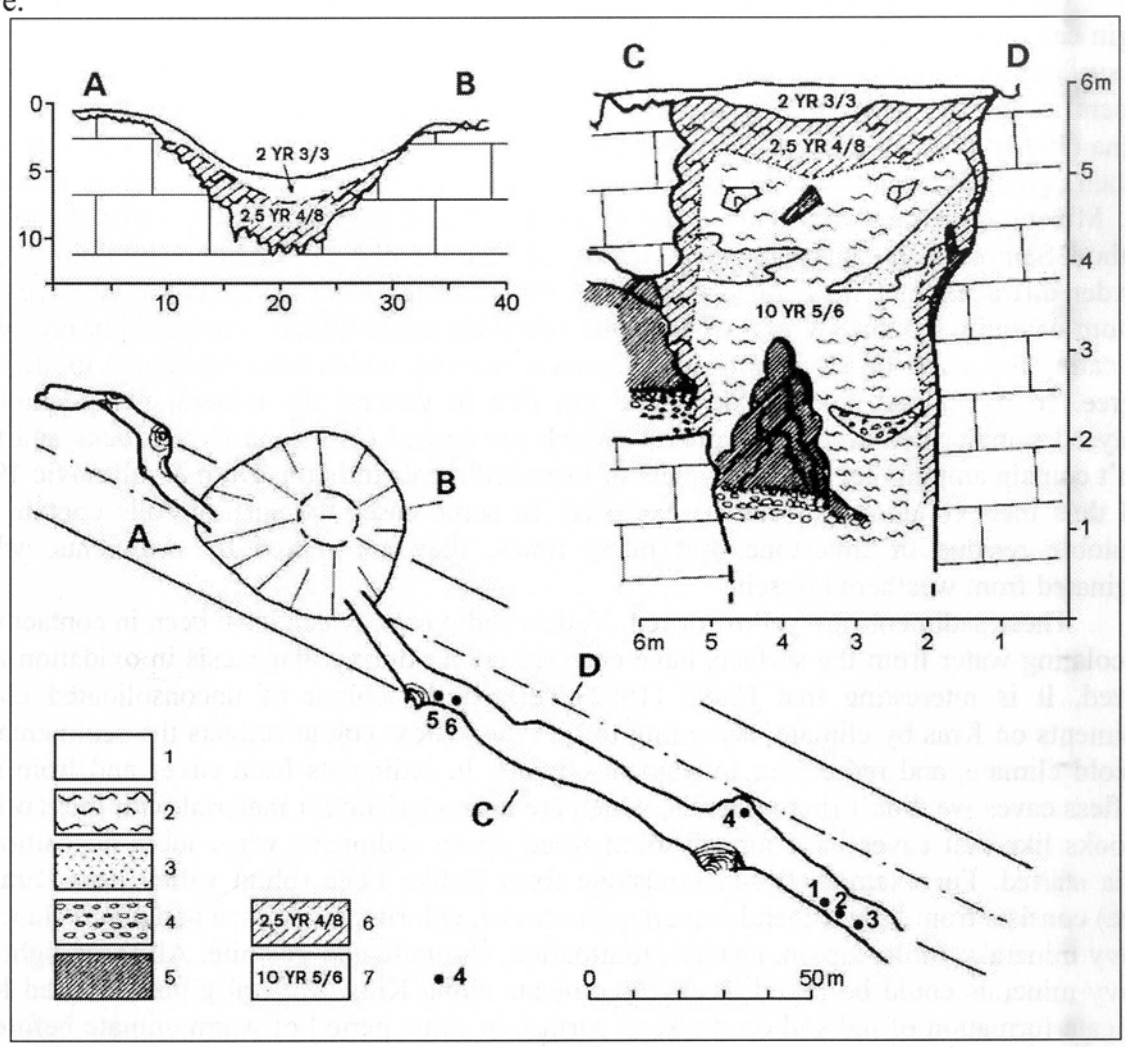
Quartz pebbles and sands, which were found on the Kras surface, were contributed to fluvial transport of weathered remains of flysch rocks over Kras in so-called pre-karstic phase (Melik 1962; Radinja 1967; Habič 1992). Discovery of unroofed caves gives a new aspect to karst developing (Šebela & Mihevc 1995; Mihevc et al. 1998) especially comprehension that many now surface clastic sediments were sedimented in caves at first (Mihevc & Zupan Hajna 1996) and that fluvial sediments from caves which roofs are already affected by denudation processes are an important source of superficial soils (Mihevc 2001).

Unroofed cave near Povir

Northwest of Divača, at Povir village, a large unroofed cave was found. About 300 m long and about 3 m dip channel, was filled up by fluvial sediments (Mihevc & Zupan Hajna 1996). Channel has lain on the surface at 400 m a.s.l. without any roof. In the cave gravel, sand, silt and clay material was found. In the sample of yellow loam some of heavy minerals

were detected. Tourmaline and rutile from the sample are also common minerals of Eocene flysch on Brkini Mountains. Red sand in the cave has the same mineral composition as yellow one that indicates the influence of percolating water rich on oxygen and with this connected dehydratation of goethite to hematite (Mihevc & Zupan Hajna 1996).

We identified some more unroofed caves on aerial photographs in the infrared spectrum range close to the destroyed unroofed cave. One of them remained untouched by the highway and is preserved. We assumed that it is the continuation of the destroyed unroofed cave.

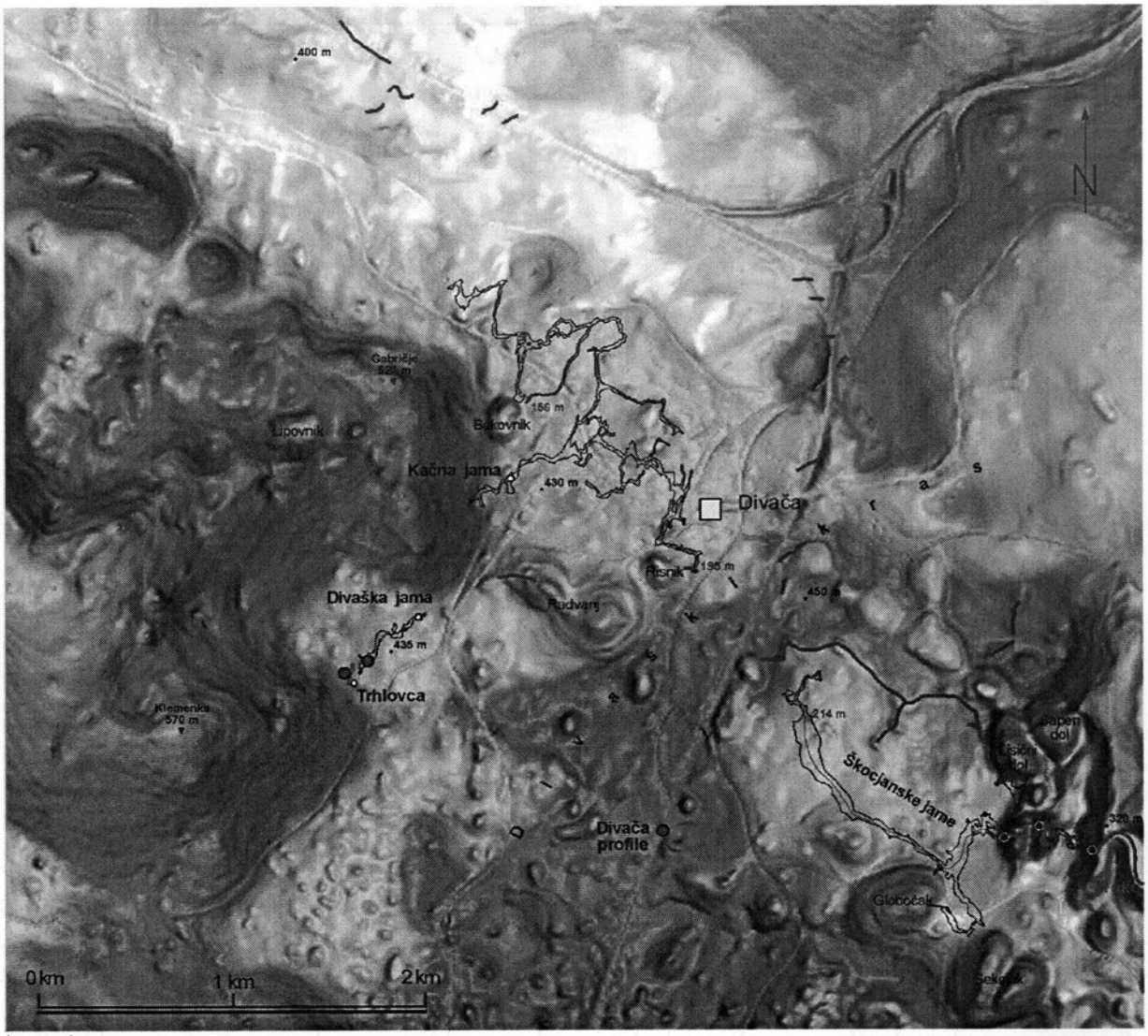


Unroofed cave near Povir (now under highway). Legend: 1 – limestone, 2 – loam, 3 – sand, 4 – gravel, 5 – flowstone, 6 – red loam, 7 – yellow brown loam (Mihevc 1996)

Divaška jama

Divaška jama (Reg. No. 741; 45°40′30.80″N; 13°57′02.79″E; 430 m a.s.l.) is situated in the south-western part of the levelled surface of the Divaški kras. Numerous dolines occur on the surface above the cave, but they are not directly connected to it. The cave is about 20 m below the surface. There are no flowing streams on the surface. Underground flow is accessible only in Kačna jama at 156 m a.s.l., which is situated about 1 km to the north-east of the site.

Divaška jama is developed in bedded limestone with rare rudist biostromes of the Sežana Formation (Senonian; Jurkovšek et al. 1996). Limestone beds dip south-westwards in the first half of the cave and southwards in the second (Gospodarič 1985). The accessible channels are transversal to the bedding, mostly following N–S-trending fractures.



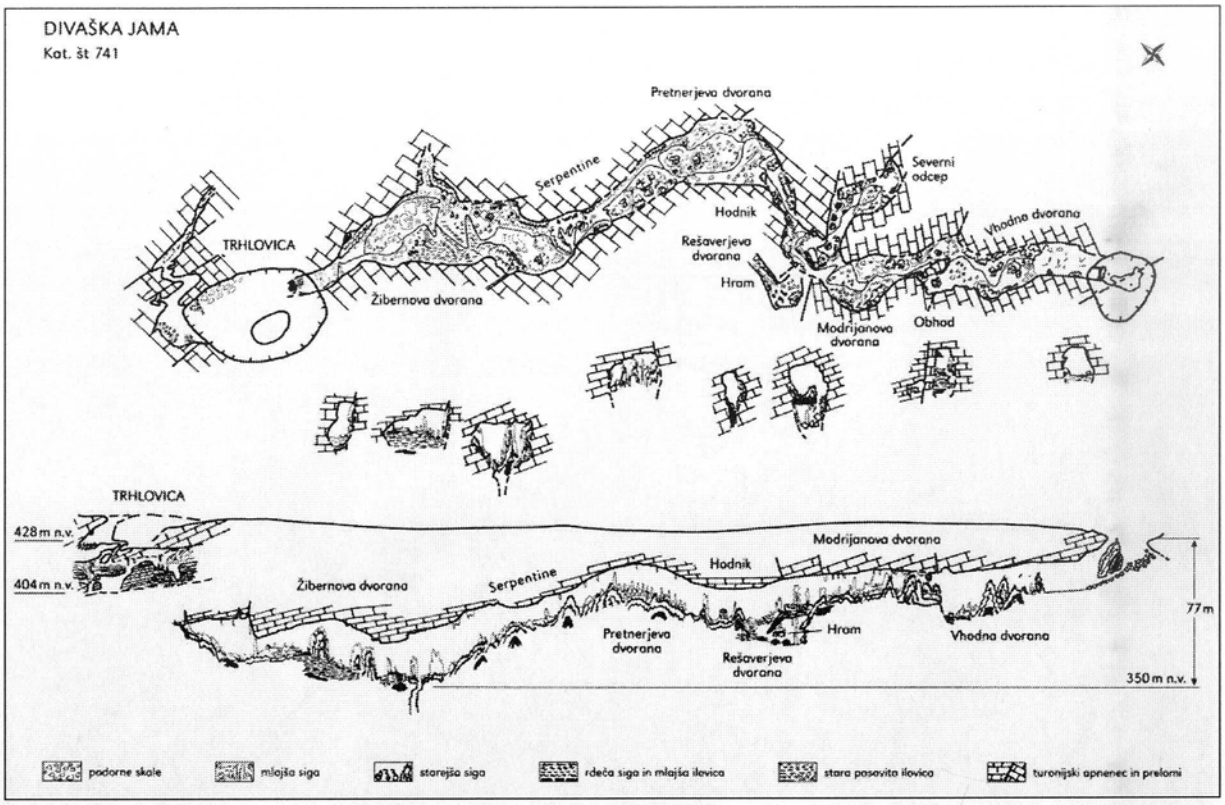
Divaški kras (Divača karst) with caves and unroofed caves (Zupan Hajna et al. 2008)

The cave represents an approximately 700 m long relict of an originally larger cave system formed at about 350 to 410 m a.s.l. Both ends of the cave are choked by allogenic sediments and speleothems. Trhlovca cave, which is not connected with Divaška jama, is situated above the south-western end of the cave. A secondary entrance is situated in the north-eastern part of Divaška jama. It was opened when the surface lowered and intercepted a chimney in the ceiling of large chamber.

The main part of the cave consists of large passage, up to >20 m high and 15 m wide. Sediments once filled completely the cave but were later mostly washed out.

Detailed study of the cave morphology, sediments and its relations to Trhlovca was undertaken by Gospodarič (1985). Mihevc (1997) dated speleothems and linked the cave with unroofed caves in the area and dated them by geomorphic methods (Mihevc 2001).

Divaška jama is filled by lithologically varied sediments and speleothems of different generations to the thickness of at least 30 m. A 2 m deep profile was excavated at the end of the cave in the Žibernova dvorana. Other individual samples were taken from yellow loams covering flowstone draperies in the same gallery.



Map of Divaška jama and Trhlovca (Gospodarič 1985)

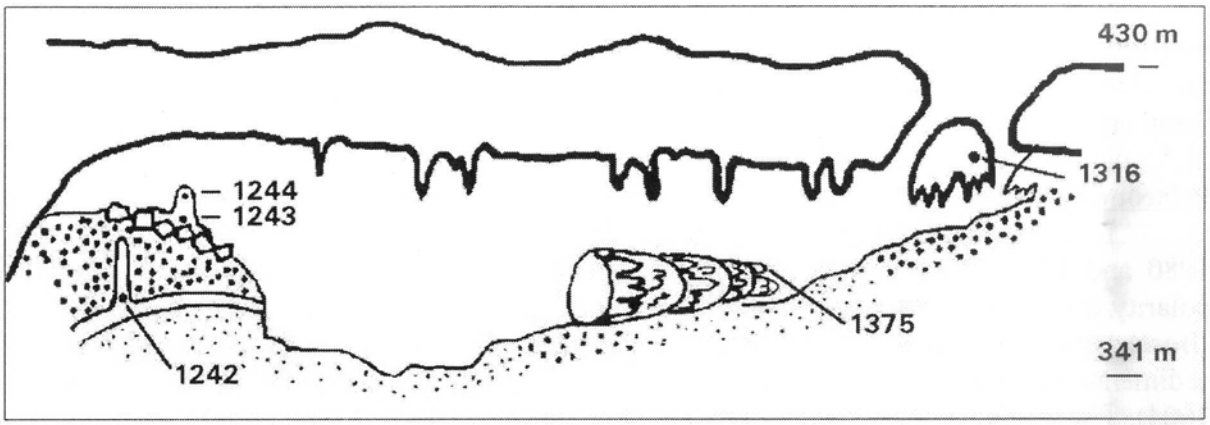
Speleothems

In Divaška jama a lot of various speleothems and flowstones are preserved on the cave bottom and walls while on the ceiling are infrequent. The common shapes of the stalagmites are club/candle and cypress like. Almost white flowstone is presented in halls Modrijanova, Pretnerjeva and Žibernova dvorana. There are also helictites which are growing from stalactites and flowstones on the cave walls. There are also coarse-grained (recrystalised) flowstones and speleothems, yellowish, brownish or reddish in colours which are older than white ones and they form domed stalagmites, fluted pillars, layered baldachins and several meters wide massive layers on the floor. Single domes and pillars are sometimes more than 1 m in diameter and up to 15 m in height. These pillars are banded, what can be seen in the domes bottoms in Vhodna dvorana and Serpentine. The shape and structure indicate long and slow growth with several interruptions.

In Vhodna, Modrijanova and Rešaverjeva dvorana, in Hram and Hodnik there are thick and tall stalagmites and columns which have mostly collapsed. The most prominent formation in Rešaverjeva dvorana is a collapsed stalagmite called Harambaša. It is a thick stalagmite, 12 m in height that was broken and overturned to the floor. On the place where it stood are now growing new stalagmites up to 10 m in height. In same parts of the cave triangular stalagmites are presented – in most of them recristalysation of "normal" stalagmites may be detected.

Th/U dating

There are several generations of flowstone in Divaška jama. Some of them were dated (Mihevc 2001). Th/U dating was performed by Mihevc (1996) at the Department of Geology, Bergen University (Norway) using α-spectrometry. Additional analyses were made in Warsaw by Helena Hercman.



Schematic cross section of the Divaška jama with flowstone sampling points (Mihevc, 2001).

The oldest was the speleothem that grew on yellow clay and was after buried with red clay (1242), its age was beyond the limit of the dating method (350 ka). The age of the flowstone (1316) that is now at the entrance to Divaška jama is 243 ka. This indicates that the cave's ceiling above him was then still preserved and cave closed.

The age of the tip of parasitic stalagmite growing on the top of 16 m high massive stalagmite (1375) is 176 ka. When this collapsed, the tip of it stops to grow, giving us the time of collapse. As the growth of the stalagmite did not continue after it broke off, this probably means that it was stopped by the cold Riss period and, at the same time, there was a heavier washing of sediment, and thus the destabilisation of stalagmites. The growth could not return in the same degree later on. The reason may be sought in the thinning of the ceiling and alteration in water percolation related to that, or to the thinning of the soil cover.

The two other samples 1243 and 1244 were taken from the small stalagmite which grew on break-down rubble. The age at the bottom (16.42 +1.24 -1.22) and in the middle (7.48 +0.82 -0.81) indicate most likely a talus cone stabilisation a new stable phase of flowstone deposition which is expressed also with several other datings in the area (Mihevc 2001).

Sample no.	Sample.	U ppm	$^{234}U/^{238}U$	$^{230}Th/^{234}U$	$^{230}Th/^{232}Th$	Calculated age ± error (±2σ)	Corrected age ± error (±2σ)
1242	DIVAILA	0.25	1,026	1,019	10000.0	> 350	
1244	DIVAPODB	0.206	0.988	0.066	10000.0	7.48 +0.82 -0.81	
1243	DIVAPODA	0.240	0.976	0.140	258.0	16.42 +1.24 -1.22	
1316	DIVAVHO	0.06	1.09	0.928	10.372	254.04 +79.79 -46.49	243.70 +81.21 -47.69
1375	ORJAK	0.243	1.0874	0.827	23.966	181.81 +17.13 -14.87	176.34 +17.36 -15.09

Table with the results of the datings of the samples from the cave (Mihevc 2001)

Fluvial sediments

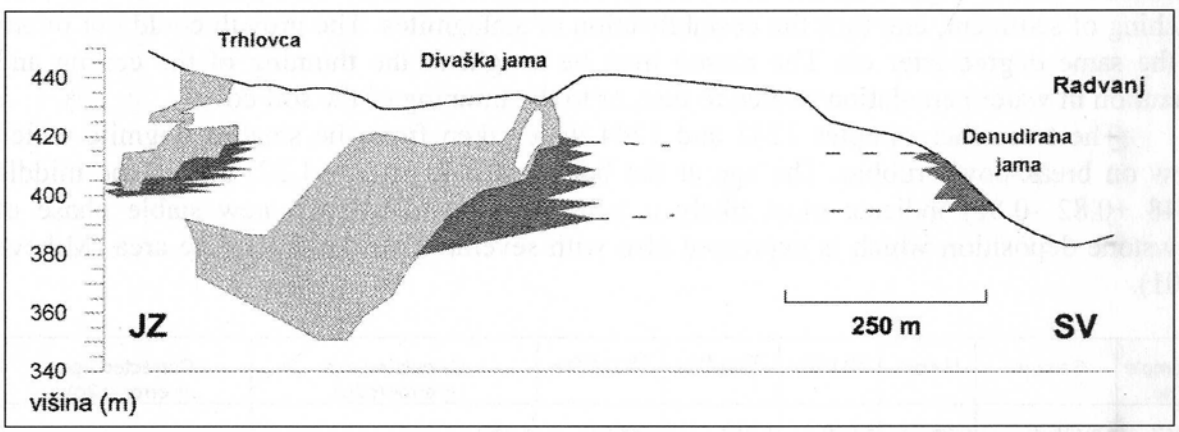
Mineral composition

Nine samples were taken from the excavated pit of fluvial sediments for mineralogical analyses and 104 samples we were studied for their palaeomagnetic properties (Zupan Hajna et al. 2008). All samples contain: quartz (56–74 %), chlorite (13–28 %) and muscovite/illite (11–13 %). Plagioclase was found in two samples (about 2 %) and in traces in one sample. Hematite was found in one sample (4 %) and goethite was detected in traces in another sample. Apatite was determined in traces in three samples. Apatite was also indicated by chemical analysis in one sample (P_2O_5 content of 0.127 %).

Quartz, muscovite and plagioclase were derived from flysch rocks, illite and chlorite probably originated in weathered remains of flysch rocks. Hematite thinly coated individual particles in sediments, which were re-deposited from surface red soils. Apatite may indicate some organic material reacting with sediment.

Palaeomagnetic results

Laminated sediments from Divaška jama were attributed to the Mindel (Gospodarič 1980 and 1988; Fig. 2) because they were expected to be younger than the Jaramillo N polarity event within the Matuyama R epoch. Preliminary results of palaeomagnetic research (Bosák, Pruner & Zupan Hajna 1998; Bosák et al. 2006) showed a substantially older age of sediments. The palaeomagnetic sampling was carried out in three campaigns (1997, 1998 and 2004). The original analysis with relatively large distance between sampling points resulted in geometry of magnetozones which was interpreted as straddling the Brunhes/Matuyama boundary (0.78 Ma) and Jaramillo subzone (0.99–1.07 Ma; Bosák, Pruner & Zupan Hajna 1998). The magnetostratigraphic picture obtained from high-resolution analysis (2004) is more complicated than was detected by previous results (1997 and 1998). The upper part of the profile is N polarized but with two R polarized magnetozones, the lower part of the section is R polarized. The new high-resolution results offer quite uncertain interpretation. But there clearly exists the possibility of an age greater than 1.77 Ma (base of Olduvai subchron), i.e. identical to the Trhlovca cave – a part of the same cave system – and some other sites situated in the Kras.



Schematic cross section across Trhlovca, Divaška jama and unroofed cave (Mihevc 2001; Legend: light grey – cave space, dark grey – fluvial sediments

WHOLE DAY EXCURSION (5), 20 June 2008

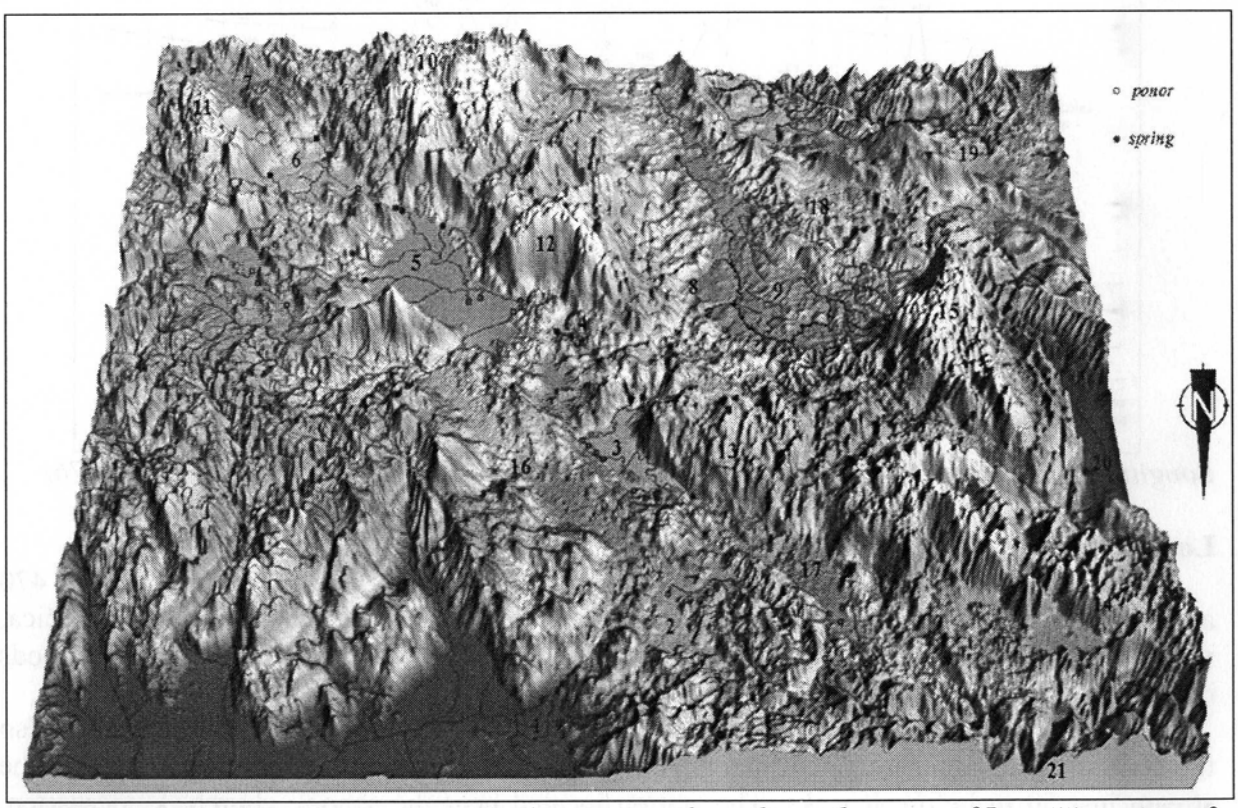
CLASSICAL KARST

Classical karst

Slovene Classical karst is a part of karst of Dinaric mountains. This karst has abundance of interesting karst phenomena like large sinking rivers and springs, intermittent lakes, numerous large caves and relief features like karren, dolines, collapse dolines, uvalas, poljes and levelled surfaces and plateaus. But it was the exploration of the people that were driven first by curiosity and later by land use or water management issues and tourism that make the Kras famous. Well researched, described and mapped natural phenomena in the 19th century made the area cradle of a new scientific discipline – karst studies.

The Ljubljanica river system

The Ljubljanica river collects the water from SW part of Dinaric karst in Slovenia and belongs as the right Sava affluent to the Danube and Black Sea. The Ljubljanica water basin is about 1100-1200 km^2. Nearly all watershed of the river is in karst and therefore is not well defined. The mean annual precipitation in the basin is 1300 - 3000 mm, during 100 to 150 rainy days. The one-day maximal amount to 100 mm, in extreme cases even 300 mm.



Legend: 1. Ljubljanica springs at Vrhnika, 2. Logaško polje with ponor of Logaščica river, 3. Planinsko polje, 4. Rakov Škocjan, 5. Cerkniško polje, 6. Loško polje, 7. Babno polje, 8. Postojna, 9. Pivka basin and polje. High karst plateaus: 10. Snežnik, 11. Racna gora, 12. Javorniki, 13. Hrušica, 14. Trnovski gozd, 15. Nanos. Karst levelled surfaces: 16 Logaški ravnik, 17. Hotenjski ravnik, 18. Slavenski ravnik; 19. Škocjanske jame cave, ponor of Reka river, 20. Vipava spring, 21.Divje jezero spring of Idrijca river.

Most of the river basin is formed on the Mesozoic rocks, mostly limestone. On these rocks the precipitations infiltrate directly into the karst and there are no surface rivers. Triassic

dolomite is important, allowing some surface flow, forming bottoms of some karst poljes or forming hydrologic barriers.

The highest parts of the basin are high karst plateaus Hrušica, Javorniki, Snežnik and Racna gora. On the poljes among them surface rivers appear only, but they have different names: Trbuhovica, Obrh, Stržen, Rak, Pivka, Unica and finally after the springs at Vrhnika the name Ljubljanica. The highest lying is the karst polje near Prezid (770 m), followed by Babno polje (750 m), Loško polje (580 m), Cerkniško polje (550 m), Rakov Škocjan and Unško polje (520 m), Planinsko polje (450m), Logaško polje (470 m) and finally by Ljubljansko Barje (300 m) where the Ljubljanica springs are at 300 m a.s.l. There are several large springs dispersed along the edge of the Ljubljana Moor, which is connected with gradual tectonic subsidence of the area. Mean annual discharge of the Ljubljanica at springs is 38.6 m^3/s.

There are 1540 caves, accessible fragments of underground drainage system known in the catchment area of the Ljubljanica. The average length of the cave is 48 m and the depth 18 m. However, the largest caves are the ponor or spring caves; in them we can follow the 71 km of passages of the main rivers, tributaries of the Ljubljanica.

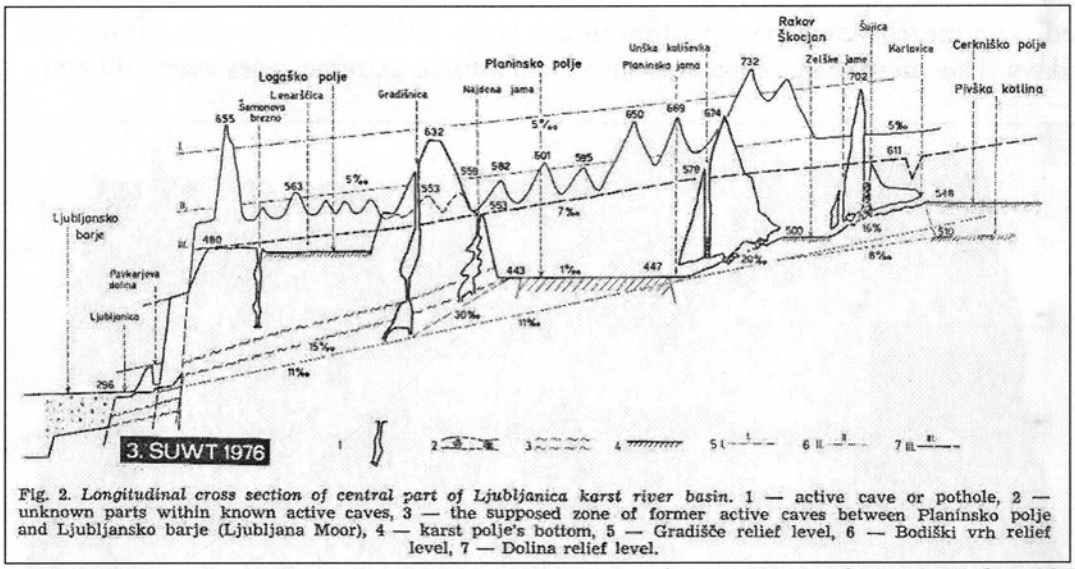


Fig. 2. *Longitudinal cross section of central part of Ljubljanica karst river basin.* 1 — active cave or pothole, 2 — unknown parts within known active caves, 3 — the supposed zone of former active caves between Planinsko polje and Ljubljansko barje (Ljubljana Moor), 4 — karst polje's bottom, 5 — Gradišče relief level, 6 — Bodiški vrh relief level, 7 — Dolina relief level.

Longitudinal cross section of the Ljubljanica karst river basin (Gospodarič & Habič 1976)

Logaško polje

The Logaško polje developed on the contact of dolomite and limestone between 470 and 480 m a.s.l. A number of small streams flow into in, the largest being the Logaščica, which collects run-off from an area of 19 km^2. The mean flow is 0.3 m^3/s. Short lasting floods occur at the swallow-holes Jačka on the Logaško polje when the flow exceeds 30 m^3/s.

The ponor of the Logaščica river is in the centre of the town, and there is located also the central waste water treatment plant. The water from the plant is directly flowing into the stream just 50 m before it sinks. The station located near the school, church, kindergarten, cemetery and school playground and direct injection of often not enough treated water is interesting case of understanding the sustainable use of karst resources.

The bottom of the polje is covered by thin sediment cover of sinking streams that flow from Triassic dolomites and marls and Palaeozoic rocks. Sediments deposited on levelled surface reveal the catchment areas of the depositing streams. However, at present there is no deposition of sediments on the polje, the recent processes connected with sediment cover of the polje is erosion of the sediments. There are washing of sediments that fill ponors, some

erosion of the river banks and on the surface numerous cases of subsidence connected with piping of sediments.

On the about 10 m higher terrace that surrounds the polje there are numerous dolines and there is no more sediment preserved. Both surfaces, the polje and the terrace, are now exposed to intensive house building. On the terrace because of surface dissected by dolines no regular distribution of the houses or streets is possible, which makes an interesting pattern of the settlement. There are no problems with the foundations of buildings and subsidence or collapse of the surface.

Planinsko polje

Planinsko polje is an overflow polje, of rectangular shape, 6 km long, 2 km wide, with two narrow pocket valleys on SW part, 50 m deep, with 16 km^2 flat surface at height of 450 m. Its wider surrounding is built by Upper Triassic dolomite, Jurassic and Cretaceous limestone. The development of closed karst depression is result of accelerated corrosion, controlled by geological structures.

It presents the most important water confluence in the river basin of Ljubljanica. Tectonically crushed and less permeable dolomite barrier along the Idrija wrench fault zone, which crosses the polje, forces the karst waters to overflow from higher karstified limestone background to the surface and after crossing Planinsko polje toward NE they can sink into the underground again. The principal Unica springs, with mean annual discharge 24 m^3/s (min. 0.3 m^3/s, max. 100 m^3/s) are situated in the southern polje's part in Cretaceous limestone, where the confluence of waters from Cerknica, Javorniki Mt. and Pivka is located. Main spring is 6656 m long Planinska jama cave.

Planinsko polje and the karst around it. Legend: 1. Postojnska jama cave, 2. Planinska jama, 3. Tkalca jama, 4. Zelške jame – Karlovica cave, 5. Logarček, 6. Najdena jama, 7. Gradišnica, 8. Vetrovna jama, 9. large collapse doline.

The principal Unica swallow-holes are disposed at NE edge, where mostly medium and high waters are sinking. At low waters the whole Unica is disappearing in swallow-holes at eastern polje's border. The water is sinking directly from the Unica bed through the polje's bottom across more than 150 swallow-holes and impassable fissures. Only at Dolenje Loke and in Škofji lom, up to 160 long ponor caves are known, but there are several horizontal caves in vicinity of the polje, where water oscillations can be observed. Larger caves behind the ponors are over 4987 m long Najdena jama cave and Logarček.

Planinsko polje is flooded several times in a year. The minimum inflow to the polje amounts to 1.5 m^3/s; mean 23 m^3/s, maximal was estimated to 100-120 m^3/s, the total ponor capacity is about 60 m^3/s. At floods, lasting 1-2 months, the water increases up to 10 m and up to 40 millions of m^3 of water inundate the polje.

There is only few m thick layer of sediments deposited on the polje. No subsidence or piping is recorded in the centre of the polje, only close to ponor zone on the E side of polje piping of sediments and subsidence is common.

Planinska jama

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

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

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

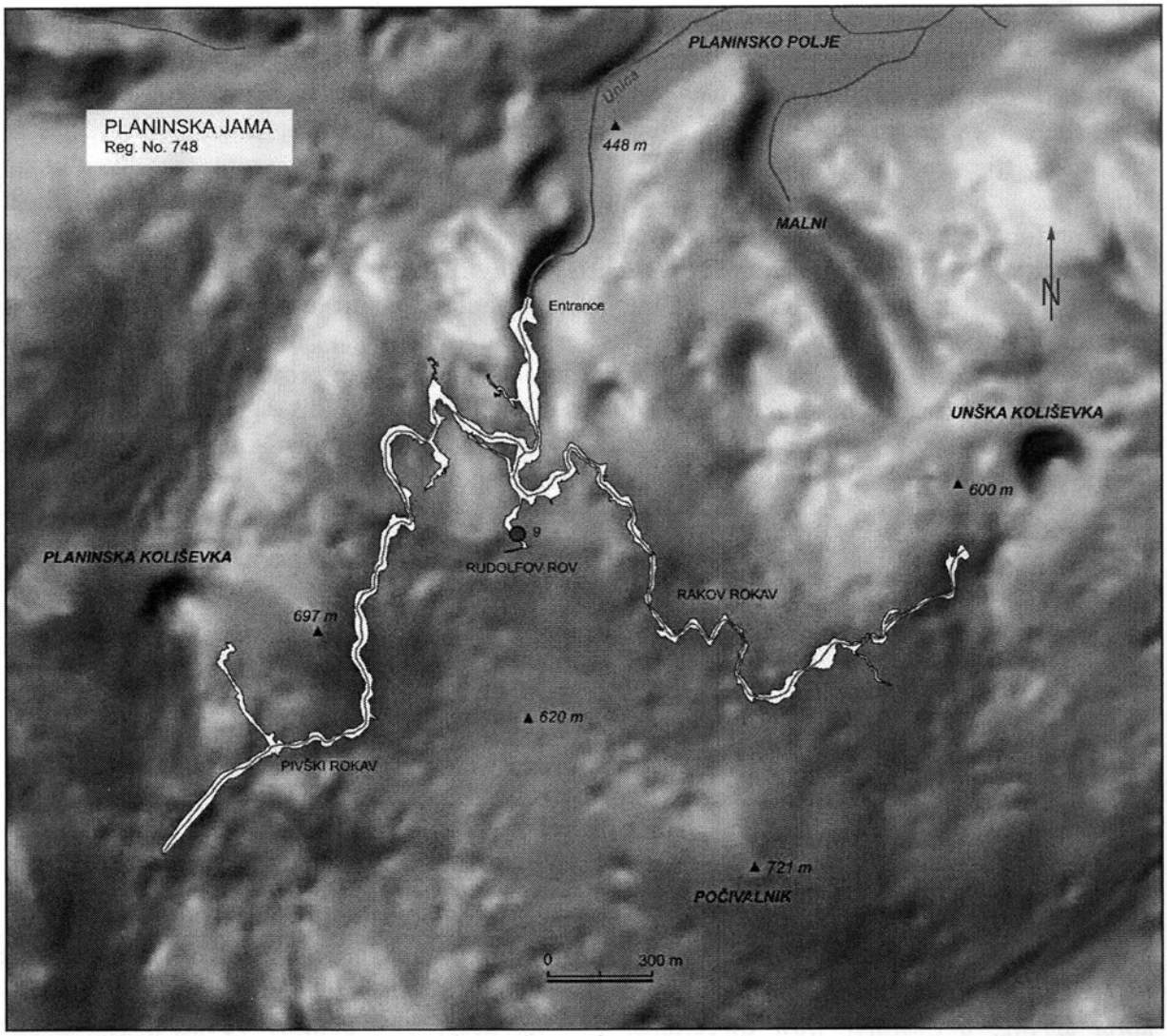
The confluence of the Pivka river, which arrives from Postojnska jama and the Rak river from Rakov Škocjan is situated within the cave. The two main passages were named after the tributaries: Pivški rokav and Rakov rokav. Both rivers flow into the cave via deep sumps.

Sediments in Planinska jama

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

The Rudolfov rov was expected by Gospodarič (1976) to be filled by the older laminated loam, which rested upon the erosion bottom of the channel. This loam was expected to be overlain by white chert gravel. He expected that chert gravels of this colour were old and thus that the older laminated loam could be dated to about 350 ka, like all the oldest sediments in other caves of the region (Postojnska jama, Otoška jama, Risovec, Divaška jama and Križna jama). The mineral composition of sediments indicates that the

waters depositing the clastic load in the cave arrived from the Pivka basin where Eocene flysch rocks were eroded (Gospodarič 1976; Zupan Hajna 1992). However, modern water in Rudolfov rov flows from Javorniki mountain and Cerknica polje. This water eroded the sediments that once completely filled the passage.



Map of Planinska jama with the surface above the cave.

Šušteršič, Šušteršič & Stepišnik (2003) re-interpreted stratigraphy of Gospodarič and his evolution phases of the Planinska jama, but added no new data. They considered the development in Planinska jama during the last 100 ka to be very "vigorous". The possibility cannot be excluded that their proposed succession of events is correct, but the amount of time proposed for such dynamics of infilling and erosion phases is unrealistic in our view (too short).

The older laminated loam of Gospodarič (1976) was sampled for palaeomagnetic analyses from Rudolfov rov by Gospodarič and Šebela (Šebela & Sasowsky 1999). Šebela & Sasowsky (1999) published results from an approximately 4 m thick profile of yellowish brown laminated loams at about 460 m a.s.l. Normal polarization of all samples was interpreted as younger than 0.73 Ma. They suggested that the palaeomagnetic results are in good accordance with Mindel age (0.35–0.59 Ma) proposed by Gospodarič (1981).

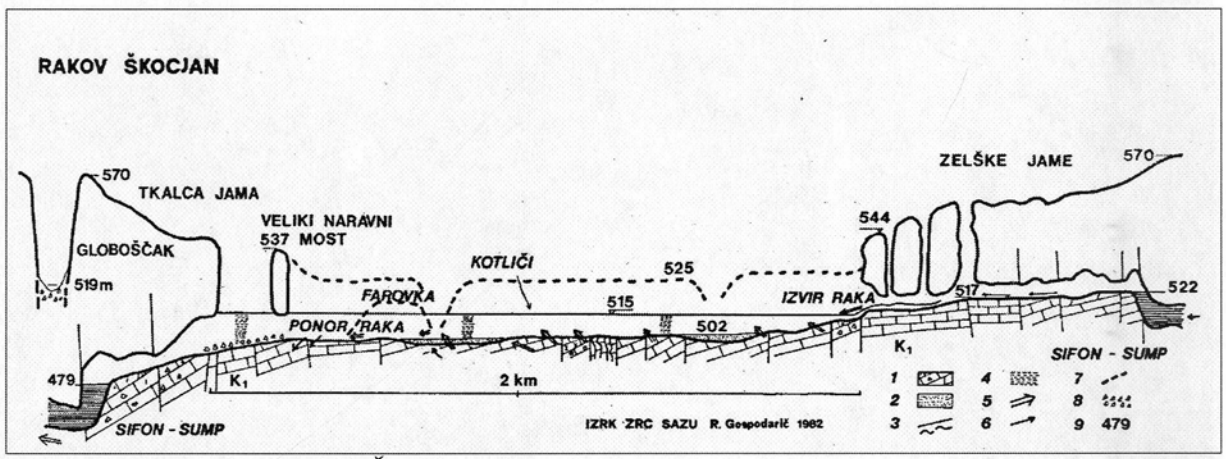
Our results confirmed a N polarization without any R polarized samples. It appears that the profile can be placed within the Brunhes chron, i.e. the sediments are most probably

younger than 0.78 Ma, as expected by Šebela & Sasowsky (1999). But without any comparative data (Th/U dating, fossils) we cannot be certain.

Rakov Škocjan

Rakov Škocjan is a karst depression about 1.5 km long and 200 m wide. It is situated below the N side of Javorniki mountain at elevation about 500 m between Planinsko and Cerkniško polje. Through the depression flows the permanent Rak river. The Rak springs from Zelške jame cave, bringing water from Cerkniško polje. Zelške jame are about 5 km long; the end of the cave is in huge collapse doline Velika Šujca, where from the other side the Karlovica cave system ends. Karlovica system is the main outflow from Cerkniško polje. Numerous collapse dolines are situated around the entrance of Zelške jame. In one of them the Small natural bridge is present. Downstream the valley widens and several springs bring additional water to the Rak river. The valley is narrowed at the Veliki naravni most (natural bridge) and afterwards the Rak sinks into Tkalca jama cave from where the water flows towards cave Planinska jama at Planinsko polje. The connections of the Rak with water from Cerkniško polje and with the Unica springs at Planinsko polje were proved by water tracing.

Before World war I Rakov Škocjan was owned by the Windischgrätz family and was closed as their private park; between 1st and 2nd World war, the Italians also closed the area for the public. Since 1949 Rakov Škocjan is a Landscape Park.



Cross-section along Rakov Škocjan karst depression between spring at Zelške jame and sink in Tkalca jama. Legend: 1 – rocky bottom, 2 – alluvia, 3- fault zone, 4 – flood in 1982, 5 – karst spring, 6 – water flow directions, 7 – terraces, 8 – boulder rocks, 9 – altitude (Gospodarič et al. 1983)

Cerknica polje

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

It is a karst polje developed in the important regional fault zone – Idrija fault. Idrija fault has "Dinaric" direction (NW-SE); in the same fault zone are developed: Planinsko polje, Loško polje and Babno polje. Bottom of Cerkniško polje covers 38 km^2 in elevation of about 550 m. Bottom is formed on Upper Triassic dolomite, which is presented also on the N, E and SE side of the polje, there are some Jurassic dolomites. On W and NW there is the Cretaceous limestone. Inflows are on E, S and partly on W sides of polje. The largest tributary to polje is the Cerkniščica draining the dolomite catchments area. The important karst springs are

Žerovnica, Šteberščica and Stržen. Stržen flows on the W side of polje towards the ponors in the middle of the polje, from where water flows directly to the Ljubljanica springs, and towards NW side of polje, from where the water flows to Rakov Škocjan.

During the last centuries a lot of plans for the change of polje hydrology have been made, but not any of them was realised. In 1965 was proposed to make Cerknica polje a permanent lake, in the years 1968 and 1969 entrances to the caves Velika and Mala Karlovica were closed by concrete walls and 30 m long tunnel was made to connect Karlovica with the surface, but small effect of retention in dry period and less moistened years were assessed.

The bottom of Cerkniško polje covers 38 km^2 in elevation of about 550 m. Inflows are on E, S, and partly on W polje's side. There are some small superficial tributaries to polje, the largest is Cerkniščica, with about 45 km^2 of hinterland mostly dolomite.

Flattened bottom of Cerkniško polje is regularly flooded for several months in autumn winter and spring time, at floods it alters to spacious karst lake. Lower waters are sinking mostly in marginal swallow holes and in numerous ground swallow holes and estavellas, which are disposed in central polje's bottom. Principal ponor caves and swallow holes are disposed at NW polje's border.

Next to the polje border, from the foot of the Javorniki to the contact with dolomite in the polje bottom there are 12 ponor caves. They are all connected with the system of the Velika and Mala Karlovica cave. Most of caves are short; they get narrow or are blocked by breakdown. The highest waters run off through the caves Mala and Velika Karlovica, where more than 7 km of passable channels are known.

Outflow from the polje was not oriented to one channel, rather to a mesh of channels, which about 200 m from the edge of polje combine into a couple of larger galleries. They are generally low, because the bottoms are filled with sediments. The sediment fill is at 550 m a.s.l. in all the ponor caves, its thickness is possibly the same as a thickness of alluvia in Jamski zaliv, 8 - 15 m respectively.

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ABSTRACTS

A PROPOSED METHOD FOR MODELING THE EROSIONAL COASTAL PROCESSES OF ROCKY COASTS WITH THE USE OF REMOTE SENSING AND GIS: A CASE STUDY ALONG THE LEBANESE KARSTIC COASTLINE

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Many sites along the Lebanese coast (Levantine Basin) are composed of weathered and fractured carbonate rocks affected by intense erosion and the development of slope instabilities. In Lebanon, coastal morphology was mostly produced by Quaternary tectonics, the severe and selective action of modern erosion by sea waves, and locally, was strongly conditioned by human influences. In addition, due to the carbonate nature of rock masses, the role exerted by karst processes has to be considered. This study provides a critical review of the common eroding processes and factors affecting coastal morphology in a typical Mediterranean coastal carbonate environment. A stretch of the Lebanese coastline north of Beirut (between Jounieh and Jbail (Byblos) made up of cliffs and shore platforms interrupted by small pocket beaches, was considered. For qualitative and quantitative assessment of shoreline recession, the coastal stretch was monitored by means of field surveys. Furthermore, a comparison of vertical aerial photographs (scale 1:25000) and satellites images covering the period 1962–2005, topographic maps (scales 1:20000, year 1963), and archival terrestrial photographs was also employed. In some zones, characterised by a gently sloping shore platform, a significant shoreline retreat was noticed, which was caused, above all, by human activity. Here, in fact, the presence of small ancient coastal quarries and artificial salinas is widespread; they are located where soft and porous calcarenites crop out. Cliff recession is episodic and discontinuous in time and space, and occurs in response to single large sea storms. A significant shoreline retreat was calculated at about 10 m in the last 40 years (0.25 m/year), which was caused, above all, by human activity and severe storms.

MICROBIAL ORIGIN OF OPAL SPELEOTHEMS IN VENEZUELAN QUARTZITE CAVES (RORAIMA GROUP, GUYANA HIGHLANDS)

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The largest and longest silicate caves in the world created in arenites of the Roraima Group in Venezuela have been explored on Chimantá and Roraima plateaus (tepuis) of Guyana Highlands. Geological and geomorphological research showed that most feasible way

of the caves genesis is winnowing and erosion of unlithified or poorly lithified arenites. Dissolution is also present but it probably plays neither the trigger role, nor volumetrically important role in the cave-forming processes. The strongest dissolution/reprecipitation agent is the condensed air moisture which is most likely the main agent contributing to growth of siliceous speleothems. As such, it can be active only after, not before the cave is created. Siliceous speleothems are mostly microbialites except of some normal stalactites, cobweb stalactites and flowstones which are formed inorganically. They consist of two main types: 1. fine-laminated columnar stromatolite formed by silicified filamentous microbes (either heterotrophic filamentous bacteria or cyanobacteria) and 2. a porous peloidal stromatolite formed by *Nostoc*-type cyanobacteria. The initial stages of encrusted shrubs and mats of microbes were observed, too, but the surrounding arenitic substrate was intact. This is a strong evidence for the microbial mediation of the silica precipitation.

Keywords: speleology, tepuis, Venzuela, sandstone caves, siliceous speleothems, microbialites, cyanobacteria, stromatolites. Cueva Charles Brewer. Cueva Ojos de Cristal.

GEOCHEMICAL AND ISOTOPIC RESEARCH AT PLITVICE LAKES SYSTEM

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The Plitvice Lakes, situated in the Dinaric karst in Central Croatia, consist of 16 lakes of different sizes, connected by streams and waterfalls. The altitude of the area ranges between 636 m and 505 m a.s.l., the climate is continental, the 5-year average air temperature is 8.7°C, and the average yearly precipitation is 1473 mm. The lakes receive water from two main springs (Bijela Rijeka and Crna Rijeka) and two tributaries (Rječica and Plitvica). The lakes are characterized by intense calcium carbonate precipitation from the water, forming tufa barriers and fine-grained lake sediments. The surrounding area is covered largely with deciduous forests. The area is sparsely populated, is protected as a National Park, and is included in the UNESCO World Heritage List. Consequently, human activities in the lake watersheds are relatively limited. However, numerous tourists visit this area every year.

Intense plant growth has been observed in some lakes and water streams at the Plitvice Lakes area and here we investigate whether this phenomenon is a consequence of anthropogenic pollution or due to naturally produced organic matter in the lakes. We applied mineral and organic fraction analyses, trace elements, measurement of stable and radioactive isotopes of surface lake sediments in four different lakes: Prošće, Kozjak, Gradinsko and Kaluđerovac. Kozjak Lake with confluence of Rječica tributary is investigated more detail so sediment is sampled at four sites.

Lake sediments consist mainly of autochthonous carbonates (mainly calcite) with higher sedimentation rate in small lakes. Sediments from the two large lakes, Prošće and Kozjak, showed constant stable isotope profiles for the carbonate fraction and full agreement between the ^{137}Cs and ^{210}Pb chronologies. Sediments from the two small lakes, Gradinsko and Kaluđerovac, showed synchronous increases in ^{14}C and $\delta^{13}C$ in the surface 10 cm of sediment and disturbed ^{137}Cs records. All lakes showed an increase in a ^{14}C in the carbonate sediments above the first occurrence of ^{137}Cs which was interpreted as a damped (č10 pMC increase in a ^{14}C), and decades-delayed consequence of the thermonuclear bomb-induced increase in a ^{14}C in atmospheric CO_2. For the small lakes, increased $\delta^{13}C$ in the last two decades and part of the a^{14}C increase is probably due to an increase in primary productivity that enhanced

biologically-induced calcite precipitation with concomitant changes in the carbon isotopic composition of carbonate sediments.

$\delta^{13}C$ values of a near-shore sediment core close to the confluence of the Rječica tributary of Lake Kozjak showed that the carbonates in this core are a mixture of autochthonous and eroded allochthonous mineral carbonate. Fraction of organic material and the C/N ratio are the highest in this core indicating that the organic matter is mainly of terrestrial origin. Tributary influence decrease rapidly with increasing distance from tributary Sedimentation rate at this core site was high, but it could not be quantified by ^{210}Pb or ^{137}Cs. The content of organic matter, C/N ratios, isotopic measurements in sediment organic matter ($\delta^{13}C$, ^{14}C) and measurement of total ^{15}N in all Plitvice sediments/cores showed mainly autochthonous origin of sediment material.

There is no significant difference among the trace element concentration in the upper segment of all cores, deposited approx. during last 50 years when higher anthropogenic influence is expected due to development and touristic activity, and the lower part of the cores, corresponding to the period approx. 100-200 years before present. The content of trace elements and organic matter in sediments decreases from the uppermost lake downstream.

According to our results there is no indication of significant recent anthropogenic pollution in water and sediment.

UNDERGROUND KARST FEATURES AND GLACIAL SEDIMENTS – EXAMPLE FROM "SNJEŽNICA U ŠTIROVAČI" CAVE ON THE VELEBIT MT. (CROATIA)

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Geomorphologic researches have shown that the Pleistocene glaciation spread over a large part of the northern, central and southern Velebit. Various types of glaciers were differentiated, and surface morphologic (denudation and accumulation) proofs of their expansion were found. As we are talking about a karst area, this work analyses the possibility that the glaciation proofs are also deposited in the underground, i. e. in some speleological features especialy in the cave "Snježnica u Štirovači" (central part of Velebit Mt.). Cave position has been analysed in relation to the proved expansion of glaciers, as well as their interior morphology and the possibility of glacial and fluvioglacial origin of clastic sediments inside of the cave.

HYDROLOGY OF THE KARST RIVERS LIKA AND GACKA

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Two of the largest sinking rivers in Europe, the Lika and Gacka rivers, are located in the region called Lika in Croatia. Studied region is the central part of the Dinaric karst and the divide between Black Sea and Adriatic watersheds is running through it. Both of the rivers belong to the Adriatic watershed. The water, swallowed in the karst underground on the

numerous swallow holes, can be traced to the submarine karst springs along the Adriatic Sea coast. Lika and Gacka are the rivers of a great interest for the hydrologists because of their close vicinity, yet extremely different hydrologic regimes. The Lika River has torrential water regime and its tributaries with characteristics of ephemeral streams, generate a ratio between its minimum, mean and maximum discharges: 1:130:3800. On the other side, that ratio by the River Gacka, a perennial river, is: 1:4:27, where its minimum discharge values are no less than 2,2 m^3/s. The water losses by the both rivers along their open watercourses are significant, especially in the case of the Lika River. In the summer months, the River Lika can have no discharge at all. According to topography of the two chatchment areas and its hydrogeological characteristics, an assumption can be made, that a great part of water losses of River Lika reappears in the springs of River Gacka. Physical evidence in the form of the karst connection through the conduits in the underground between two rivers hasn't been discovered yet, but many of geologists and hydrologists are working on it. The origin of the water in the springs of the Gacka River can be partially assigned to the topographic catchment, but the most quantities of water are feeding the springs by the karst underground flow.

ENTRANCE FACIES OF CAVE SEDIMENTS

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Entrace cave facies is developed in the from of cave opening, in cave entrance and in entrance part of the cave, more o less in the photic zone. It differs substantially from the interior cave facies, which led Kukla & Ložek (1958) to define both cave facies. Entrance cave facies (ECF) develops where cave conduit intersects with the land surface. The principal processes, which take part in the formation of the ECF is slope retreat and unroofing causing the cave shortening. The ECF is represented from talus fan of colluvial material derived from hill slopes, breakdowns and slope retreat and it covers former internal cave facies. Surface material fall, roll, slide, creep and flow into the cave, where becomes interbedded or mingled with autogenic material derived from walls and ceiling of the cave.

The ECF can be divided to several segments, i.e. (1) outer zone (in the front of cave portal) up to line of falling blocks from the slope, (2) portal (entrance) segment, where falling stones can roll on the cone surface, and (3) internal segment fed by breakdown of cave walls and ceiling and creep and solifluction. Outer and portal segments can be changed by pedogenic and post-depositional processes. Internal segment is usually unchanged after the deposition, except burrows (animal, human).

The ECF is well stratified and represents the most valuable section of the cave, especially due to well-preserved palaeontological and archaeological remains. Each layer is stratigraphically important and can be used for palaeoecological and palaeogeographical analysis. The sediments consist of autogenic portion (coarse-clastic material derived from slope retreat, destruction of cave walls and ceiling, biogenic accumulations, chemical deposits) and allogenic portion (wind and water transported relatively fine-grained sediments, marine, glacial, fluvial and volcanic materials). Materials originating in glacial and interglacials differ substantially. Glacials are typical by angular clasts of smaller sizes, aeolian deposits (wind-blown sands, loess) and bone accumulations (especially of small mammals). Interglacials are characterized by fine-grained sediments, mostly wind and water transported,

pedogenic sediments derived from surface (due to negligible post-depositional modifications their sequences allow to study individual stages of pedogenesis on the surface), coarser up to rounded (corrosion) clasts of larger size and chemical deposits (foam sinters and bioconstructions). Fauna remains (both bones and coproliths) occur as thanatocenoses (rests of animal, which died on place) and taphocenoses (rest of animals brought by carnivors). The most important for stratigraphy are land snails, (mollusks), vertebrates (especially small mammals like rodents and insectivores, bats and also large mammals). Humans left tools, bones, fire places, graves, parts of building constructions and other traces of their activities (art), including disturbances of sedimentary profiles.

Nearly identical are fills of rock shelters (abbris) and sequences of colluvia below steeper slopes. The same patterns result from the same depositional processes provoked by slope retreat.

The ECF represents conserver of information often lost on surface by later geological and geomorphic processes. Its disadvantage is (1) the small volume and (2) continuous slope retreat shifting depocenter inside the former cave. Both factors do not enable the deposition and preservation of thicker sedimentary complexes. These results in relatively short stratigraphic record captured in the ECF in caves and rock shelters; in the Central Europe mostly only the Last Glacial up to Holocene.

CLASTIC SEDIMENTS FROM INNER CAVE FACIES

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Clastic cave sediments represent those materials which have originated from both allochthonous and autochthonous sources and normally represent the phases of the evolution of the cave and its surrounding environ often from early initiation of the cave system through to the present day. Since caves are now regarded as very often being extremely ancient features, and since caves act as 'the trash cans of the region' the materials within cave systems can prove very important indicators of surface palaeclimatological change. Sediments can be introduced into a cave through surface soil wash down, translatory flow and more conventional fluvial deposition (although the latter can take the form of full pipe flow both in vadose and phreatic regimes). Further, deposits can be introduced into a cave by aeolian conditions and indeed by mud flow events, although both of these represent nearer entrance facies and deposition.

The clastic component of cave sediments can be studied to provide provenance indicators of surface events here demonstrated with the use of quartz surface texture analysis in order to provide the sequential provenance and palaeohistory of the materials. Examples are taken from North America, Europe, China, Asia, the Middle East and Australia.

ANTHROPOGENIC SEDIMENTS IN THE CAVES ON KRAS

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Many times we can find in caves also sediments that have anthropogenic origin. These sediments are usually archaeological and waste sediments. In the poster there will be presented kinds of sediments found in caves in the community of Sežana. Special attention is based on some examples of caves that are in the vicinity of underground Reka River.

BIOGENETIC POTENTIAL OF MOONMILK DEPOSITS: SPIDER CAVE AND PAHOEHOE CAVE, NEW MEXICO; THURSDAY MORNING CAVE, COLORADO; THRUSH CAVE AND CATARACT CAVE, ALASKA

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Moonmilk is a pasty carbonate deposit that occurs within various subterranean systems. Many secondarily formed deposits within caves are known to be the result of primarily physiochemical processes. However, moonmilk does not appear to be explainable via the same abiotic mechanisms, nor have the same morphologies and textures as traditional speleothems such as stalagmites and stalactites. Moonmilk is currently loosely defined as a microcrystalline aggregate cave deposit composed of various mineralogies with a distinguishable texture. Moonmilk differs from other speleothems due to its biological content, highly variable mineralogy, water content and texture. A microbial role is suggested by the presence of visible pits in bedrock apparently caused by organism attachment, mineral encrustation around microbial filaments, and significant biofilm content.

Our research investigates a wide latitudinal range of moonmilk deposits from five various cave systems within the United States: Alaska, Colorado and New Mexico. The moonmilk deposits vary in mineralogy, host lithology, water content, and depositional scale (extensive coating to random patches). The majority of the deposits are subaerial, while one deposit is subaqueous. It is clear that moonmilk can be produced at both near freezing and warm cave temperatures.

In order to test the relative biogenicity of moonmilk, this study aims at distinguishing the biotic components and interactions from abiotic. The research presented in this thesis utilizes a pragmatic interdisciplinary approach encompassing geomicrobiology and geochemistry. Geochemical methods consisted of carbon analyses, X-Ray diffraction, stable isotopes and petrography. Biological examination included a combination of cultural techniques, microbial quantification and microscopy.

PALEOKARST FORM IN THE LATE TRIASSIC ROCKS OF MT.RUMIJA, SOUTHERN MONTENEGRO

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Southeastern Montenegro is the only part of the Adriatic Carbonate Platform (AdCP). Upper Triassic carbonates of Mt. Rumija are the basal unit of the AdCP. The facies is made of 0.5–1.5 m thick incomplete and seldom complete lofer cycles. The cyclic deposition of peritidal and subtidal sediments.

These carbonates contain abundant birds-eye and fenestral structures, black pebble conglomerates, mudcracks, and intraformational conglomerates/breccias, paleokarstic with speleothems, Neptunian dikes, limonite crusts, and bauxite representing a supratidal environment, which was frequented by storms.

Focus of this paper is types of porosity; moldic cavitiec, shelter and fenestral porosity; crack, cavern and vug porosity, time of their production, size and forms of pora and else inhereti for genetic karsta of Upper Triassic (229 to 200 million years ago).

"OLD THEORIES AND NEW INSIGHTS ON THE MORPHOGENESIS OF THE DANUBE'S KAZAN GORGE – THE ROLE OF KARST PROCESSES"

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Along its course from the Pannonian Basin towards the basin of the Black Sea, the Danube River has entrenched a gorge known as Iron Gates, in the Southern Carpathians. The narrowest section of the Iron Gates is its karstic section called the Kazan Gorge, cut in Upper Jurassic Limestones along Mt.Miroč. The paper gives the overview of the known theories on morphogenesis of the Iron Gates, and more specifically, Kazan Gorge. These theories include the overview of Danube River terraces positions, as well as the hypotheses of antecedence and piracy. The suggested new hypothesis on Kazan Gorge morphogenesis takes into account the role of karst processes in its development. The activity of the regional Cerna-Jiul fault (dextral strike-slip) and the substantial quantities of water enabled the formation of cave passages simultaneously with the surface incision. Gradual collapse of cave ceilings lead to the partial change in the river's course and to its positioning in the place of the present Kazan Gorge.

MINERALOGY OF CAVE DEPOSITS ALONG CERNA VALLEY, ROMANIA

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Over 30 caves are known to develop in the Jurassic and Cretaceous limestone that outcrops on both sides of the Cerna Valley in south-western Romania. There are three aspects that strike when entering most caves on Cerna: the amount of guano deposits, the temperature, and the presence of impressive gypsum deposits. Given the microclimatic conditions (warm, poor cave ventilation) that characterize the caves we visited, the existence of large guano deposits is not entirely surprising. However, temperature anomalies are rather uncommon in the cave environment, especially when one can measure air temperatures (in some of the caves) as high as 40 ºC. This situation is due to the presence of thermal water pooling or flowing through the caves or to the hot steam that rises along fractures from deeper thermal water pools. There is no need of sophisticated analyses to realize that some of the thermal waters are enriched in H_2S and therefore, occurrences of large gypsum deposits are somehow normal.

Because of the above-mentioned features, we can now argue that many of the caves along the Cerna Valley could provide a unique set of conditions that allow the deposition of a suite of unusual minerals. This preliminary study presents the results of a limited number of mineral samples that were investigated by means of X-ray diffraction, thermal, scanning electron microscope, and electron microprobe analyses. In addition, oxygen and sulphur measurements ($\delta^{18}O$ and $\delta^{34}S$) on gypsum speleothems were performed with the scope of ruling out the origin of cave gypsum (i.e., vadose, hypogene, bacteriogenic, etc.).

The minerals identified so far in Sălitrari, Ion Barzoni, Diana, Adam, and Grota cu Aburi caves, are: calcite [$CaCO_3$], aragonite [$CaCO_3$], gypsum [$CaSO_4.2H_2O$], anhydrite [$CaSO_4$], pickeringite [$MgAl_2(SO_4)_4.22H_2O$], hydroxylapatite [$Ca_5(PO_4)_3(OH)$], carbonate-hydroxylapatite [$Ca_5(PO_4,CO_3)_3(OH)$], brushite [$CaHPO_4.2H_2O$], darapskite

[$Na_3(SO_4)(NO_3).H_2O$], and nitratine [$NaNO_3$]. More investigations are planned to shed light on the way these minerals (and others to be documented) precipitated in each cave.

GEOCHEMICAL CHARACTERISTICS OF THE MORACA RIVER BASIN-UPSTREAM FROM THE CONFLUENCE WITH THE ZETA RIVER

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The main investigation subject in this paper is a geochemical approach to the protection of the water quality of the Moraca River basin, as a mountainous karst stream, and the estimate of ecological impacts at geochemical balance of the basin.

There are several tasks, which were carried out during investigation period; establishing of the appropriate observation network; determination of hydrogeological properties and functions of the present rock formations; observation of the geomorphological and hydrogeological occurrences; determination of the groundwater flow direction; correlation with groundwater geochemical characteristics, and estimation of the ecological conditions at the investigation karst area.

According to the tasks mentioned before geochemical-ecological characteristics of the karst area of the Moraca River basin were investigated, as a main hydrological resource in water recharge of the Skadar Lake, which is a potentionally water supply resource.

Key words: geochemical characteristics, Moraca River basin, karst area

PALAEOKARST CLAY CORTEX FROM THE LUBLIN-VOLHYNIA REGION (SE POLAND, NW UKRAINE) – GENETIC AND PALAEOGEOGRAPHICAL CONTEXT

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Clay cortex from the contact zone of carbonate rock and filling deposits was examined in palaeokarst forms (pockets, pipes and dolines of different age) from the Lublin-Volhynia karst region. In the light of the micromorphological and mineralogical analyses of samples it seems possible to work out a model/scheme forming the basis for genetic and stratigraphic discussions.

1) Old, preglacial dolines with the Paleogene or Neogene mineral infillings are characterized by: (a) homogeneous, residual type of massive clay diffusively passing into the chalk monolith, and at the same time (b) relatively thick weathered zone.

2) Pipes with glaciogenic mineral infilling from the Saalian Glacial are characterized by: (a) sharp contact of rock and clay, (b) narrow weathering zone of carbonate rock, (c) diffusive nature of the contact zone between residual clay and mineral infilling, and (d) contamination of clay with clastic material.

3) Pockets with glaciogenic mineral infilling and traces of the Vistulian periglacial transformation are characterized by: (a) strong contamination of chalk with quartz grains, (b) diffusive transition between clay and infilling deposit: from clayey matrix with single quartz grains (at the contact with chalk) to clayey coatings and intergranular bridges (in the infilling deposit), (c) intensive weathering (cracking) of mineral grains in the infilling deposit.

RECONSTRUCTION OF HUMID CONDITIONS DURING THE LAST INTERGLACIAL (MIS 5E) INFERRED FROM TUFA DEPOSITS IN TRABAQUE CANYON, CENTRAL SPAIN.

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Tufa deposits are widespread in Trabaque valley (central Spain) below a narrow calcareous canyon. Three tufa terraces were previously recognized and dated in this area. Further research along the Trabaque Canyon allowed the recognition of a previously undocumented depositional system, which is the focus of the present study.

Tufa was deposited 1 km along the canyon, and five sections were studied in order to reconstruct the vertical and lateral evolution of palaeoenvironments. Sedimentological analysis allowed the recognition of a complex system which alternates from fluvial to barrier depositional systems. Four U-Th dates were obtained within the same strata in order to evaluate the consistence of ages and discard the chance of an open system in the tufa sediments. Dates were similar within errors, and the average age is 127.8 ± 5.6 ka. So, we can conclude that the tufa was deposited during the last interglacial (MIS 5e).

Trabaque canyon is a dry valley where running water only occurs after heavy rains. Thus, continuous water flow in the valley only appears downstream from the spring intersecting the water table. Studied tufa sediments are interpreted to be deposited downstream from a palaeo-spring. This interpretation is supported by the recognition of paludal and lacustrine facies which otherwise would be dried out, as well as the analogies from the current system. Previous studies demonstrated that other carbonates deposited in the Trabaque valley during the period 90-105 ka are located at lower elevations downstream in the canyon. This suggest that the Eemian interglacial was much humid in central Spain than other periods during MIS 5, causing larger recharge of aquifers which resulted in a higher elevation of the spring feeding the tufa formation.

REGULAR STALAGMITES: THE THEORY BEHIND THEIR SHAPE

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Under growth conditions constant in time stalagmites grow into an equilibrium shape, which is established, when all points of its surface are shifting by the same vertical distance $W_0 = \alpha(c_{in} - c_{eq}) \cdot \Delta t \cdot 10^9 (\mathrm{cm/year})$ during a time interval $\Delta t(\mathrm{years})$. Thereby $\alpha(c_{in} - c_{eq})$ is the precipitation rate in $\mathrm{molcm^{-2}s^{-1}}$, c_{in} is the calcium concentration of the supersaturated solution dripping to the apex of the stalagmite, and c_{eq} its equilibrium concentration with respect to calcite and the p_{CO_2} in the cave atmosphere.

From these ingredients a numerical model of stalagmite growth into an equilibrium shape is presented. In this model one assumes idealistically that the water dripping to the apex flows continuously down the stalagmite, spreading out radially. By simple mass balance one finds

that the equilibrium radius is $R_{eq} = \sqrt{V / \pi\alpha\tau}$, where $V = 0.1\,cm^3$ is the volume of a drop and τ the drip interval. Furthermore numerical modeling reproduces the vertical shifting of the stalagmite's equilibrium shape. Finally an interesting similarity rule is found. If one scales two stalagmites of differing R_{eq} to the same size and chooses their growth axes as common axis and their apexes as common origin, both show identical shapes. In other words regular stalagmites are similar geometrically. This similarity rule is verified by digitizing the shapes of various natural stalagmites with diameters between 5 cm and 20 m. Within small natural variations, the rescaled shapes are identical and close to the shape of the numerical model.

IMPLICATIONS OF BACTERIAL DIVERSITY AND ACTIVITY IN CARBONATE DEPOSITS, BUS DE LA FOOS CAVE, ITALY

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Chemical deposits in caves, such as speleothems, are important for paleoclimate studies, and the hydrated to permanently wet surfaces can serve as a habitat for cave animals. Previous work suggested that some carbonate deposits (e.g., moonmilk) can be influenced by microbial activity, although the microbial diversity of these deposits has been poorly investigated. In this study, we examined the microbial diversity from flowstone that has formed from moonmilk in a hydrologically active part of Bus de la Foos Cave, Campone-Pordenone, Italy. The microbiological sample originated from scrapped carbonate mud on the surface of the flowstone. The percolating waters associated with the carbonate material were Ca-HCO_3^--type, having a pH of 8.3 and temperature of 8 ^oC, and were supersaturated with respect to calcite and aragonite mineral phases. Microbial cells in the percolating waters and sediment ranged from 10^5 to 10^7 cells/ml. Sequenced 16S rDNA genes from the sediment were affiliated with at least 14 major taxonomic bacterial phyla and classes, dominated by the *Proteobacteria* phylum (57%), and specifically the *Betaproteobacteria* class (26%), including members of the genera *Acidovorax*, *Variovorax*, and *Janthinobacterium*. The next most abundant group was the *Bacteriodetes/Chlorobi* (34%). Rarer sequences, representing <10%of the total sequences, included (in order of decreasing relative abundance) the candidate division TM7, *Planctomycetales*, *Verrucomicrobia*, *Acidobacteria*, *Actinomycetes*, *Firmicutes*, *Nitrospirae*, and the candidate division WS3. Most of the clones were related to previously described strains, or to clones retrieved from other habitats, including freshwater and soil. Some of the microbial groups identified from the Foos Cave flowstone were similar to 16S rRNA gene sequences that have been previously retrieved from carbonate deposits in other caves. For instance, among the *Gammaproteobacteria*, clones were closely related to *Acinetobacter* spp. that have been isolated from speleothems in Cervo Cave, Italy. These results provide evidence that subaerial cave habitats offer rich and diverse environments for microbes, and that these habitats, from cave to cave, are potentially inhibited by similar microbial groups. Consequently, microbial colonization of cave carbonate deposits, and the microbial activity associated with these deposits, may influence chemical precipitation rates. This has direct implications for the reconstruction and analysis of cave deposits for climate records. Specifically, microbes could alter carbonate precipitation rates from abiotic

geochemical reactions, and could potentially impact the carbon and oxygen isotopic signatures recorded during precipitation or alteration of mineral phases.

POLJE SOILS: UNIQUE KARST SEDIMENTS?

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The Early Farming in Dalmatia Project (EFDP), of which our site-specific geoarchaeological study is a part, is an interdisciplinary effort toward understanding the origins of agriculture in Dalmatia, Croatia. This region was the conduit for transmission of agricultural technology from Middle Eastern domestication centers to mainland Europe. The EFDP aims to elucidate this momentous cultural change through detailed study of the Danilo Bitinj and Pokrovnik sites. Current evidence indicates a physically high-energy, generally infertile environment in a locale thought to have been geomorphically stable and agriculturally productive for the last 6000 years. Rather than providing a conclusive context for the transition to agriculture, findings to-date raise new questions concerning changes in sediment transport processes and local sediment budgets. Further knowledge of these parameters is critical for understanding the taphonomy of archaeological remains and the possible effects of human land-use on the evolution of the polje landscape.

The Danilo Bitinj and Pokrovnik sites are located in poljes – open, lowland locales preserving the landscape context of earliest agriculture. The need to contextualize Neolithic settlement forces us to examine polje sediment character and sedimentation history in relation to occupational history. Polje soils are difficult to classify, but appear mollic (dark and well-developed). The soils vary in depth (0-200 cm) and commonly contain large (5-50 cm) clasts which were clearly deposited, rather than produced through *in situ* bedrock weathering. Preliminary laboratory tests of Danilo Bitinj material show the soil to be organic carbon-poor and sodic, a condition normally resulting in infertility and plant toxicity. We continue to analyze these unique soils in an effort to understand the polje – both as a cultural locus and a karst landform.

KARST FEATURES IN CHAHARMAHAL VA BAKHTIARI PROVINCE(SW OF I.R. OF IRAN)

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Chaharmahal Va Bakhtiari province is situated in the central part of the Zagross mountains in SW of Iranthat said "High Zagross zone". The most of the province surface is covered of The crushed and karstic limestones.

Karstic water resources is very important in Bakhtiari province and it was recognized almost 550 years ago when Iranians kings desided to transferring Kuhrang huge spring to the Zayandehrud basin

Many karst features such as huge springs, caves, sinkholes, poljes and … are exposed around the area. Karst features are mostly seen around Zardkooh and Kalar mountains that

discharge main water resources in the province. Although, Bakhtiari province is in low latitude, it includes high precipitation and concequently caves are well developed in stratigraphical formations in the area. The typic example is conglomeratic cave named Sharmak cave in south side of Zardkuh mountain that is formed in the young Pliocene conglomerates. The glacial cave of Sheykh Ali Khan in the north side of Zardkuh is one of the another unusual features in the area.

THE GEOMORPHOLOGICAL HERITAGE (KARST) OF THE TERRITORIAL UNIT OF ALVAIÁZERE: FROM ITS INVENTORY TO A PROPOSAL OF VALUING IT

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The territorial unit of Alvaiázere is situated in the Sicó Massif, in the so called Orla Ocidental domain, in central Portugal, with its 618 meters high, the mountain of Alvaiázere is the highest elevation of the Sicó Massif and an area with a rich but unknown geomorphological heritage. Being an area with very particular geological and geomorphological characteristics, its not strange at all the fact that other characteristics directly related with the biotic and human elements stand out.

This work consists in evaluate and valuate geomorphological resources in this particular karst area, using a particular method for it. The concept of geomorphosites is still barely known to the local authorities, this way it is very important to study this aspect and to explain the importance of knowing this particular heritage, this can be not only an opportunity to preserve some very important karst sites but also to show to the local people how karst can be a source of income without destroying it.

In this poster presentation a general approach is done about the several existent values in the area that comprises the territorial unit of Alvaiázere, those ones can be an excellent basis for the long socioeconomic development, not only for that area but also for the proximal areas, the so called "Terras de Sicó".

CHEMICAL DEPOSITS IN CAVES

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The systematic study of the minerogenetic mechanisms and processes which may allow for the development of secondary chemical deposits inside natural caves has started very recently (Hill & Forti 1997). But even if only a few caves of the world have been studied from this point of view, it is now clear that this environment is one of the most interesting due to the great variety of processes (Tab. 1) taking place even contemporaneously, most of which are represented by low enthalpy reactions.

The great variety of processes together with the dramatic changes in the mineralogical composition of the host rocks allow for the development of plenty of different cave minerals, some of which new for science.

The different cave environments (volcanic, thermal, karst, mine, etc..) exhibit different peculiarities and consequently very different speleothems develops therein: anyway some

important processes, like the biogenic ones, are present in rather all the natural caves and consequently the related cave minerals.

After a short description of the most important minerogenetic processes active in the cavern environment, the mineralogical peculiarities of the volcanic, thermal and karst cavities are outlined.

Then a short overview is given over the main mineralogical researches that should be performed inside cave in the near future with specific attention to cave deposit's preservation.

Tab. 1- Temperature range, process, minerogenetic mechanisms and main related chemical deposits in natural caves: the first process is restricted to volcanic caves, while the others may be active in all kind of natural cavities

Process			Mechanism	T (°C)	Products
1	Degassing	A- High temp.	Sublimation	> 100	Sulphur, sulphides, oxides, hydroxides
		B- Low temp.	Deposition by aerosols and vapours	100 ÷50	Sulphates, halides, opal
2	Solubilization		Evaporation	100 ÷10	Sulphates, nitrates, halides
3	Alteration		Oxidation, hydration-dehydration, ionic exchange	100 ÷0	Si-, Al-, Fe oxides-hydroxides, sulphates
4	Karst		Diffusion	40 ÷0	Carbonate
5	Biogenic activity		Digestion, dissolution-precipitation, double exchange	40 ÷0	Phosphates, Nitrates, Sulphates, Halides
6	Phase change		Freezing, sublimation, segregation	< 0	Ice, sulphates, halides

PRESENT-DAY SEDIMENTARY FACIES INTO THE COASTAL KARST CAVES OF MALLORCA ISLAND (WESTERN MEDITERRANEAN)

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In spite of the increasing amount of references on cave sediments, published during the last decades, are only a few the synthesis works dealing thoroughly with this topic. Furthermore, among the great amount of recent papers devoted to sediments in caves, no one has focused from a sedimentological point of view on the processes that take place specifically into the coastal karst areas of carbonate islands.

During the last decade, there has been a great increase in the speleological and karstic research in Mallorca island, especially in those peripheral areas where the coastal karst reaches a remarkable development. The recent explorations of extensive underwater galleries and chambers, into some outstanding littoral caves of the island, allow a detailed observation and survey of some tens of kilometres of drowned passages. These investigations have permitted to recognize the morphogenetical characteristics of the underwater part of these caves, being noteworthy the existence of different kinds of present-day sedimentary infillings in most of the explored extensions.

The objective of the present work is to deal with the sedimentary processes that take place inside two coastal caves of Mallorca, characterizing the different facies existing in the particular geological, geochemical and hydrological setting that represents this so specific hypogean sedimentary environment.

Both the Pirata-Pont-Piqueta cave system, as well as Gleda cave, have important accumulations of sediments in its drowned chambers, passages and conduits. Most of the cave floors are covered by muddy and/or sandy sedimentation which, in a wide sense, is marked by two very different characteristics. On one hand we have red mud sediments (mainly siliciclastic) and in the other hand yellowish carbonate mud or sands. The mixing of both materials is also frequent as well as the accumulation of large blocks and debris due to the breakdown of roof and cave walls.

A series of 21 manual cores were obtained by scuba-divers in both caves, in order to collect the existing sediment till the cave floor was reached. Soil samples at the entrance of the caves, as well as rocks samples of the walls of both sites, were also obtained for a posterior comparison.

Four different types of sediments can be observed inside the caves comprising several sedimentary facies: Coarse-grained deposits, that include *Breakdown facies* (originated by the collapse of roofs and walls, mainly favoured by the repeated flooding and emptying of the original passages during the Pleistocene glacio-eustatic oscillations), and *Entrance facies* (loose heterometric deposits, mainly found at the entrance talus of some wide openings that acts as sinking points of precipitations and surface runoff); Fine-grained deposits, that correspond to *Brown organic silts* (vertically infiltrated soil and weathering particles, including abundant vegetal fibres, deposited in the cave pools after intense periods of rainfall with limited lateral transportation; correspond to the *backswamp* facies of the literature), *Reddish mud* (mainly clays and silts placed into the passages and chambers as suspended load, analogous to the *slackwater* facies deposited in continental karst aquifers); Carbonate deposits, with the presence of *Calcite rafts sands* (pool-bottom accumulations of epiaquatic calcite precipitates), and *Carbonate grains* (released by physico-chemical weathering of the limestone walls); and finally, the Older or Relict deposits mainly composed by *Red silts* present in some parts of the inner drowned passages and showing cracks caused by splitting into polygonal blocks. These older sediments indicate a drying period of the sediment surface (low sea stand) after the deposition of mud by slow-moving water.

All these types of sediments and facies can be found isolated or intermingled between them in different proportions, according to the location into the cave system and the sedimentary processes involved. We consider them as Mixed facies.

The deposits and facies described herein correspond to different sedimentary environments that can be individualised inside the caves (collapse entrances, breakdown chambers, fully drowned passages and chambers, pools with free water surface…), being characterised by very specific hydrological, geochemical and mechanical processes related to the coastal nature of the studied karst caves.

ASSESSMENT OF GEOLOGICAL RISK AND ENVIRONMENTAL FACTORS OF THE AREA SURROUNDING CAVES: A PROPOSED NATURAL RISK INDEX AND SAFETY FACTOR

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It is important to study the geological factor as well as surrounding area of the cave for the sedimentary records and delimit the beds in which the cave was formed. The cave forms part of a karstic complex, which is characterized by karstic forms and landslides as the main geomorphologic elements. In the present study sediment and watershed of Shankar khola cave and area surrounding it in the central India was done. In this study, short-term variations in discharge and chemistry were examined from a tile outlet collecting subsurface tile flow from agricultural watershed. Study objectives were to apply analytical techniques from karst springs to tile discharge to evaluate water sources and estimate the loads of agricultural pollutants discharged from the tile with conduit, intermediate and diffuse flow regimes. A two-member mixing model using nitrate, chloride and specific conductance was used to distinguish rainwater versus groundwater inputs. The strong relationship between sinkholes and faults within the area was also revealed, with sinkholes of oval morphology aligned along the faults. Inside the cave, the subhorizontal bedding is intersected by subvertical joints, generating geometrical blocks prone to falling down. This is the main process of the present evolution of the cave in addition to the dissolution and precipitation of carbonates in local zones. Landslides, water flow towards the cave, rock falls within cave and karstic features are the main geological risks affecting the karstic complex. In our investigation we take these geological factors for the concluding about the history of cave and sediments. In the study, for the determining the risk level and other safety factor two semi-quantitative indexes were proposed, the natural risk index (NRI) and safety factor (SF).The information provided by geological studies as well as water quality parameters obtained using the proposed indexes allowed definition suitable protection areas around the cave.

DEPOSITION OF THE SEDIMENTS IN CICLOVINA CAVE (SUREANU MTS., ROMANIA)

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The sedimentary deposit from Cioclovina Cave (Sureanu Mts., Romania) was the base of numerous paleontological, anthropological, and mineralogical findings. A complete and complex study of the sediments of the main gallery was necessary in order to determine the origin, depositional mode and processes, direction of the paleocurrents, and speleogenesis of the cave. 16 sedimentary profiles were analyzed and mapped in the Main Gallery. They are covering a total height of 19 m of the cave sedimentary deposit. For every sample all the granulometric parameters have been calculated.

Although the deposition of the sediments is very complex, the distribution of the three main sedimentary complexes (silt, sand, pebbles) can be clearly distinguished, indicating a typical cave channel lithofacies. Seven stages of cave evolution were observed, including the indications of a sudden change in the climatic conditions at the surface. The direction of the paleocurrents and the origin of the sediments were also determined, the exact path of the

paleoriver at the surface will be determined in the close future by analysis of the surface geomorphology.

SEDIMENTS, MORPHOLOGY, DATINGS, DIFFERENT CAVES - ALL IN ONE?!

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The basic principle of geology says that overlying strata are younger than the lower ones. This is, as a general rule, also true for cave sediments, therefore it is often used to check reliability of datings. Much less known is the fact that single deposits within caves can also be linked by morphology, and that morphology allows to link separate caves. A recipe for establishing such a relative chronological frame is given.

US/CHINESE COOPERATION AND TRAINING IN KARST WATER RESOURCE INVESTIGATION IN FOLDED CARBONATE STRATA, QING MUGUAN KARST GROUNDWATER BASIN, CHONGQING, CHINA

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The Qing Muguan Groundwater Basin in China's Chongqing Municipality has recently been established as a demonstration field site for collaborative research and training by scientists and students at Southwest University of China in Beibei, Chongqing, and the China Environmental Health Project (CEHP) at Western Kentucky University (WKU) with major support from the US Agency for International Development.

Fieldwork in summer 2007 allowed the WKU CEHP team to share experience in procedures for karst groundwater investigations, while the Southwest University students provided details of hydrogeologic background and previous research. The area of Qing Muguan is serving as a new study area where students from opposite sides of the world can benefit from learning new approaches to karst water resource investigations.

AN ANALYSIS OF CAVE SEDIMENTS FROM JENNINGS CAVE, MARION COUNTY, FLORIDA: GEOMORPHIC IMPLICATIONS

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Since it is known that cave sediments can be used as indicators of geomorphologic changes that occur during karst landscape evolution, an analysis of these sediments can provide primary geomorphic information about transportation mechanisms, depositional history, and landscape and cave formation. This project attempts to provide insight on certain topics regarding Jennings Cave, Marion County, Florida. Before 1,870 years ago, the sediment that was being transported to the collection site, some 100 meters from the entrance,

consisted mostly of fine-size to medium-size clay and silt deposits. However, around 1,870 years before present, certain climatic events caused the sediment input to the collection site to change. Unfortunately, little research has been completed on the landscape of west-central Florida, with past research focusing on the Dames Caves area, Citrus County, Florida, and Briar Cave, Marion County, Florida. In-depth research on Jennings Cave and the surrounding environment is necessary in the attempt to understand the evolution of the west-central Florida's karst landscape.

TUFA AS A KARST PHENOMENA: ENVIRONMENTAL AND PALAEOCLIMATE CONDITIONS OF TUFA FORMATION

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Tufa is a product of calcium carbonate precipitation under open-air conditions from ambient temperature waters in areas of carbonate bedrock, i.e. karst areas. The carbonate is precipitated in association with a biofilm which is a by-product of the microbial metabolic activity of diatoms, bacteria and/or cyanobacteria. Tufa formation is favoured where well-developed plants exist in streams and waterfalls and these results in different morphological forms. This process is very sensitive to physico-chemical or biological changes in the water and also to seasonal fluctuation, e.g. temperature change.

Physico-chemical conditions of tufa precipitation will be presented and compared with conditions of speleothem formation. Geochemistry of tufa formation involves also the isotopic exchange processes of carbon and oxygen isotopes between dissolved inorganic carbon and atmospheric CO_2 and by the decisive role of biota. Assuming isotopic equilibrium during calcite precipitation then terrestrial carbonates such as tufa, speleothem or lacustrine sediment can provide a record of environmental and climatic information. Results of investigation of tufa deposits from the Dinaric Karst in terms of the conditions of formation, using physical and chemical parameters in conjunction with isotopic measurements (14C, δ13C and δ18O) will be presented. Variations of growth frequency of tufa deposits based on 14C and 230Th/234U dating demonstrate that the formation of calcite deposits was stimulated by changing climate, e.g. during interglacial periods with warm and humid conditions.

TRENDS OF ENVIRONMENTAL CHANGE AND GEOCHEMICAL STUDY OF SEDIMENTARY RECORDS IN MEDITERRANEAN ROCKSHELTERS AND CAVES

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The Rockshelters and Caves of the region form important environmental and sedimentary archives. These are also part of a wider sediment system, and their investigation must be accompanied by detailed geomorphological, sedimentological, paleoecological, and geochronological studies of the off-site quaternary record. It is important to develop rigorous methods and robust conceptual models for the interpretation of rockshelter and cave sediment records so that the cultural sequences they contain can be considered in their proper environmental context. Much of what we know about the prehistory of the mediterranean region and adjacent areas has largely been pieced together from materials excavated from

sedimentary sequences in these environments. In this context, the two main characteristics of a rockshelter or cave site which control its usefulness as trends of environmental change are the temporal resolution of the sedimentary record and the environmental sensitivity of the site. Many rockshelters and caves can be described as either active karst settings or passive karst settings and site type is an important influence on climatic sensitivity with a direct influence upon the usefulness of the sedimentary sequence as a proxy record of climate change. It is now clear that some sites may preserve detailed paleoclimatic records and the climatic signal may be represented by distinctive suites of micromorphological features, by variations in the input of allogenic sediment, or by fluctuations in the mineral magnetic properties of the fine sediment fraction. The most favorable sites for detailed paleoclimatic reconstruction appear to be in active karst settings such as Ambagarh Cave (Eastern part) and Kutumsar Cave (Southern part) where micromorphological analyses offer insights into the stratigraphic record that are not otherwise obtainable. The temporal resolution of a site can only be established through a rigorous stratigraphic analysis and a comprehensive dating program. These are fundamental considerations in the study of cave sediment records, especially when attempting to correlate between sites and draw comparisons with other proxy records of environmental change derived from sedimentary environments with rather different characteristics.

IN-SITU FLOWSTONE OUTCROPS AT MACHNÍN – THE FIRST INDICATION OF UNROOFED CAVE IN THE CZECH REPUBLIC

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Residues of flowstone crust overlying calcite-cemented breccia found on the karst surface at the village of Machnín (the Ještěd Ridge, Northern Bohemia) can be considered as the first unroofed cave discovered in the Czech Republic. It represents former cave highly transformed by denudation processes, including rock weathering, stream erosion and slope processes. Typical features of unroofed caves (depression-like form, cave walls) are missing and also geomorphic position on the top of a limestone ridge is unique. Its development is connected with neotectonic uplift of the area and backward stream erosion as well as periglacial processes in the foreland of Pleistocene continental glaciers.

Dating of flowstone samples using palynology and paleomagnetism methods indicate Upper Pliocene to Lower Pleistocene age (about 3.6 to 0.7 Ma). On the basis of these data and relative altitude position of the outcrop above the valley bottom it was possible to calculate the valley incision rate ranging from 28 to 143 $mm.ka^{-1}$.

APPLICATION OF REMOTE SENSING METHODS FOR INVESTIGATION OF KARST PROCESSES

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Remote sensing methods are unique for investigation of exogenous processes and their progress forecast. Besides traditional remote sensing methods, such as aerial mapping and space survey, for investigation of karst processes laser scanning and hyperspectral aerial surveying can be used. Each of them allows obtaining important additional information about karst processes.

Analysis of aerial and space photos allows to reveal surface karst forms in open areas. Also we can obtain information analyzing forms of drainage network. Within karst regions it often has orthogonal pattern following crakes direction, or dead-end river valleys with sudden disappearance of water stream.

Laser survey allows obtaining 3D data with high accuracy (+-5-10 cm) practically in the real time. Laser locator is capable to fix distances to several objects on the way of laser beam (the most modern models fix up to 4 responses of pulse). The first one - to the closest object within locator's field of view and is effective for definition of tree canopies. The last one - to the object being an absolute obstacle for laser beam. Thus karst forms can be revealed and monitored even under dense vegetation, in the regions of difficult access, nature reserves and in the monotonous areas without landmarks. Laser scanner can be completed with aerophoto camera or hyperspectral scanner (combined surveying).

Hyperspectral surveying is effective for object recognition, which is impossible with other remote sensing methods. Hyperspectral images provide distinctive spectral shapes that allow identification of mineral types, clay soil types, plant species and plant health within species types. Also they permit to analyze vegetation stress due to mechanical or chemical influence, for example the shock of the ground motion forces the plants to shut down their root systems, dehydrating and thus stressing the plants) So, hyperspectral surveying allows to estimate the possibility of karst danger in the region and make some forecast about karst form progress.

Using the complex of remote sensing methods investigators can follow landscape changes promptly, efficiently and at lower cost.

USE OF MATHEMATICAL MORPHOLOGY OF LANDSCAPE TO STUDY KARST PROCESSES

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In our work we use remote sensing data and method of mathematical morphology of a landscape. Mathematical morphology of a landscape is a branch of landscape science, investigating quantitative laws of landscape mosaics and methods of the mathematical analysis of these mosaics.

Theoretical basis of mathematical morphology of a landscape is formed by mathematical models of morphological structures – the quantitative dependences describing the basic properties of morphological structures. Canonical initial mathematical models play a special role in mathematical morphology of a landscape. They should develop in uniform conditions and under unique process.

At present there are the following canonical models, developed by Victorov A.S:

- Erosion plain landscape pattern
- Karst and suffusion plain landscape pattern
- Wetland and solonchak plain landscape pattern
- Eolian plain landscape pattern
- Thermo-karst lake plain landscape pattern
- Alluvial plain landscape pattern

In a nature conditions we as a rule have some combination of different processes. But basing on these models we can describe most of such combinations. And the most important thing is that with the help of those models, we can describe similar landscapes in quite different climate, geological and other conditions.

The equations of the mathematical model of a morphological pattern for karst processes proposed by A.S. Viktorov were used for the analysis of data and forecast constructions. They represent combination of the probabilistic mathematical relations reflecting the most essential geometrical features of the pattern. The equations include:

- Probabilistic distribution of a number of karst depressions, which have appeared within a specified site during the given time interval (Poisson process).

$$P(\kappa, t) = \frac{(\gamma t s)^k}{k!} e^{-\gamma t s},$$

where γ – is an average of the reductions appearing on unit area for unit time; s – is a size of a test site; t – is a time.

- Probabilistic distribution of changes of karst depressions areas (Winer random process relative to logarithms of areas)

$$F_r(x) = \frac{1}{\sqrt{2\pi}\sigma x\sqrt{t}} e^{-\frac{(\ln x - at)^2}{2\sigma^2 t}},$$

where α, σ - are distribution parameters, t - is a time;

Theoretical conclusions were verified on several model parcels.

PALAEOKARSTIC RECORDS AS A PART OF DIAGENETIC EXPRESSIONS OF THE MIDDLE PALAEOCENE SUBAERIAL EXPOSURE ON THE PYRENEAN CARBONATED PLATFORM (NORTHERN ARAGON, SPAIN)

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The study of the diagenetic process associated to the « Middle Palaeocene Unconformity » (MPU) reveals that palaeo-karstic systems affect the whole southern pyrenean carbonated platform. The aim is to exhibit the climatic and environmental records contained on karst fillings. The study is focused on the Campo-Merli transect of 8 kilometre long (northern Aragon, Spain). The two sections are composed of an alternation of shallow marine carbonates and continental marls dated from the Late Cretaceous to the Early Eocene. The Cretaceous alluvial marls system is surmounted by a Danian carbonated bar of which the thickness laterally decrease from 80 meters at Campo to 4 meters at Merli. The « MPU » corresponds to the surface of this carbonated corps. Campo and Merli sections were sampled and analysed on thin sections in order to identify each different diagenetic process and their relative chronology. Data are completed with cathodoluminescence and Scanning Electron Microscopy (SEM) observations. The observations made on Campo and Merli sections show

that the Middle Palaeocene subaerial exposure is characterized by two successive stages of karstic dissolution. In Campo section, the palaeo-exposure surface shows evaporites dissolutions originally of a palaeo-karstic depression expressed by a collapse breccia. In subsurface, micro-caves with jagged aspect are developed down to 60 meters and essentially along subvertical fractures. Caves are filled with dolomitic cements, interpreted as a possible record of an episodic relative sealevel rised. In Merli section, palaeo-topographically highest than Campo section, a horizontal microscopical epikarst is developed down to 3 meters and shows microstalactite concretions. Above the « MPU », the favourable topographic, climatic and hydrological conditions lead to the formation of a freshwater lake laterally extended by marsh system. The lake is filled by 20 meters of marls and lacustrian limestones. It is surmounted by a laterally develloped soil horizon. This sedimentary expression of drainage and a karstic dissolution resumption are evidence of a second relative ground water fall of approximatively 30 to 50 meters. In conclusion, sedimentary, diagenetic and karstic process recorded during the Middle Palaeocene subaerial exposure prove that the hydrogeological system evolves from evaporitic karst to marshed karst and climatic conditions evolve from half-dry to humid.

COMPARISON OF TWO LOESS COVERED KARST REGIONS IN HUNGARY: THE TÉSI-PLATEAU (BAKONY MOUNTAINS) AND THE ABALIGET – ORFŰ KARST (MECSEK MOUNTAINS)

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The Tési-plateau (in the eastern part of the Bakony Mountains) and the karst of Abaliget – Orfű (in the northern part of the Mecsek Mountains) are rich in karst forms: both areas have many dolines, ponors, caves and gorges too. They are typical karst covered regions: the significant part of their karstic bedrock is covered by several meters of pleistocene loess sediments.

We would like to present these two lesser-known karst regions and collect the similarities and differences based on observations on the spot and through lab experiments of soils and sediments. Besides, we used geoinformatics analyses to obtain knowledge of the morphometric parameters of the most representative karst forms, the dolines, and the connection between dolines and structural, geological and relief conditions.

CALCITE MOONMILK: MICROBIOLOGICAL AND GEOLOGICAL ASPECTS

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Moonmilk, a secondary cave deposit, represents controversary theme because of its origin. Although the hypotheses about the origin are still discussed, many studies revealed an occurrence of microorganisms, which might influence its formation. Our study involving geological and microbiological aspects showed presence of culturable microbiota - bacteria and fungi. Calcite moonmilk was sampled in 5 caves developed in the Devonian limestones of The Moravian Karst, Czech Republic.

Microbiological aspect

Sixty-nine bacterial strains were isolated from the moonmilk samples on three different media. The samples were aerobically cultivated at 10°C. The isolated psychrotrophic bacterial strains were characterized by biochemical, physiological tests and whole-cell proteins analysis by SDS-PAGE. Selected group of strains was also characterized by ribotyping. Only one isolate represented gram-positive pleomorphic rod and the rest of strains were gram-negative non-fermenting rods. The majority of them were classified as fluorescent pseudomonads with some atypical biochemical properties.

Nineteen strains of filamentous fungi were isolated by using dilution method and subsequent cultivation on 2 % malt extract agar. Plates were incubated at 16°C. Fifteen isolates represented class of anamorphic fungi Hyphomycetes, two isolates were recognized as Zygomycetes and remaining two isolates shared inability to express diagnostic characters and were grouped as 'sterile mycelia'. Hyphomycetes have appeared to be dominant mycobiota of moonmilk. Determination of isolates was based upon microscopic and macroscopic morphological characteristic.

Geological aspect

Analyses of a mineral composition by using X - ray diffractometer reveal that the specimens are compound only of calcite. There were no differences in outcomes between wet and dry samples. A content of water was probed by comparing weights of the specimens before and after dehydratation. The amount of crystalline water oscillates between 0.88 and 3.13%. Moisture of moonmilk samples varies from 34 to 85.8%. A chemical composition of moonmilk was investigated by the Electron Micro Probe Analysis. Morphological features were studied from the photos of samples procured by method using Back Scattered Electrons. Needle-shaped fibres, nanofiber veils, rods and polycrystals were observed.

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CONTRIBUTION TO CONTACT KARST MORPHOLOGY: A CASE STUDY OF NOVOKRAČINE (SW SLOVENIA)

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Village Novokračine lies at the Slovene - Croatia border in the heart of Jelšane hills, the eastern-most part of Brkini hills. Novokračine lie at the edge of the last blind valley in the Brkini blind valley series.

Sušački potok stream and its tributaries from flysch have created a typical contact karst formation - a blind valley. From the edge of the blind valley a dry valley runs towards the south and over the state border. The dry valley has a typical shape of a river valley, is morphologically related to former but genetically inseparable from Novokračine blind valley.

The position of the contact karst forms is predominantly controlled by lithographic structure of the region. Detailed geomorphologic mapping of Novokračine contact karst has revealed a duality of the blind valley: an active, accumulative part with flat, often flooded surface with a ponor cave and a 20-meter higher, inactive, erosional and uneven-bottomed part. The most suspended form, the dry valley, slowly descends towards the south and is left hanging some meters above the flat Brgud lowlands.

Also presented in the poster is the most probable sequence of processes which led to the development of Novokračine contact karst.

GENERATIONS OF TECTONIC EVENTS AND THEIR INFLUENCE ON GENESIS OF THE CAVES (SLOVAK REPUBLIC, HIGH TATRA MTS., UPLAZ MASSIF)

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The studied area is located in north region in the High Tatra Mts. within the Uplaz massif. Vernych and Ciernohorsky cave system is situated in massive Gutenstein member and massive organogene limestones. During the structural field mapping of the presented caves the collected cave-related data. From the measured values we were able to separate six monogenetic groups of discontinuities. The complex of six monogenetic groups of discontinuities we divided to two groups, based on their compared orientation to the paleostress axes. As the comparative criterion we used the tectonic tilting of the High Tatra Mts., dated as Sarmatian to Pannonian age.

Via the back-rotation of a group of tectonic failures affected by the measured tilting (0/27°) we obtained their original orientation. Individual generations of failures were further timed, based on the general knowledge of the studied area. The Ottnangian to early Badenian failures are supposed to belong to the lower generation, representing the early stage of the Tatras upheaval. The second group, affected by tilting, generated under extensional regime, is timed to late Badenian. The third generation of failures originated under compression tectonic regime is dated to Sarmatian age.

After this time the High Tatra Mts. block horizontally rotated and the later generations of failures generated under normal orientation of the paleostress axes. As the oldest monogenetic group of discontinuities we regard those, which are in normal extensional regime generated probably during the final stages of the Tatras tilting. After this stage, there started a compression tectonic regime coincident with the present orientation of the principal stress axes. As the youngest failures we can regard the discontinuities, connected with gravitational sliding. These failures were generated by gravitational collapse of the massif stability, due to a deep erosion generate by a glacier of Rissian, and later of Wurmian age. The motion along the sliding planes was enabled also by a proper orientation of a significant mylonite zone.

CAVE SEDIMENTS IN SV. ROK CAVERN (CROATIA)

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Sv. Rok cavern was discovered in April, 2003 during road construction in "Sveti Rok" tunnel (southern Velebit). The cavern was explored in total length of 1137 meters and sediments deposited within cavern are collected. The cavern is situated within Jurassic limestone, and formed by tectonic movements much later. The base of the cavern is filled with bedrock breakdown blocks covered with fine grained sediments sourced from insoluble residue during phreatic enlargement. The sediments were analyzed and $CaCo_3$ ratio between 10,9 and 15,1 % indicates the activity of corrosion process.

INVISIBLE BUT POWERFUL KARST SEDIMENTS

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Karst sediments are usually seen as material phenomena, and (natural) sciences deal with them. But there are some immaterial, invisible, cultural sediments, and their influence on the overall perception of the karst is crucial. They comprise all the knowledge, every fact, skill and belief about a landscape. Cultural sediments are a product of a current way of life. The most important of them are traditional, industrial and eco-system cultural sediments. In every landscape there are several of them at a time, but some are significantly more influential than others. In common sence, Dinaric karst is still mainly looked at through industrial cultural sediments, best described by the view that karst is a poor landscape and needs to be nurtured from outside, while its main advantages are in hydro-energy, oil, quarries, cement plants, etc. Such views not only lead to depopulation of these areas, but also hide the numerous information provided about the karst by its main discipline – karstology – not only in traditionally overlooked bioscience but also in the geoscience. Some examples in Dinaric karst show that such picture is a consequence of an economic policy that is not sufficiently aware of the delicate relations within the karst. Such policy is based on taking from the karst area, but rarely does it give anything back. Industry leads to temporary or permanent loss of some karst values. New views take eco-systems into account and discover a multitude of their new, and valuable characteristics. According to them, karst is not a poor eco-system, but an extremely diverse and rich one and it is necessary to get rid of the old cultural sediments in order to preserve its basic values. Only then will it provide an opportunity for a good life.
Key words: karst, karstology, sediments, cultural landsacpes, perception, industry, eco-system

BAT STUDY CONTRIBUTION TO THE CHRONOLOGY OF THE PALEOGENE KARSTIC FILLINGS IN WESTERN EUROPE

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Since 130 years the Quercy area, SW France, had yielded a huge quantity of vertebrate fossils, mostly paleogene in age. They are preserved within clay karstic fillings which are organized as sedimentary sequences. Only a part of the available fossil material was studied, and also the methods in study got much improved. The recent study of the bat material from more than 80 Quercy paleokarstic localities allowed us to update and increase the diversity of this group, and to follow with valuable precision its evolution along about 15 million years (from – 43 Ma up to – 23 Ma). A number of these localities were already studied as regards their fossil contents, or part of it, and « numerical ages » (as defined by Escarguel *et al.* 1997) were given to them. Nevertheless many localities could only be approximately stated as regards the mammalian MP scale, or even remained fully unstudied and without dating up to now.

From now, taking in account the observed tooth morphology and size condition, many phyletic lineages are defined from the recent systematic study (E. Maitre thesis). Refering to localities the numerical age of which is established from well defined mammal faunas, the

definition of evolutionary steps within bat natural lineages allows us to improve the chronological succession, and to check it with the one previously obtained from other mammal groups (e.g. rodents or ungulates). Relative ages are proposed for the localities till now undated, by taking in account the tooth size and morphological condition of the represented bat specific lineages. These data allow us to update and complete a biochronological mammalian scale for the Western Europe, from the MP 13 (Middle Eocene) up to the MP 22 (Early Oligocene), the time resolution power of which having never been attained up to now.

PALEOKARST AND ASSOCIATED SEDIMENTS AT DUBCI GEOSITE IN DALMATIA, SOUTHERN CROATIA

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This short paper brings preliminary results of sedimentological study of Dubci bone-breccia site as an update to former research. The study site is located on the saddle between the mountains Omiška Dinara and Biokovo 404m a.s.l. The site was discovered already at the end of 19th century during road construction between Makarska and Zadvarje. The road cut exposed a cross section through a paleocave covered with coarse clastic sediments in alternation with paleosols. The Dubci site is of Cromerian age, one of several Lower Pleistocene sites in Dalmatia with bone breccias rich in fossil skeletal elements of macr mammals and micro mammals. Detailed geological context of the Dubci site was first described by Malez. More recent study of the site indicates even more complex origin of this paleocave and associated sediments, which comprise three sedimentary units. New sediment samples revealed presence of well preserved ostracod fauna, glass spherules and microtectites of probable impact origin, black glass shards, rare microscopic fish bones, benthic and pelagic foraminifers, and particles of various allochthonous lithologies, which all give new input for interpretation of the Dubci site.
Keywords: Croatia, Early Pleistocene, paleocave, cave sediments, coarse clastic sediments, paleosol, spherules, shards, foraminifers, ostracods, geosite

GLACIAL SEDIMENTS IN DINARIC KARST

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Dinaric karst in Croatia hosts, among other, rather extensive sediments of Pleistocene age, some of which are interpreted as of glacial, proglacial and periglacial origin. The detailed field study of northern Adriatic islands and Croatian eastern Adriatic coast, as well as southern Velebit Mt. revealed presence of ice derived sediments, sediments reworked by glacial meltwaters, glaciolacustrine sediments, as well as glacial, periglacial and glaciotectonic features. The age of these sediments is so far constrained only by ostracod fauna found in associated lacustrine sediments which yield an Early Pleistocene age. More

precise age determination may become available by dating of tillite cements, which at the moment of writing were not completed.
Keywords: Adriatic, Dinarides, glaciation, Pleistocene sediments, diamictons, moraine, kame-terrace, eratics

EXAMPLE OF RECENT SUBAERIAL DIAGENESIS

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The Castañar de Ibor Cave comprises a wide variety of speleothems which are undergoing recent diagenetic processes. Dissolution, micritization, inversion, cementation and dolomitization are the main ones. These processes are occurring now and in recent times and their study offer a good model to understand ancient diagenetic processes in meteoric environments. The vadose waters are rich in Mg because of the dissolution of Precambrian dolostones, favoring so the formation of aragonite and dolomitization. Changes in the water composition of the vadose fluids caused by possible variations in the climatic regime could control the diagenetic path.

HUNTITE, DOLOMITE, MAGNESITE AND SEPIOLITE IN MOONMILK DEPOSITS: CASTAÑAR CAVE, SPAIN

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Castañar Cave, located in Cáceres, Spain, was formed by dissolution of Precambrian dolostones and magnesites interbedded with shales and grey-wackes. The cave contains a wide variety of speleothems, being the eccentric and acicular aragonite forms very abundant. Moonmilk deposits are found covering the tips of these aragonite speleothems and forming part of crusts that develop on the cave floor and walls. They are white globular and pasty deposits that can contain up to 35% water, showing more crumbly aspect when they are dry. The most important mineral of these deposits is huntite $CaMg_3(CO_3)_4$, together with dolomite, magnesite and sepiolite. One of the main features of moonmilk deposits is the grain size, extremely small. In this cave, huntite, magnesite and sepiolite appear as micritic masses, while dolomite forms spheroids and dumb-bells of 50-300 μm. SEM images show that huntite is composed of flakes or platelets less than 5 μm size randomly disposed and magnesite forms rhombohedrons of 1-10 μm. Sepiolite forms fibres few nm wide and some μm long that are grouped forming films that intergrow with huntite, dolomite and magnesite. The magnesium needed to form these Mg-rich minerals is provided by the dissolution of Precambrian dolostones and magnesites in which the cave developed. Additionally the sequence of precipitation of calcite, Mg-rich calcite, and aragonite in the speleothems provides the necessary increase in Mg/Ca ratio in the residual water to reach the necessary oversaturation in the minerals.

Textural relationships and chemical studies also reveal that metastable minerals as aragonite or huntite could act as precursors for the formation of dolomite. In this last case, the

excess of Mg produced in the huntite-to-dolomite transformation or in the dissolution of huntite could be used in the formation of sepiolite.

THE IMPACT OF ROCK BLASTING ON CAVE VELIKA PEĆA

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Cave Velika Peća is situated near Grabovac village, which is positioned in the background of mountain Biokovo on the part of motorway Šestanovac-Zagvozd. The cave is a natural speleological object which is important archeological site. Velika Peća consists of limestones, upper Cretaceous.

On the part of motorway route above the cave test blasting was made with the purpose of evaluating the possibility of damage beginning in limestones in the cave and measuring seismological impacts of rock blasting with calculation of permitted quantity of explosive charge.

The route of motorway Šestanovac-Zagvozd which is in construction passes close to the cave. The technology of excavation includes drilling and rock blasting. The nearest distance of final slope from the cave is 10 m. The impact rock blasting and propose drilling rock blasting parametars for the future was determinated towards execute measuring of oscillation velocities on the occasion of test rock blasting. On the occasion of rock blasting oscillation velocities of the ground were measured with transport seismographs and relative deformations with LVDT sensors. Six points of monitoring for a test blasting field MP-1 were placed and eight points for a test blasting field MP-2. Quantity of the explosive charge of blasting field MP-1 was 25,5 kg and for a MP-2 36,0 kg with the sequence of milisecond delay blasting. During the both rock blasting measuring oscillation velocities of the ground in a points of monitoring in the cave were under the permitted standard DIN 4150. LVDT sensors did not record any deformations on the measured points on the limestones of Cave Velika Peća. Intensity of shaking caused by rock blasting was determinated by measuring the oscillation velocities of the ground in a points of monitoring. Permitted oscillation velocities of the ground for the cave is middle value of a permission velocities between the historical monument and the apartament v_{per}=1,0 cm/s. Quantity of explosive charge was determined according to permitted oscillation velocities of the ground v_{per}=1,0 cm/s for a continuation of blasting works on the part of motorway route above the cave. Applied standard is DIN 4150 with frontier permission of oscillation velocities from v_{per}=1,0 cm/s.

Keywords: limestones, rock blasting, seismological impacts of rock blasting, relative deformations, archeological site

HYPORHEIC FAUNA FROM RIVER SEDIMENTS OF THE SOMEŞ RIVER BASIN (TRANSYLVANIA, NORTH-WESTERN ROMANIA)

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Biodiversity in hyporheic habitats (interstitial water habitats in river bank sediments) has been studied on the Someşul Cald (Warm Someş) and the Someşul Rece (Cold Someş)

rivers (north-western Romania, Transylvania), from March to October 2004. pH and conductivity were measured monthly at each site, and animals were collected with the Karaman-Chappuis method and by filtering water through a 250 µm planktonic net. The relative abundance of the well represented hyporheic invertebrates (oligochets, nematods, and insect larvae) was higher in the Someşul Cald interstitial habitats than in the Someşul Rece. Special attention has been given to the water mites (Acari, Hydrachnidia), cyclopoids (Crustacea, Copepoda, Cyclopoida) and oligochets (Annelida, Oligochaeta) due to their role in the hyporheic communities as shown in literature. Nine water mites and five cyclopoid species were identified in five sampling sites of the two rivers. Their higher diversity was recorded at two stations on the Someşul Cald river: Someşul Cald gorges and Doda Pilii. The cyclopoid *Diacyclops disjunctus* is a new record for Romania. As for the oligochets, 17 species were identified and their higher diversity was recorded on the Someşul Rece river. The CCA statistical analysis showed that presence of some water mites and cyclopoids species can be associated with measured chemical parameters (ph, conductivity). The PCA and DCA analyses show similarities between stations and the dominant taxa in some samples.
Keywords: hyporheic communities, river sediments, water mites, cyclopoids, oligochets, biodiversity, statistical analyses

SEDIMENTARY STRUCTURES AND MOVEMENTS OF THE CAVE ENTRANCE SEDIMENTS, EXAMPLES FROM CAVES IN SLOVENIA

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Clastic autochthonous cave sediments, boulders, gravel and finer particles are in caves often locally moving or are displaced and arranged in different sedimental structures, relief forms or can shape the whole cave passage floor.

The most important and distinct are such features caused by cryogenic processes. They are formed by cyclic freezing and thawing of the water in the sediments. These processes were not limited only to Pleistocene cold climates or on caves in high altitudes. They are present now in caves in lower positions where temperatures in winter drop below 0ºC. Cryoturbatic features are best expressed in vicinity of the cave entrances, but sometimes we can find them deep in the underground.

Recent ground upward movements 5 –20 cm of selected stones were measured in Skednena jama in elevation 450 m a.s.l., and Potočka zijalka in elevation 1630 m Vertical movements are also causing horizontal shifting of the particles down dip. This is morphologically important, and it levelled the whole cave floor bottom to even dip.

Observations from Postojnska jama, Snežna jama na Raduhi and Bestažovca show the differences in the cave floor morphology between frozen and unfrozen part of the cave and can help to reconstruct former cave morphology and closings of the entrances of some caves.
Keywords: cave, sediment, morphology, cryoturbation

KARSTIC HYDROLOGICAL ECOSYSTEM OF CEMERNICA MOUNTAIN, WESTERN SERBIA

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The territory of the Republic of Serbia is characterised by vast karst terrains (30% of its total territory). Sets of various ecosystems have been formed on such significant areas, representing almost untouched "pearls of nature". Abundance in water, hundreds of distinctive sorts of flora and fauna, fresh air and other climatic factors arouse growing interest in these terrains, not only from scientific point of view, but even more from economic, and tourist industry view, as well. Bearing in mind that more than 70 karst springs are used for the water supply of towns in Serbia the sustainable development of karst hydrological ecosystems is a high priority in further development. One of such karst terrains is Cemernica Mountain in Western Serbia.

The complete Cemernica mountain karst aquifer is dealt with in this paper. Hydrogeological investigations and the clarification of hydrological ecosystem, water flows across and through Cemernica mountain represent a fundamental element both in the further development of ecology and environmental protection on this mountain.
Keywords: hydrogeoecology, water balance, water quality, karst

SIGNIFICANCE OF THE TOPOGRAPHICAL MEASUREMENTS PERFORMED BETWEEN 2006 AND 2007 FOR ANALYSING THE MORPHOLOGY OF THE COLLAPSE SINKHOLE ESTABLISHED ON THE ANTHROPIC SALT KARST FROM OCNELE MARI, ROMANIA

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The Field No. 2 from Ocnele Mari region, in the Vâlcea County, Romania, was an important salt exploitation from 1970 to 1991, using dissolution to produce brine. The brine was send by pipelines to adjoining chemical works. By means of echo measurements taken in 1993 and 1995 by SOCON (Sonar Control Kavernenvermessung, Germany), disproportional large voids were detected. The improper management resulted in a gigantic cavern of 4 million m^3, filled with brine, with a diameter of approximately 350 m - one of the largest caverns in the world. This cavern was linked with the acceleration of karst processes by human impact.

In 2001, the cavern collapsed and it formed a very large sinkhole, with a diameter of 300 m on E - W direction and 260 m on N - S direction. The brine evacuated on this collapse has caused the contamination of the river that crosses the Ocnele Mari region. In 2004 and 2005, similar events have enlarged the sinkhole. Since the cavern extent is still larger than the sinkhole dimensions, the morphology of the collapse sinkhole is currently very dynamic. The latest topographical measurements, made outside and inside the collapse sinkhole, gave us its new outline and the impact of this extinction on the residential area.

SEDIMENTOLOGICAL CHARACTERIZATION OF THE CAVE DEPOSITS IN THE GABAL CRYSTAL, EGYPT.

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The Western Desert of Egypt is the largest hyper arid area in the country, but the high amount of cave deposits especially in the central part of the desert indicate the huge amount of water in this area in old pluvial periods (during Pliocene). At Gabal Crystal there are several types of cave deposits, the unroofed caves shows several types of sediments with different forms. Cave deposits and sediments have different types and shapes, from fine sands, coarse sands, and organic reach sediments. The heavy metal analysis for the sediments, indicate very low organic content, so the caves are not inhibited by any animals or human. Clastic cave deposits also indicate the direction of water flow into the caves, by the use of structures formed by current like bedding and cross bedding. The cave deposits of Gabal Crystal represent an important key to the paleogeography and karstification process that have been the main process during old pluvial periods in Egypt.

INTERREGIONAL COMPARISON OF KARST DISTURBANCE: WEST-CENTRAL FLORIDA AND SOUTHEAST ITALY

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The karst disturbance index (KDI) consists of 30 environmental indicators contained within the five broad categories: geomorphology, hydrology, atmosphere, biota, and cultural. The purpose of this research is to apply the KDI to two distinct karst areas, West Florida, and Apulia, Italy. Through its application, the utility of the index can be validated and other important comparisons can be made, such as differences in the karst legislations implemented in each region and effect of time exposure to human occupation to each karst terrain. Humans have impacted the karst of southeast Italy for thousands of years compared to decades in west-central Florida. However, west-central Florida is more populated than southeast Italy establishing differences in the scale of human occupation between the two studied areas. These two differences allowed for the determination of whether length of human occupation or population density is most influential in the anthropogenic destruction of karst terrains. Similarly, Italian karst is more diverse than the karst found in west-central Florida, aiding in the evaluation of the applicability of each KDI indicator through the application of the index in distinctly different karst terrains. Overall, major impacts for southeast Italy include quarrying, stone clearing, and the dumping of refuse into caves, while west-central Florida karst suffers most from the infilling of sinkholes, soil compaction, changes in the water table, and vegetation removal.

SPECIES RICHNESS IN SEDIMENT-FILLED POOLS AND DRIPS IN CAVES

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The epikarst fauna was studied in two caves of Padurea Craiului Mountains (NW Romania) during the period November 2005 – May 2006. The sampling from four drips and two pools was performed with a procedure which allowed continuous collection. The dominant component in terms of abundance within the faunal assemblage was copepods. In the focus of this study was the estimation of cyclopoid copepods richness from dripping water and pools filled with sediment and sampling completeness from a local point of view. Pools filled with sediment proved to be the highest in biodiversity and abundance. Statistical analyses were performed using EstimateS version 7.5 software. Based on species accumulation curves and Chao estimates of total diversity it was determined that 7 months of sampling period was not sufficient to identify all expected species in drips and pools from Ungurului cave. On the contrary in the case of Vantului cave three months of sampling from two drips and one pool were proved to be enough to reach the plato of all expected number of species. This work represents the first Romanian study which contributes to the understanding of ecology and biogeography of cyclopoid copepods in subterranean habitats. Results are in accordance with the recent study from Slovenia which showed that epikarst is a rich habitat for a wide variety of animals.

CRYSTALLIZATION PROCESSES AND SPATIAL DISTRIBUTION OF SPELEOTHEMS

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Caves are natural underground laboratories where crystal growth processes can be directly observed. In some situations perfectly developed crystals are available for detailed crystallographic studies (symmetry, intergrowths, habit, chemistry, structure, etc.). Cave minerals provide invaluable insights into the chemical and physical conditions existing within various cave environments. These studies help the specialists to understand and explain particular mineral associations, to reconstruct the crystallization processes, to establish the order in which various minerals/speleothems were deposited, and the system of links between physical factors of crystallization and the morphology of mineral aggregates in caves. Occasionally, the natural cavities provide a unique set of conditions that allow the deposition of a suite of exotic minerals. Many of these minerals are restricted to *only* a particular cave setting and were never found in the outside world.

Most morphologic, structural, and genetic features characteristic to speleothems are controlled by the type and dynamic of solution supply and by the location within the cave (ceiling, floor or walls) where speleothems form. It has been illustrated that the crystal habit of cave calcite is controlled by supersaturation and pH, whereas the fabric is controlled by flow rate. Therefore, changes in crystal habits and fabrics can potentially provide a record of water availability and its paleochemistry over the period that speleothems were growing. Given the importance of calcite speleothems in palaeoclimate reconstructions there is an outstanding need to better understand the links between crystal structure, fabrics, and their depositional environment.

CAVE TURBIDITES

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Turbidites are uncommon in caves, but are more common as palaeokarst deposits. Marine carbonate turbidites, called caymanites, are the most common cave and palaeokarst turbidites, but marine non-carbonate turbidites, freshwater carbonate turbidites and freshwater non-carbonate turbidites are also deposited in caves and preserved in palaeokarst sequences. One of the most complex sequences of cave turbidites occurs in the Wellington Caves Phosphate Mine in Australia. Cave turbidites form in ponded water in caves and may be triggered by floods and high intensity rain events. While caymanites are most likely to form during marine transgressions, they can be emplaced by tsunami. Freshwater cave turbidites are most likely to form in flooded hypogene caves located in the seasonally wet tropics and in areas with irregular high intensity rainfall events.
Key words: cave sediments, turbidites, palaeokarst, caymanites

PHYSICAL AND CHEMICAL RESEARCH IN VELEBITA PIT (CROATIA)

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Cave microclimate, water quality parameters and natural radioactivity were measured in Velebita pit (National park Northern Velebit, Croatia) down to the depth of -1000 m. The results were analysed as a function of the cave depth and geomorphological characteristics. We obtained two air temperature gradients dT/dh = -3.9 $\pm$ 0.2 ^{o}C/100 m and +0.25 $\pm$ 0.03 ^{o}C/100 m. The water quality parameters were measured in situ at 14 locations in the cave. pH of a water in the cave slightly goes down with the depth, and it is mostly between 8.0 and 8.3. The average value of specific electric conductivity is 182 $\pm$ 25 S, TDS is 120 $\pm$ 17 ppm and ORP is -5.5 $\pm$ 0.7 mV/100 m. The average value of radioactive radon concentration from the entrance down to a depth of -100 m is 181.6 $\pm$ 41.6 Bq/m3, and between -100 m and -400 m is 328.8 $\pm$ 66.4 Bq/m3.

FROM STABLE ISOTOPIC RECORD TO PALAEOCLIMATE RECONSTRUCTION

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The first two steps in a way to palaeoclimate reconstruction are a field and analytical works. After them we usually have many analytical profiles. The first question on this stage is. - How we could correlate our profiles?

First real problem with we have to pass in the correlation process - is a time scale construction. Very precise, high density stable isotope records are used usua1ly as a palaeoclimatic tools. As a time scale estimator a series of numerical dating resu1ts is used. The samples for dating are collected with less density then for stable isotope analyses. But for stable isotope record presentation an age of all analyzed points is needed. Age-depth model

construction is necessary for precise and reliable time scale of any stable isotope record. After this step we can arrange our isotopic data in a time scale.

How are the next problems. - Is a time scale accuracy good enough for precise correlations? What is the final record confidence bends?

First - usually every profile is based on a different number of analyses. It means that any isotopic curve uses different number of points. Basic question is how we can test if records changes reflect climatic or sampling density/position changes.

Second – every measurements has a uncertainty. Our analytical points are two kind of uncertainties: first from time scale and second from stable isotopes measurements. The question is how measurments uncertainties affect on correlation process.

On this poster I want to present some numerical methods based on MC-simulations and probability calculus, which can solves this problems.

ICE IN CAVES: A PECULIAR TYPE OF SEDIMENT IN LOW-ALTITUDE CAVES IN THE TEMPERATE REGION

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In this paper, we review the genesis, dynamics and paleoclimatic significance of perennial ice accumulations in low-altitude caves in the temperate region. We discuss the processes that act only in single-entrance, descendent caves, in which air circulation is restricted only to the cold season (so-called 'cold air traps').

Unlike surface glaciers, ice in caves forms mainly through the freezing of seepage water, and only to a far minor extent by snow firnification. While the former mechanism acts everywhere within a cave where air temperature is bellow 0°C and water is available, the later is present only near cave entrances, usually at the bottom of large and deep shafts, where snow accumulates and persists all year round.

The dynamics of ice is controlled by the cave's climate (and consequently external variations of air temperature and precipitation rate and timing), morphology and hydrologic parameters. The main controlling factor for ice dynamics is the amount of seepage water that, depending on temperature, can act as a favourable element for both the growing and melting of ice. Water input during cold winter and spring months leads to ice accumulation through freezing, whereas warm seeping waters in summer determine the melting of ice. In the absence of warm waters, the thermal inertia of the ice is large enough to offset the warming through conduction (no air exchange exists between the cave and the exterior in summer) and thus no melting occurs. Meltwater accumulated in summer freezes in late autumn and early winter under the influence of the sinking cold air, leading to a rapid build-up of ice.

By these mechanisms, thick ice blocks develop, containing a sequence of annually laminated layers, each layer being formed by a couplet of clear ice and sediment strata (organic matter, calcite, surface-derived soil, and pollen). This type of deposition makes the ice suitable for paleoclimatic studies, as a large variety of proxies for past climatic conditions are trapped within, one of the most important being the stable isotopic composition of the ice. By placing a stable isotope record measured in ice along a depth-age model for the same ice, long histories of past climatic changes can be reconstructed.

SEDIMENTS VARIABILITY ALONG THE ACTIVE PASSAGE OF VANTULUI CAVE, ROMANIA

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Vantului Cave is located in the northern part of Padurea Craiului Mountains, in western Romania. The entrance of the cave is situated at 320 m asl, and 19 m above the present day valley floor of Crisu Repede River. With its 54 km of passages, the cave is the longest in Romania, meanwhile being the largest labyrinth in south-eastern Europe.

The cave is carved in Ladinian limestones, overlain by Lower Jurassic age sandstones, microconglomerates and lenses of fireclay. It develops on four karstification levels (the lower one being active), with the main passages stretching parallel to the Misid Valley. It is the subject of numerous studies covering a diversity of topics (speleogenesis, morphology, mineralogy, biospeleology, climatology), being one of the best studied caves in Romania.
In this paper we presents the results of a study on the alluvial sediments located along the lower section of the main subterranean river (a 300 m long reach) and on some of the lateral passages. Granulometric and petrographic distribution of sediments was analyzed on samples collected on $1m^2$ square surfaces in the rivers bed, the thickness of each such surface being imposed by the size of the largest grains. These sites are distributed at equal distances along the river's course and at selected points imposed by the morphology of the passage (*e.g.*, restrictions, confluences etc). Additionally, morphometric characteristics of the active channel and the gallery were determined, and a detailed map of the channel, with morphologic features and talweg facies was plotted. The results of the analyses show a variable distribution of the sediments, this being influenced by the lateral input from tributaries as well as by the channel morphology. A normal distribution of sediments, similar to the ones found in surface rivers, was not observed. We suggest that this is due to more than one source for the sediments, as well as the influence of periodic floods of the passage. The study represents the first attempt for understanding the provenience of sediments and their subterranean behaviour.

PROTECTION OF LISINE WATERFALL (BELJANICA MT, EASTERN SERBIA)

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Karstic environment, including clastic sediments and speleothems are widely spread in the area of Eastern Serbia. The spring Veliko vrelo, which yield the most of water from southern part of Beljanica Mountain (50-2000 l/s), have created thick travertine sediments. Its thickness varies from 5 m to 25 m respectively.

As a result of its flow along Resava fault one of the most beautiful waterfalls in Eastern Serbia has been made. Waterfall is located near Lisine village and it became a tourist attraction in recent years in Eastern Serbia. It is protected by law as a Natural monument.

In spite of formal protection, its beauty had been affected when local villager living nearby decided to construct a fish pond. He has built a barrier upstream and has turn water away from waterfall, therefore travertine cascades temporarily dried out. Dry cliff became more fragile to the possible collapse.

Institute for Nature Conservation of Serbia immediately after, has intervened: Water has been returned to the original riverbed but minor damage has already been done. To

prevent similar cases of misuse of scenery for self-interest or selfish reasons certain steps toward protection of Lisine waterfall, should be taken in the future.

ANALYSIS OF PLANAR FEATURES IN CAVE GENESIS – EXAMPLES FROM THE TOTES GEBIRGE (NORTHERN CALCAREOUS ALPS, AUSTRIA)

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The Totes Gebirge is the largest karst massif in the Northern Calcareous Alps (NCA). It hosts several huge multiphase alpine cave systems of up to 125 km length and more than 1000 m depth. They consist of Upper Miocene galleries of (epi)phreatic genesis and younger vadose canyon-shaft systems. Morphologic evidence shows that at least some of the systems developed under epiphreatic conditions and hydrological behaviour in the "filling overflow manner" is likely.

We perform morphometric analyses on four types of planar features to reveal their influence on cave genesis: (1) Initial fissures (bedding planes, joints, and faults) are principal structural controls that enable subsurface karstification. (2) Inception horizons are a limited number of stratigraphic horizons, which favour cave evolution. (3) Cave levels are a horizontal accumulation of phreatic galleries at certain elevations which up to now were often correlated with palaeo base levels. (4) Palaeo water tables are slightly inclined planes that are inferred from morphologic evidence of speleogenetic phases such as crests of phreatic loops or canyon-tube-transitions.

The analyses reveal that (epi)phreatic cave conduits developed preferentially along vertical faults and only along a restricted number of bedding planes which is in accordance with the inception horizon hypothesis. Analyses of cave levels show distinct
peaks for each cave but it is hardly possible to correlate these elevation levels between caves of different parts of the karst massif. For some major caves, it was possible to identify palaeo water tables of speleogenetic phases that show inclinations of 1.5° ±1°. Therefore, we conclude that cave levels (strictly horizontal) indicate speleogenetic phases or palaeo water tables respectively, but they cannot be correlated with palaeo base levels or on regional scale. An exact correlation between cave development and palaeo base levels at the surface is only possible with inclined palaeo water tables of speleogenetic phases.

Another outcome of the study with regional relevance is that palaeo drainage of autogenic recharge was radial within the Totes Gebirge which is in contrast to observations from other plateaus in the NCA.

A MULTI-PROXY APPROACH TO USING CAVE SEDIMENT CARBON ISOTOPES FOR LATE HOLOCENE PALEOENVIRONMENTAL RECONSTRUCTION IN FLORIDA

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Cave sediments collected from Jennings Cave in Marion County, Florida were analyzed using a multi-proxy approach. Fulvic acids (FAs), humic acids (HAs), bulk organic matter, and phytoliths were extracted from the sediments for carbon isotope analysis to determine periods of vegetation change caused by climatic influences during the Late Holocene (č 3,000 years BP). Density analysis was also performed to compare physical sedimentary characteristics of the sediment to the carbon isotope records. The carbon isotope record ranges from -40‰ to -14‰, exhibiting variability of č26‰, within the different proxies, which indicates changes between C3 and C4 vegetation. Density analysis closes matches the FAs, indicating changes in the sediments during shifts in the vegetation regime. This likely indicates changes between a sub-tropical forested environment and more arid, grassy plains conditions.

These changes in plant assemblages were in response to changes in available water resources, with increased temperatures and evapotranspiration leading to arid conditions and a shift toward less C3 vegetation (increased C4 vegetation) during the MWP. The cave sediment fulvic acid carbon isotope record agrees well with δ13C values from a speleothem collected nearby that covers the same time period. Prolonged migration of the NAO and ITCZ affects precipitation in Florida and likely caused vegetation changes during these climatic shifts.

PALAEOMAGNETIC RESEARCH OF CAVE SEDIMENTS IN SLOVENIA IN 2007

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In 2007, sampling of cave fill for palaeomagnetic analysis was performed in several caves in the Classical Karst (SW Slovenia). Standard palaeomagnetic analyses were used (thermal and alternating field demagnetisation, magnetic susceptibility measurements, etc.). Paleomagnetic parameters (inclination, declination) indicate that the respective tectonic block has rotated since the deposition of karst sediments. The rotation differs in different time intervals of the infilling of cave passages and in different karst areas. Repeated sampling in some profiles, especially Divaška jama, Trhlovca, Markov Spodmol, confirmed that only high-resolution approach can ensure reliable results.

PHOSPHATE MINERALS FROM LILIECILOR CAVE, TRASCAU MOUNTAINS, ROMANIA - A PRELIMINARY STUDY

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Liliecilor Cave is located in the south-western part of the Trascău Mountains, approximately 25km from the city of Alba Iulia, Romania. Geologically, the area belongs to the Southern Apuseni Mountains, and more specifically to the Bedeleu Nappe. The 700m thick sparitic Tithonian limestone in which the cave has been carved represents a 'back-reef' type formation (Ianovici et al., 1976). This is the first study concerning the mineralogy of the 311m long cave, developed as a single straight passage with two large entrances. Due to the periodic existence of a bat colony the thick layer of sediments covering the floor is mixed with bat guano, which reacts with clay and limestone to form phosphate minerals. Two half-meter deep pits have been dug and sampled at different depths. The 12 samples containing phosphates are either variously colored moist earthy masses or hard nodules. XRD analyses indicate the presence of four phosphates, taranakite and fluorapatite being the most abundant and usually occurring at the top of the sediment sequence in the presence of calcite, muscovite and illite. Hydroxylapatite is found at intermediate levels, while brushite forms deeper in the sediment cover and is usually accompanied by gypsum. Sulfur oxidizing bacteria present in the guano deposit produce sulfuric acid, which contributes to gypsum formation, leading to formation of low-Ca phosphate minerals (Hill & Forti, 1997). Our results are not in perfect agreement with the general stratigraphic sequence of phosphate minerals forming in guano deposits (Hill and Forti, 1997), more detailed analyses and sampling at regular intervals throughout the sediment deposit, down to the bedrock being required.

CAVE TAPHONOMY

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Karst caves have favourable conditions for accumulation and preservation of bone remains.

In 1960-1967 Grigorii Bachynskyi developed the question about peculiarities of bone fossilisation of Vertebrates under different natural conditions. Fossil Vertebrates from Neogenic and Quaternary sites totally preserved bone structure. Inorganic component of modern and fossil bones is represented mainly with cryptocrystalline kind of carbonate-apatite, close to francolite. As longer is geological age of bone, as more this mineral is crystallized. The organic component (collagen) can be preserved in fossil bones of Quaternary and Late Neogene age; it abundance decrease with the increasing of its geological age. In Middle Pliocene bones collagen is almost absent. The caverns inside bones are filled up with calcite, iron and manganese hydrates, gypsum. In cave deposits carbonised bones prevail.
Bone material can appear in karst cavities by different ways. In cavities of different origin it can be concentrated and buried in different way. The taphonomical classification of fossil Vertebrates sites can explain peculiarities of known sites and to help to discovery new sites in caves and shafts.

The cave taphonomical type of palaeontological sites was divided by G. Bachynsky into sequence of taphonomical subtypes.

The subtype of pits and shafts. Usually pits and shafts work as traps. Animals fall into them accidentally. Bone accumulations are buried with clastic material and loam, sometime with snow and ice.

The subtype of ponor-caves and ponor-shafts. Bone material accumulated mainly inside cave alluvium, at the places of decreasing of stream speed.

The subtype of uncovered caves. Uncovered caves are the central subhorizontal parts of karst aquifer systems, divided from ponor and spring parts with different deposits. Vertebra bone accumulations occur by different ways.

The subtype of spring-caves. Bone accumulation formed also in different ways. Sometime bones are included in cave alluvium and are waterworn.

Subtype of rock abris (grottoes). Bone accumulations are mainly of zoogenic and anthropogenic origin.

This classification was used during long time, but now it needs some development.

On the assumption of our experience of palaeontological and archaeological investigations in caves of the Crimea, Urals, Carpathians, Podillja, Turkey, Pamir etc, all taphonomical sites in caves can be divided into gravitational, zoogenic, anthropogenic (definitely the anthropogenic type can be included into zoogenic) and redeposition subtypes.
Gravitational subtype associates mainly with vertical trap-caves and is concerned mainly with vertical forms like pits, shafts etc. The remains of trogloxens should predominate in such accumulations. It corresponds with subtype "of pits and shafts" by Bachynsky.

Zoogenic subtype associates with different morphological variants of caves. Bone accumulations concerned with activity of free moving animals (troglophils), mainly of predators, as well as rodents, bats etc. They consist of remains of carnivore's victims as well as from remains of predators themselves perished inside cavity. It concerned both predatory mammals and birds of prey.

Definitely the anthropogenic subtype can be included into zoogenic, because humans, especially on the early stages of evolution, carried out the same function in bone accumulation, as other predators. But looking from the position of anthropocentrism, we assert the originality of this type of accumulation.

Finally, the redeposition subtype is concerned with different transportation agents (approach gravitation and organisms) like fluids (water), wind (concerned mainly with pollen transportation), mudslides etc.

The specific examples of different types of bone accumulation in caves are described in the report.

CHARACTERISTICS OF CAVES AT THE VILLALUZ PARK, TABASCO, SOUTHERN MEXICO

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The Villaluz Park is a tourist destination located in the south of the Tabasco state, southern Mexico, and characterized geologically by outcrops of folded and faulted Cretaceous and Paleogene carbonates, Paleogene to Cenozoic clastic and igneous rocks. Apparently, most dissolution is concentrated along different permeability lithologic contacts and fractures associated to fold axis. Highly dissected and corroded haystacks (mogotes), dolines and caves characterize the karst geomorphology. Over 50 caves have been found and surveyed by local and the Caves of Tabasco Project (NSS) cavers. The approximately 4 m/year precipitation and the presence of a tropical forest vegetation favor epigenic speleogenesis. Hypogenic

speleogenesis is also suggested by five caves with brackish (sulfate, chloride, and/or H_2S-rich) springs. The overprinting of both processes result on varied and complex cave morphologies. The most distinctive characteristics of the H_2S-rich springs caves are: the rotten-eggs smell of H_2S; the white color water, due to colloidal sulfur; and the presence of gypsum paste and selenite crystals in the ceilings or walls, although elemental sulfur and chemoautotrophic microbial mats are commonly found too. The sediments in the anoxic H_2S-rich springs are autogenic (pyrite precipitation) and allogenic (micas, quartz, limestone). The few speleothems present in these hypogenic-spring caves are highly corroded, being inadequate to date the process. The brackish-spring caves and the distribution of other surface springs through the area points to a hypogenic speleogenesis regional extension. It is then possible that more caves had also a hypogenic origin, or participation, not apparent due to groundwater flow paths changes and the abundant precipitation.
A better understanding of the known hypogenic caves geological context, water chemistry and hydrology, plus a careful review of the cave geomorphological features is been done to precise the hypogenic and epigenic speleogenetic participation.

RELATIONSHIP BETWEEN KARST AND FRACTURING IN THE MIDDLE ATLAS CARBONATE AQUIFER (MOROCCO): A FRACTAL APPROACH

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The Middle Atlas reservoir is one of the most important aquifers in northern Morocco. It is mainly a fractured and karstified Lias limestone and dolomite. Fracturing is dense and has major influence on water circulation and storage capacity. The karst system is mainly superficial but important subsurface karstic springs (Bittit and Ribaa) plays a main role in water supply of important cities like Meknes (600 000 inhabitants). The 2D fracture pattern and the spatial distributions of superficial karstic forms from Ifrane region was separately and respectively analysed by fractal and multifractal analysis. The results show that the spatial organizations of both fracture intensity and karst features have a multifractal structure described by full spectra of generalized dimensions.

In the light of multifractals we analyse the links between fracturing and karst system geometries. The aim is to well describe and to understand the relationships between tectonics and karst process formation and evolution.

Keywords: Karst; fracturing; multifractals; Middle Atlas; Morocco.

HYDROLOGICAL CHARACTERISTICS OF THE PADEŽ STREAM AND THE REKA RIVER CATCHMENTS

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Understanding of interactions between hydrological and biogeochemical responses of catchments on rainfall events which is usually unclear from periodic measurements and requires tracing of the temporal dynamics of the processes. In order to understand the formation of hydrologic flow paths and the way how these flow paths affect stream chemistry, chemical measurements at time scales that correspond to hydrological dynamics are needed.

Conversely, the stream chemistry tracing enables us to decipher the hydrological processes. High frequency chemical measurements are also essential for testing hydrological models. Hydrological data alone are rarely sufficient to test the process assumptions embedded into a typical hydrological model. Both, hydrological and geochemical or other water chemistry time-series data are needed to identify appropriate model structures and constrain their parameters. Smaller streams reflect strong connections between hydrological processes of the rainfall runoff formation and biogeochemical processes in the catchment, consequently, the responsiveness of the streamwater chemistry to changed hydrological states is very high. In accordance with the analysis of hydrological factors it is therefore possible to obtain an insight into the changeable biogeochemical conditions which are reflected on the changed flux of nutrients with rainfall runoff from the catchment.

In the contribution, we present results of the measurements which have been carried out in years 2006 and 2007 in the scope of the project "Arrangement of the water supply for the Slovenian coastal region" on a forested catchment of the Padež stream in hilly area of Brkini. Detailed hydrological monitoring which included measurements of rainfall, meteorological conditions (air temperature, solar radiation) and discharges in the Padež stream and its tributary, the Suhorka stream, has been supplemented by periodical continuous measurements of streamwater chemistry (water temperature, pH, conductivity, dissolved oxygen concentration, ORP, nitrate concentration) in different seasons. Furthermore, we have measured the Reka river discharges along the stream at the stream section from Cerkvenikov mlin downstream during the dry periods in order to obtain an insight into the dynamics of the streamwater losses towards the inflow into the Škocjan caves.

Keywords: catchment hydrology, streamwater chemistry, nitrate flushing, high-frequency measurements

CONTRIBUTION TO THE KNOWLEDGE OF THE RACKING PROCESS 3D VISUALISATION ASSETS IN DYNAMIC STUDIES OF REALIGNMENT OF THE ENDOKARSTICS FILLS IN THE AVEN D'ORGNAC CAVE; FRANCE

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This contribution aims to understand the spatial and temporal arrangements in the establishment and operation of racking ("soutirage"). Previous studies in the aven d'Orgnac cave showed that the action of racking was registered in the morphology of stalagmites. The observation of polished sections from these concretions reveals that the action of racking is linked to the variation of tablewater. Some dating (U / Th) show that this phenomena was discontinuous during the last 40.000 years. Finally, the geomorphological map proves the general influence of racking in the cave. Then, how can we evaluate the volume of racked endokarstics sediments? Is it similar across the space and the time for each racking period? In order to restore this volume of clay, we are working on the information registered in the elbow of each translated stalagmite. As a matter of fact, the elbow shows the displacement of the stalagmite to racking. Thus, it contains a lateral translation (x, y) and altitudinal translation (z). Relating this information to a racking area, it may be possible to calculate a volume which was racked. To test this hypothesis, we conducted a survey of translated stalagmites with laser scanner (LIDAR). The volume of clay racked and its model of evolution in the past could be calculated with 3D processing.

Keywords: sediment endokarstics, clay, translated stalagmite, laserscan, 3D representation

THE IDENTIFICATION OF LAND SPONGES FOR FLOOD RISK REDUCTION IN UK (GLOBAL ENVIRONMENTAL ISSUE)

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Traditional wetland land uses have hitherto been able to absorb some of the impact of extreme weather events, especially flooding. Recent changes in land use and land developments have encroached into areas that have historically contained 'Land Sponges'. This has had a negative impact on the buffering capacity of the land against flooding.
The objective of this proposal is to develop and apply a land sponge model within a Geographic Information System (GIS) framework to:
- Model the location of different land sponge types;
- Analyse historic land use changes that have altered the flood risk;
- Describe their buffering flood capacity;
- Quantify the importance of sites and separate sites to be preserved from for development;
- Identify sites that can be returned to traditional land management methods of flood defence;
- Provide a decision-making tool for land managers, planners and other stakeholders.

Historically different types of land use and land cover have acted as buffers against flooding. These include sea marshes (e.g. salt flat meadows), wet grasslands, (flood meadows, washes, water meadows, grazing levels, wet heaths), swamps, marshes, and flood plain mires.

There has been a general trend of wetland loss and degradation in the UK since Roman times (Davison et al 1991; RSPB, 1993) as traditional buffers against flooding have been improved for agriculture or developed upon. Tollan (2002) notes that such changes (urbanisation, deforestation, and cultivation) result in increased flood frequency and severity because of reduced infiltration capacity, lower soil porosity, loss of vegetation, and forest clearing, meaning lower evapotranspiration. This has exaggerated the impacts of normal rainfall events in normal climate cycles. This situation is further compounded by predicted climate changes and proposals for the continued development floodplains (Hoojer et al, 2004), who concluded that "the most effective and sustainable reduction of flood risks could be achieved by reducing the potential damage (vulnerability) in flood-prone areas through adapted land use and spatial planning".

Technology-led solutions to this problem of flood risk management (e.g. barriers) may be effective in the short term but are expensive and represent a management strategy that avoids real choices without actually solving the problems in a long-term view (Middelkoop et al, 2004). By adopting such a Canute-like approach to holding back the tide, with respect to flooding, the factors contributing to flood risk are ignored. Bohm et al., (2004) note that floods and risk can only effectively be reduced if, in addition to technical measures, spatial planning regulates land use in flood-prone areas.

BURIAL AGE DATING OF CAVE SEDIMENTS FROM THE SOUTHERN CALCAREOUS ALPS, N SLOVENIA

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Speleogenesis and surface landscape development are linked processes which, especially in mountainous areas, are driven by interplay of tectonic uplift and climate-controlled erosion. In karst regions, gradual lowering of valley floors and local base levels by river incision or glacial erosion promotes cave development at lower elevations resulting in the formation of multi-level karst systems (Audra et al., 2007). Dating sediments from various cave levels can provide information about the pace of landscape development, and in particular valley incision rates, provided that a relative chronology can be established between the morphogenesis of the cave and the deposition of the studied sediments (Häuselmann, 2007).

Ages for sediments deposited over the past 5 Ma can be obtained by using the burial age dating method, which relies on the differential radioactive decay of the 26Al-10Be isotope pair. The two isotopes form inside quartz grains at or close to the surface of the Earth, under the influence of high energy cosmic radiation (Gosse & Phillips 2001). The dating method can be applied as long as (1) the investigated sediment contains quartz which was exposed to radiation long enough for the two isotopes to accumulate, and (2) the sediment was effectively shielded from further radiation at the moment of its deposition.

Our current project aims to compare valley incision rates during the Pliocene and Pleistocene over a N-S transect of the Eastern Alps, based on the age of cave sediments in both the Northern and Southern Calcareous Alps. In Slovenia, sampled locations include so far the Julian Alps (Spodmol pri Planini Jezero), the Kamnik Alps (Snežna Jama), and the Huda Luknja gorge (Huda Luknja and Špehovka caves). Additionally, a sample was taken from a cave developed in conglomerates in the Udin Boršt karst area.

CAVE SEDIMENTS - USES, PROCESSES, AND STORIES

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Caves, whether of karst or other origin, have the potential to transport, accumulate, and preserve a variety of detrital and chemical sediments. Humans have had an interest in these materials since prehistoric times, when deposits were mined for ritual or medicinal purposes. In the first century Plinius Secundus (77) made observations on the variation in color and processes of speleothem deposition in several caves. Cave deposits have served as critical agricultural resources, providing guano for fertilizer, and also as important military assets, providing saltpeter for gunpowder. These deposits are now valued for the scientific information that they contain, primarily of a paleoclimatic/paleohydrologic nature. In all cases, caves serve to "protect" deposits that otherwise might quickly weather in the terrestrial environment.

Detrital sediments are both allogenic (brought in from outside of the cave), and autogenic (developed within). The former includes mainly fluvial sediments, but can also

involve windblown and gravity deposits. Autogenic materials are mainly breakdown (incasion) but in some cases insoluble residues, including chert, are important. Neither class should be called "soil" because they do not usually fit this definition.

Chemical sediments are mainly present as speleothems, and are usually made of calcium carbonate. Gypsum is prevalent in settings that are dry, and many other minerals are known from caves. Chemical deposition has classically been attributed to drip water, which percolates in through the walls or ceilings. It has been recognized more recently that significant deposits can be generated during the actual cave forming process, such as the massive gypsum found in the Frasassi Caves (Italy) or Guadalupe Mountains (New Mexico, USA).

Sometimes the deposits are mixed together, but more frequently they develop in separate time phases, with clastic sedimentation occurring during cave growth, followed by speleothem deposition during stream abandonment. Biological activities can add, remove, or modify materials. Bone deposits are particularly important for paleontological study.

These sediments are all intriguing in themselves, but the major scientific applications are those that decipher the deposits as stratigraphic records. These records can then serve as a proxy for factors, such as temperature, rainfall, etc. The use of modern analytical approaches reveals information that was hitherto un-imagined.

A MULTI-DISCIPLINARY STUDY OF FILLING DEPOSITS OF DOLINES IN FAVERGHERA PLATEAU, BELLUNO, ITALY

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Two dolines of the Faverghera plateau in the Venetian Fore Alps, south of Belluno have been investigated from the point of view of the filling deposits. This small plateau is a sub-horizontal surface about 0.5 km^2 wide, located inside the northeastern slope of Mt. Faverghera (1640 m s.l.m.) hosting nearly 40 karst dolines partially filled by periglacial slope deposits. Topographic survey, electric resistivity tomography (ERT), soils and pollen analysis have been carried on. The structure of the dolines and the characters of the filling deposits indicate that the evolution of these forms has been controlled by the alternation of different climatic and environmental conditions during the Pleistocene. The results indicate that the dolines are not good traps, archiving only some of the climatic and environmental changes.
Keywords: dolines sediments, paleosols, pollen analysis, Venetian Fore-Alps.

TRANSPORT OF THE PESTICIDE ATRAZINE WITHIN THE LOGSDON RIVER, MAMMOTH CAVE, KENTUCKY

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Understanding the potential for karst aquifer contamination by sediment-sorbed pesticides is important for cave conservation efforts in agricultural landscapes. Research was conducted to test the hypothesis that storm-period transport of sediment-sorbed atrazine through conduit-flow karst aquifers depends on the magnitude and characteristics (particularly grain size) of surface-derived fine sediment inputs. In addition, the use of commonly measured water quality parameters

(turbidity and specific conductivity) to provide an easily measured proxy for the likelihood of atrazine contamination during the pesticide application season was evaluated.

Flow rate, water quality parameters and suspended sediment concentrations were measured in Logsdon River, a 10km karst conduit within the Turnhole Spring Basin. The Turnhole Spring Basin constitutes the largest karst aquifer within the Mammoth Cave System draining 240 km^2 and includes three major groundwater sub basins: Cave City, Pakota Creek, and Mill Hole which all discharge into the Green River. Logsdon River drains the Cave City basin, and is a vadose stream with a total drainage of 25 km and a base flow rate of < 100 liters/second. An acoustic Doppler velocity profiler mounted on the river bed measured flow depth and velocity for estimation of flow rates. The depth and velocity readings were used in conjunction with measured stream flows to develop discharge estimates using an index velocity approach. Water temperature, pH, specific conductivity, and turbidity were measured continuously with a multiparameter water quality sonde. Supplementary information on sediment concentrations were obtained from a laser diffraction sediment sensor. In addition, water samples for analysis of suspended sediment concentration were collected during flow events when turbidity readings exceed a threshold value.

Analysis of several flow events demonstrated that the Logsdon River reacts rapidly to precipitation events, with an initial flow of cleaner water and a secondary phase of more turbid water. Changes in specific conductivity and turbidity reflect the inputs of meteoric water surface derived sediment, as well as the mobilization of in-cave sediment. Levels of pesticide contamination can be correlated with these changes in water quality parameters, with adsorption to surface derived sediment as a primary influence on the measured atrazine concentrations in samples.

OFENLOCH CAVE SEDIMENTS

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In 1976, a big cave entrance 250 m above the Walensee in eastern Switzerland, and about 23 m high and 8 m wide, caught our attention. The ground ascending by 45° to the top and the rock partially faceted, motivated us to dig. The gallery, wide enough to work with a wheelbarrow, already had a length of 35 m, which had been cleared by hand after I had found a professor who was interested in the sediments. We were always fascinated by the different colours, the interbedded strata and their deformations.

Benjamin Urs Müller's PhD, written at the Swiss Federal Institute of Technology in Zurich, comes to the result that the sediment consists of very fine material consisting of the rock formations of the Churfirsten mountain range. By using palaeomagnetic and other studies, he also examined the geotechnical attributes of the sediments. Only a few calcite concretions were found. It is possible that the pressure of a glacial influence changed the sediment layers in the entrance area of the cave.

The begin of sedimentation in the Ofenloch has not been determined. The magnetic inverse Matuyama epoch began 780 000 years ago. The estimated age of the lower sediments is older.

This is only a very small overview of the Ofenloch sediments to stimulate the interest for more research. Although Müller's PhD already presents comprehensive results, there are still many open questions which could be explored by another PhD candidate.

HOW SPELEOTHEMS GROW

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A speleothem is a secondary mineral body which can be physically defined by its morphology and internal organization, without regard to its chemical composition or mineral species. A stalactite found in a natural cavity in a mineral mine may have an exotic chemistry, but it is still recognizably a stalactite. About 300 mineral species have now been identified in caves, but only three can be considered common – calcite, aragonite and gypsum. However these few minerals display a bewildering variety of speleothem forms. To understand why, it is necessary to study the physical aspects of the cave environment and how this affects the growth of individual crystals. This branch of genetic mineralogy is known as ontogeny and has mainly been studied in Russia. Ontogeny is the study of single crystals (mineral individuals), how these crystals combine as aggregates, and their growth as physical bodies.

The obvious environmental factor to consider first is the degree of supersaturation of the supply solution, but we find that this only controls the structure of crystal individuals. A low degree of supersaturation allows the slow growth of large spar crystals, whereas a high degree of supersaturation causes rapid nucleation of many small and complex individuals, often forming split crystals or dendrites. Structure does not tell us what causes different types of speleothem to grow in caves.

Most speleothems are mineral aggregates, formed from several (sometimes many) crystals of the same mineral species. The component crystal individuals do not simply grow together, they interact and compete for growth space and/or the supply of new material. This interaction between individuals causes a distinctive pattern of crystal boundaries to develop in the aggregate. This pattern is called *texture*. Texture describes the geometric aspects of construction of an aggregate and depends mainly on the characteristic (Curie) symmetry of the medium from which crystallization occurred. For example, the capillary film environment has conical symmetry because of the geometry of evaporation physics, so branching aggregates such as coralloid speleothems and frostwork are found here.

The many different speleothem types are classified not only by their internal construction, but also according to their morphology. Morphology describes the typical physical shape of a speleothem. Stalagmites, flowstone and draperies are the same type of aggregate and often form together in the same gravitational water environment. Because they have a different geometry of supply of the feeding solution, these texturally similar speleothems have a different morphology.

PALEOGENE KARSTIC FILLINGS OF SOUTHERN FRANCE; GEOLOGICAL DATA AND TIME CONSTRAINTS

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Large outcrops of Mesozoic limestone formations of SW and SE Massif Central borders (France, Quercy and Bas-Languedoc areas, the first one being the most extended and studied) were submitted to strong karstic processes at the end of the Cretaceous. The resulting deep underground nets were the place for intense water circulation and deposition of sediments from surface alteration, mostly clays and associated products, including vertebrate

remains. This represented a long duration of alternating filling and widening phases. According to the associated fossil data, the process was already active during the Early and Middle Eocene, then intense during the Late Eocene and most part of the Oligocene. It was almost un-active during Neogene times because of an extended lacustrine limestone deposition over the surface. Then the strong Plio-Quaternary erosion uplifted the Paleogene karst structures much closer to the surface, and reactivated the karstic process with new caves and fillings.

The tertiary faunas obtained along the last decades provided the evidence of natural evolutionary processes within long lasting specific lineages, among the best documented mammalian genera, families and orders. The increase of data and improved statistics made it possible to obtain more precise and confident results as regards the evolutionary condition in morphology and size among specific samples, and by the way to confidently display the natural populations along long lasting phyletic lineages. After previous studies performed mostly on rodents and ungulates, the most recent attempt is the one dealing with bats, a group well documented in karstic environments. From now this work provides a significant step ahead in biochronology, for a long time extent from the Middle Eocene to the Early Oligocene. In addition to the progress in paleobiology, the available biochronology is more precisely stated than in previous attempts, from an enlarged number of recorded localities and populational fossil data. This work step as expected further attempts will provide an enlarged checking and overview of involved geological and paleoenvironmental contexts, which include : the prospect for a better calibration of the events expressed by the sediments ; a surer reading of sedimentary sequences, as checking the exposed structures within fillings (either long continuous sequences, either disruptions, abnormal contacts, registered tectonic effects) ; the real time extent of faunal transition periods (e.g. the Grande Coupure event encompassing the Eocene – Oligocene boundary, as other significant faunal changes) ; climatic trends, etc. The biochronological correlation between faunas from open basins and those from paleokarst is confidently provided by the shared quadrupedal mammal taxa. The minerals developed within the clay fillings (calcite, apatite) offer the prospect of independent time and paleotemperature data, leading to a better calibration of the mammalian standard-levels scale, as well to a better appreciation of the environmental changes.

THE RELATIONSHIP BETWEEN CAVES IN KARST AREAS AND RELIGION – THE PORTUGUESE CASE

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Most of the portuguese known caves are in karst areas, which represent less than twenty five percent of its territory. The two main existent karst areas in Portugal, the so called Meso-Cenozoic Ocidental Edge and the Meridional Edge, are near or proximal to the shoreline, in an area which presently is facing a big concentration of population, this problem started by the end of the sixties of the XX century and is creating some problems concerning to the preservation of many karst sites like caves.

In many caves of these karst areas there are some ancient rituals, concerning religion, mainly from Christian origins, many of them are the so called "Senhora da Lapa", it is an issue that it has not been studied at all by the Portuguese scientists, and it has a big potential to develop.

This research represents the effort of the authors to promote other aspect of karst areas and could represent a big step for the preservation of some of these sites. Portugal still is a Christian country and to take advantage of this aspect to promote preservation of karst sites like these ones could be the only way to save some of the most beautiful places of the forgotten Portuguese karst places.

FRESH SPELEOTHEMES DAMAGES VERSUS ACTIVE FAULT MOVEMENTS IN SELECTED CAVES OF THE BOHEMIAN MASSIF AND WESTERN CARPATHIANS

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During geodynamic research of selected caves in the Bohemian Massif and Western Carpathians breaks affecting sinter decoration were found and documented. These failures dominantly occure along faults which predisposed genesis of main corridors in these studied caves: Západní, Pod Šeptouchovem, Rasovna, Sedmička, Plavecká, Driny, Slopy, Zbojnícka, Beckovská and Čachtická. Moreover, to observe the potential fault displacements along the cracks, we installed 3D-dilatometric gauges there. Registered displacements along discontinuities are very likely connected with changes in the recent tectonic stress field. Moreover, responses to last local earthquakes occured in the Bohemian Massif and Western Carpathians in 2005 – 2006 were registered too.

ELECTRICAL RESISTIVITY IMAGING OF COLLAPSE DOLINE FLOORS: THE KRAS PLATEAU, SLOVENIA

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Electrical resistivity imaging (ERI) is a widely used tool in geophysical surveys for investigation of various subsurface structures. In this study an ERI was conducted in some collapse doline floors, located in the Kras (Karst/Carso) plateau, Slovenia.

The results of ERI profiling in collapse doline floors show zones with important differences in electrical resistivity. The resistivity of the subsurface depends mainly on water saturation and chemical properties of pore water. The bottoms of collapse dolines show smaller resistivity as a result of retention of water by the sediment. On the slopes there are zones with more resistive carbonate bedrock due to lower porosity. The application of ERI revealed that the resistivity value for carbonate bedrock exceeds 1000 ohm-m. Loamy material has resistivity values lower than 150 ohm-m. For soil, weathered bedrock and scree the resistivity values are between 250 and 1000 ohm-m. Due to the lack of moisture active scree slopes without soil cover and vegetation have resistivity values higher than 1000 ohm-m. If scree is covered with a layer of soil and vegetation, resistivity values are approximately 500 to 600 ohm-m.

In all investigated collapse dolines we can clearly see the difference between slopes and floors. The slopes show highly resistive rock, which is limestone or scree, possibly

covered with weathered bedrock or a layer of soil or loamy sediment which display lower resistivity values. At the floors there are thick infills of loamy sediment and patches of slope material at the foot of the active slopes. Loamy sediment completely inundates original collapse doline floors. The depths can be higher than 30 m.

The origins of loamy material are not clear. On some collapse doline slopes are present traces of demolished cave passages filled with finer sediment and flowstone. It implies that loamy material originates from cave infill that appeared on the slope surface during or after the collapse dolines were formed. Similar floor level elevations inside many collapse dolines also suggest that the process that led to the sedimentation of the fine allochtonous particles from stagnant water was active across a wide area, not just locally inside isolated collapse dolines. Traces of aeolian transport can be found on quartz crystals in the fine grained sediment.

HOLOCENE HIGH FLOODS OF THE PLANINSKO POLJE, DINARIC KARST, SLOVENIA

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Planinsko polje is one of the karst poljes on the Classical Dinaric karst in Slovenia. It is situated within Ljubljanica River basin where eight karst poljes are situated. Planinsko polje is typical karst polje with karstic inflow and outflow. Annual floods cover the whole flattened floor of the polje and reaches depth of approximate 10 meters. Detailed investigations of Planinsko polje and the cave systems in the inflow part of the polje conducted during this investigation have revealed numerous traces in the surface morphology and sediments which do not correspond with the level of known floods that appear on the polje. Patches of allochtonous loamy flood sediments can be found in inflow part of the polje on surface and in the caves as high as 50 meters above the polje's floor.

On basis of fine grained sediment on the surface and in the caves of the inflow part of the polje was established that depth of the floods was as high as 50 meters. The radiocarbon date of 7589 +-65 BP was established for the last phase of flooding of the Planinsko polje.

ELECTRICAL RESISTIVITY IMAGING OF DIVAŠKA JAMA CAVE

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Results of Electrical resistivity measurements above known passages of caves and supposed filled segments of Divaška jama are presented.

Karst leveled surface Divaški kras is situated on SE part of the Kras plateau. The surface is at elevations between 420 and 450 m. At the edge of it there are sinks of river Reka which flows trough two caves, Škocjanske jame and Kačna jama cave from the sinks at 317 m to the terminal sump at 156 m a.s.l. Above these active caves there are segments of older caves that are located at a shallow depth below the surface and also numerous unroofed caves. They are segments of caves exposed to the surface due to denudation lowering which re-shaped them into the surface relief forms. They were filled with allochtonous clays, sands and flowstone which testify their cave origin.

Divaška jama is a cave in a shallow depth with only 10 – 20 m thick ceiling. The cave is simple, 15-20 m wide and 600 m long passage stretching in direction SW-NE. It on both

sides ends with sediment fill. Above it, on its SW side there is Trhlovca cave, while on the NE side no cave continuation is known. However, 400 m NE from its end there is a large unroofed cave which in type of sediments, elevation and size matches to Divaška jama and is supposed to be its continuation already transformed into the unroofed cave.

Electrical resistivity measurements were performed to confirm the filled connection of the Divaška jama, Trhlovca cave and the unroofed cave. For electrical resistivity imaging data collection was used SuperSting R1/IP earth resistivity meter. Application of the ERI method has turned out as appropriate for detailed investigation of subsurface structure with high difference of electrical resistivity.

Parts of roofless cave and parts of cave, which are filled with clay or sand, can be clearly distinguished from less resistive carbonate bedrock. On the other hand underground parts of the caves with huge chambers were not detected by ERI method as resistivity difference between voids and highly resistive carbonate bedrock is negligible.

MINERALOGY OF CAVE DEPOSITS ON SAN SALVADOR ISLAND, BAHAMAS

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The island of San Salvador, located on the eastern edge of the Bahamian platform, is home to a number of caves. The limestones on the island are carbonate eolianites which are relatively pure. Caves for this study fall into two categories: Pit caves and Flank Margin Caves. Pit caves form as a result of percolating meteoric water, which collects in epikarst, dissolving limestone. Flank Margin caves form on the distal margins of the fresh-water lens at the location where fresh water and seawater mix.

Based on the limestone's simple mineralogy, one would expect only calcite and aragonite speleothems to form. However, a preliminary study looked at deposits in 10 caves and found 14 minerals. The surprisingly diverse mineralogy of these deposits is due to the presence of bat colonies, sea spray aerosols, tidal fluctuations of seawater/brackish water in some caves, and microbiological processes acting in the cave atmosphere and the air/water interface in these caves.

Mineral samples from the caves include: speleothems, wall crusts, nodules, earthy material on the floor of caves, and corroded products recovered from walls or different cave formations. The minerals identified so far are: Calcite [$CaCO_3$], Aragonite [$CaCO_3$], Gypsum [$CaSO_4.2H_2O$], Celestite [$SrSO_4$], Cesanite [$Na_3Ca_2(SO_4)_3(OH)$], Ardealite [$Ca_2(HPO_4)(SO_4).4H_2O$], Chlorapatite [$Ca_5(PO4)_3Cl$], Fluorapatite [$Ca_5(PO4)_3F$], Collinsite [$Ca_2(Mg,Fe)(PO_4)_2.2H_2O$], Whitlockite [$\beta$-$Ca_3(PO_4)_2$], Hydroxylapatite [$Ca_5(PO_4)_3(OH)$], Brushite [$CaHPO_4.2H_2O$], Niter [$KNO_3$], and Nitratine [$NaNO_3$]. Measurements of pH, Eh, conductivity, temperature, TDS and CO_2 concentrations in the cave environment indicate the mechanism of deposition and the stability of the minerals (especially any unusual/rare minerals found). Isotopic analyses ($\delta^{18}O$, $\delta^{13}C$, and $\delta^{34}S$) should distinguish between abiotic and biotic processes resulting in precipitation. Further mineralogical analysis (X-ray, scanning electron microscope, and microprobe investigations) and geochemical analysis (major, minor and trace elements) provide detailed assessment of the nature of deposition.

CAVES OF MACIZÓ CHIMANTÁ AND RORAIMA TEPUY IN LA GRAN SABANA AREA (ESTADO BOLÍVAR, VENEZUELA)

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The paper describes the speleological discoveries of several international expeditions to the table mountains in Gyana Highland, in the border area of Venezuela, Brasil and Guyana. Three table mountains (tepuis) were attended – Macizó Chimantá, Kukenán, Roraima and we discovered more than 30 caves in total length of more than 30 km. After the last expedition, "Tepuy 2007", which scientific tasks were geological, geochemical and biological field research, the longest one – Cueva Ojos de Cristal is 16 140 m long and it is the longest cave in silicious rocks in the world. Nowadays, the 4.8 km long cave Cueva Charles Brewer with the hall "Gran Galería Karren y Fanny" (400 000 m3) and the passages of average 30 × 60 m, is the largest cave in quartzites in the world.

Keywords: caves, Venezuela, Cueva Charles Brewer, Cueva Ojos de Cristal, Chimantá, Roraima, speleology, tepuis, quartzite karst.

THE MINERALOGY OF A WEATHERING DEPOSIT (IZA CAVE, RODNEI MOUNTAINS, NORTHERN ROMANIA)

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The Iza karst system is located in the north-western part of Rodnei Mountains (Eastern Carpathians, North of Romania). Iza Cave (D= 3655 m, H=177m) is a lithologic contact cave with the entrance in limestones of Upper Eocene age. Its main passages are developed at the contact between the Eocene sedimentary series (conglomerates and limestones) and Precambrian metamorphic rocks. This geologic setting strongly influences Iza cave morphology, where larger passages are formed in the crystalline rocks, showing preferential erosion of the metamorphic basement.

The metamorphic rocks exposed by the cave consist of quartz micaschists with garnet, marbles and marble breccias. They were initially metamorphosed in the amphibolite facies and later on affected by a variscan retrograde metamorphism in the greenschist facies (Balintoni 1997; Strutinski et al., 2006).

Iza cave has few classic speleothems, calcite stalactites grown along faults and smaller fractures in the ceiling being the exception. However, due to the varied nature of the host rocks inside the cave, several peculiar cave deposits have formed. Wall crusts and small stalactites found along the main cave passage consist of goethite, jarosite and gypsum (Tămaş & Ghergari, 2003). Subaerial weathering of the quartz micaschists in this high humidity environment led to the formation of a particular deposit, up to 30 cm thick and covering a surface of more than 5000 m^2. Viehmann et al. (1981) were the first to study this deposit,

which they initially called "kaolin". They reported quartz and muscovite as main minerals, with kaolinite and illite as minor components.

In a new attempt to characterize the mineralogy of the weathering deposit, more than 50 samples taken from the cave were analyzed by means of X-ray powder diffraction, transmission and scanning electron microscopy, energy dispersive spectroscopy, thermal analysis and infrared spectroscopy. Our results show that three main phases form the heavy fraction, namely quartz, pyrite and muscovite crystal aggregates. Secondary iron minerals such as goethite, jarosite and hematite are a common presence at several levels. The fraction < 2μm consists of illite, kaolinite and jarosite as main minerals, with smaller amounts of montmorillonite, halloysite, hematite and gypsum.

DATING CAVE LEVELS IN RHONE VALLEY USING COSMONUCLEIDE 10BE AND 26AL, PALEOMAGNETISM AND BIOSTRATIGRAPHY: IMPLICATIONS FOR REGIONAL GEODYNAMIC FOR THE LAST 6 MY

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Recent studies led on the karst of Rhone Valley (South France) show several cave levels linked to Messino Pliocene eustatic cycle (Messinian Salinity Crisis). Our aim is to date those cave levels by coupling absolute and relative methods of dating. These methods are: cosmogenic nuclides of 10Be and 26Al, magnetostratigraphy (paleomagnetism), and biostratigraphy of micromammals. The results permit a better constraint of regional geodynamics (Alpine tectonics and Messinian Salinity Crisis).

MAJOR PASSAGE ELEVATIONS AND PALEO-WATER LEVELS AS INDICATORS OF RELATIVE SPELEOGENETIC CHRONOLOGY IN THE GUADALUPE MOUNTAINS, NEW MEXICO, USA

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Measurement of major passage elevations and paleo-water level markers in Lechuguilla Cave and Carlsbad Cavern, New Mexico, USA, has clarified the relationships between the caves and helped establish relative chronologies for several speleogenetic stages. Both caves contain paleo-water level markers consisting of various pool deposits, mineral stains and/or a calcite crust. Geologic surveys in Lechuguilla and parts of Carlsbad were done with a tripod-mounted Brunton compass, with maximum loop closure errors of about 0.04%. The tour section of Carlsbad and the surface connection between the caves was surveyed with a T-2 theodolite.

Surveyed passage elevations suggest a common timing for certain stages of sulfuric acid speleogenesis. Major passages in each cave, specifically the Big Room and correlative Left Hand Tunnel in Carlsbad and the Western Borehole in Lechuguilla, correlate vertically within 25 meters. Although it is unlikely that both passages were once part of the same system, the Left Hand Tunnel and Western Borehole apparently formed at approximately the

same time and elevation at the paleo-water table. It is possible that the offset between the two passages is either the result of tectonic shifting of this portion of the Guadalupe Mountains and/or the localized nature of sulfuric acid speleogenesis.

Water lines on passage walls indicate post-speleogenetic flooding. Within Lechuguilla the highest paleo-water levels on passage walls correlate vertically within instrumental error (roughly one meter), indicating that these water lines were formed after the most recent tectonic tilting of the Guadalupe Mountains.

Inlets for H_2S-rich water to Lechuguilla and Carlsbad help reveal the relative chronology of these two systems. Rising H_2S-rich water responsible for the formation of the Left Hand Tunnel and Big Room originated from below the Lake of the Clouds and similar deep rifts, whereas similar inlets in Lechuguilla are located at the level of Lake of the White Roses and Sulfur Shores, approximately 50 meters lower in elevation. This may indicate that inlets of H_2S-rich water to Lechuguilla Cave are more recent than those in Carlsbad or that paleo-inlets to Lechuguilla are simply less inundated with calcite wall deposits than those in Carlsbad.

KARST SEDIMENTS IN OF THE SANA RIVER DRAINAGE BASIN

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The river Sana basin is found in the north-west part of Bosnia and Herzegovina and is a part of the river Una basin. Karst relief in the researched area was created on melting carbonate cliffs, south-west from the imaginative line Bosanska Krupa-Sanski Most-Ključ-the river Pliva spring, segregated in the area of Manjača-Zmijanje and in some edging parts of Sana-Una Palaeozoic (Japra valley). Karst relief is presented in exokarst, endokarst and accumulative karst forms as well as karst hydrography. The river Sana is a tuff river from delta of Velijašnica stream (upper flow). Tuff mainly appears in river-bed of Sana, shaped in the so called tuff aits – which represent small tuff grounds and coverings. In the case of the river Sana, those under-water tuff sediments can grow up to size where they reach or overreach level of the water in the river. That way, tuff aits occur in the river-bed where vegetation can settle. In the researched area, pendant jewels are found in speleogic objects, and are very much expressed in the caves Hrustovačka and Dabarska (near Sanski Most).
Keywords: Bosnia and Herzegovina, river Sana, karst sediments, tuff

CLASSIFICATION OF KARST DEPOSITS – EXAMPLES FROM THE FRANCONIAN ALB (SOUTHERN GERMANY)

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Karst areas are characterised by typical hydrologic and geomorphologic features. Due to the geologic and landscape history they differ distinctly in their geological structures and sedimentary content. After corrosion has created local or temporal depocenters at the surface or the endokarst karst deposits can be accumulated within these cavities. On the example of the Franconian Alb, a karstic region showing limestones and dolomites of Jurassic Age in Southern Germany, karst deposits were studied at superficial outcrops and within several caves.

Clastic karst deposits formed at or near to the surface often exhibit allochthonous components and a wide range of petrographic attributes, mostly they show close relations to the specific geology of the surrounding area. They have to be interpreted as "pedo-sedimentary complexes". Characteristic of these deposits is the mixing of different components at which corrosive, gravitative, pedological and several sedimentary processes are acting.

By means of an actualistic approach a sedimentpetrographic differentiation of clastic deposits was made for the endokarst zone. First purpose of the study was the classification of cave deposits which did not exhibit relations to any forming process.

Cave deposits of the Franconian Alb are classified as follows:

Fluvial cave deposits (gravel, sand, silty sand / sandy silt, silt, clay) can be identified by their textural features or classical sedimentpetrographic attributes (e.g. sorting, roundness). Mostly, the assignment of a sedimentary facies is possible by field or laboratory data.

By gravitational action or slowly percolating water within small fractures clay and loam descend within the vadose karst zone. These sediments show a close relation to soils or the loamy cover resting upon the carbonate rocks at the surface.

Autochthonous sediments resulting from a gradual corrosion of carbonate rocks are formed within protected areas of open fractures where the transport of material is limited. Occurrences are of local extent. Final products of this decomposition are pure clay or loam consisting of insoluble residues. The enlargement of cavities creates interconnections and the sediments are removed or mixed with allochthonous components from the surface.

The breakdown of carbonate rocks from the ceilings or walls of caves can create individual deposits but mostly such material is incorporated into other sediments. Under the corrosive action of water these carbonate fragments will be removed especially within the phreatic karst zone.

Ultimately the present work focus both on a static view to the source resp. remainder of clastic material and a dynamic view to several acting processes. During transport through a karst area clastic sediments are formed and changed continuously by erosion, selection and resedimentation. Consequently, an individual clastic karst deposits represents a section of a cascade of different sedimentary environments interconnected between surface and the final depositional area.

SPELEOTHEMS AND THEIR HISTORICAL SACRED VALUES: TWO EXAMPLES FROM THE STATE OF MINAS GERAIS, BRAZIL

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Compared with international karst studies, those in Brazil can be considered relatively new. Since the first studies of Peter W. Lund in 1833, Brazilian karstology developed slowly for at least 175 years. The majority of scientific papers concerning national karst areas were produced by the end of the 50's to the 90's, and continue today. Greater emphasis should be given to the pioneering work of Kohler (1989) on the Karst Geomorphology of Lagoa Santa, Minas Gerais, the first of PhD thesis on the subject in Brazil. More recently caves are studied with respect to their use as temples as religious and ritual sites. In Brazil, by the end of the 17th century (1691), the pilgrim Francisco de Mendonça Mar inhabited a cave on the banks of the São Francisco River, giving rise to the Sancturay of Bom Jesus da Lapa, the oldest

registered example of religious use of a cave in Brazil. In other regions, as early as the 18th century, supposedly appearances of Our Lady occurred in the cities of Antonio Pereira and Vazante, State of Minas Gerais. In these two caves both water as well as some speleothems, are considered to be sacred. When a cave is made sacred, the fundamental opposition between good and evil, sacred and profane is established even though not all caves had experienced miraculous appearances. Some of them are just considered to be a divine work, and consequently worshiped. Even though the religious use of caves causes numerous negative environmental impacts, their cultural importance is enormous. This makes cave conservation a very difficult situation. The simple prohibition of cults is not acceptable because religious beliefs usually have positive impacts on regional economies and the pilgrims' quality of life. It's believed that what is should be done is to work towards maintaining such heritage sites that exist while discouraging the use of other caves for this purpose.

Key words: speleothems, sacred values, Our Lady of Lapa, religious tourism.

PALAEOTEMPERATURE RECORD IN THE UPPER PLEISTOCENE CLASTIC SEDIMENTS AT DIVJE BABE 1 CAVE

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Divje babe I Cave (450 m a. s. l.) is an important archaeological (Palaeolithic) and paleonthological site in Slovenia and central Europe. It is located in W Slovenia, 230 m above Idrijca River. Region has submediterranean climate. Horizontal cave was formed in Cordevol dolomite.

Our research is focused on interpretation of Pleistocene palaeotemperature conditions, due to the analysis of cave sediments. It is important that chronology of sediments at Divje babe I Cave is very well determined. Various chronological methods were performed such as independent dating methods (^{14}C-AMS, electronic spin resonance – ESR, U/Th), palaeobotanical research and analysis of faunal remains.

Methodology is based on an interpretation of the structural characteristics of the sediments, which we attempted to explain by changes in the palaeotemperature.

Profile of cave sediments was arbitrarily divided into 28 levels, which represent 12 layers. In each level, 300 to 400 clasts 10–40 mm large and all clasts 40–65 mm large from 20 dm^3 of bulk sediment were studied. Total number of clasts of fraction 40-65 mm ranged from 52 to at most 189 clasts. All studied clasts were divided into three groups:

- Sharp-edged clasts, which were only slightly weathered chemically in the sediment.
- Rounded clasts, which were rounded in the sediment mostly because of chemical weathering.
- Congelifracts: clasts which had been rounded in the sediment mostly because of chemical weathering and later shattered by frost action.

Main characteristic of congelifracts is that their morphology is a consequence of frost action. Relative abundance of congelifracts in each level was calculated. Levels in which there is a larger percentage of congelifracts presumably represent sediments deposited in a colder climate than levels, which contain a smaller percentage of congelifracts.

Interpretation is based on fact, that clasts are exposed to chemical and physical (frost action) weathering only in the cave topsoil, near the entrance. Topsoil represents exclusively relatively thin surface in which intensive post-sedimentary processes (such as weathering) take place. When topsoil sediments are buried with new sediment cover, all weathering processes stop and morphology of clasts remain preserved in the form previous to burial.

The rate of sedimentation alternates and it may cause some problems for our methodology due to low and high sedimentation rates and time resolution. First problem may be solved with datings, which indicate important gaps within sediments. Anyway some data may be missing and palaeotemperature interpretation is therefore incomplete.
Problem of time resolution is solved with exact definition of congelifracts. Only such rounded clasts, which have relatively fresh broken plains with sharp edges, were classified as congelifracts and used in determining palaeotemperature. There are many generations of clast with broken plains. Older generations were classified as rounded clasts, because they have relatively less fresh broken plains with rounded edges due to longer exposure to topsoil post-sedimentary processes (combination of physical and chemical weathering). Exposure time of congelifracts in all levels is supposed to be approximately equal, it is 1000±500 years. Such is also a maximal time resolution of studied profile.

On the basis of the 28 examined levels, a curve of relative appearance of congelifracts was produced. On the basis of the curve, we concluded changing palaeotemperature conditions in the profile (relative warm and relative cool periods), which covers the period from 80,000 to 40,000 years BP as shown by dating with the ESR method.
The relative appearance of congelifracts was compared with results of other, independent studies of palaeoclimatic conditions. Such are palaeontological and palaeobotanical research in Divje babe I Cave, palaeoclimatic record of Lago Grande di Monticchio Lake (based on pollen diagram), GRIP (Summit) palaeoclimatic record ($\delta^{18}O$ variation of Greenland ice) and sedimentological research in La Baume de Gigny Cave (France).

Comparison of Divje babe I palaeotemperature record with other palaeoclimate records and other climate indicators in the site (such as floral and faunal remains) shows clear accordance.

EVALUATING LANDSCAPE DEVELOPMENT AND KARSTIFICATION OF THE CENTRAL SCHWÄBISCHE ALB (SOUTHWEST GERMANY) BY FOSSIL RECORD OF KARST FILLINGS

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In the central part of the Schwäbische Alb (Southwest Germany) relics of the Bohnerz-Formation (claret to violet clay stirred with iron concretions) are widely spread in karst fissures and depressions. Considerable translocations into karst holes took place during land forming processes most likely caused by tectonics. Periods of translocation can be reconstructed through mammal fossils, that were admixed within the Bohnerz-sediments when they were flushed into karst fissures. For analyzing geomorphological processes and landform genesis such datable sediments provide time aspects that can be refered to distinct positions in relief and thus help to reconstruct landscape evolution through time. Focussing on that the distribution of fossiliferous sediments in the karst holes (mostly roofless caves) in the hilly Kuppenalb, around Salmendingen and in the Bärenhöhle (Bears Cave) nearby Erpfingen, are of outstanding importance. In both sites karst sediments are preserved today in exposed positions in isolated hills which tower above a lower and younger relief. Thus they provide a minimum altitude of the former land surface. Due to palaeontological data the Salmendingen karst holes are bound to the Upper Miocene land surface. Post Upper Miocene denudation by the river Danube caused the next deeper sedimentation relief-unit to which the Bärenhöhle belongs. Fossil molluscs and mammal bones and teeth confirm that this cave developed during the Upper Pliocene and the older Pleistocene over a period of more than 5 million years.

As a result, it can be shown that in the northern Schwäbische Alb both the present-day relief and the deep karstification mirrored in a large number of caves, developed essentially in the late Tertiary and early Pleistocene. Denudation and endogene karst corrosive processes were initiated by incising of the river Danube and its tributaries into the bedrock, causing gradual the lowering of the karst water table.

THE COMPARISON OF RED SOIL FORMED FROM CALCAREOUS ROCK UNDER THE DIFFERENT CLIMATIC CONDITION

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The red soils formed from calcareous rock under the influence of different climates were compared. Two different climates were chosen as follows: (1) The Mediterranean climate (Cs) on the Dalmatian coast and in South Australia. (2) The subtropical Monsoon climate (Cf) in the Southwest Islands of Japan.

The most effective difference between both climates is seen in summer: climate (1) has hot and dry summer, but climate (2) has hot and humid summer. These conditions resulted strongly in the property of soils. Especially high CEC appears under the hot and dry summer condition, but low CEC does under the hot and wet summer conditions.

Iron crystallinity was also examined in the both areas. It was made clear that it is related to the longer geological period of the condition. Because of difficulty of dating soil, dating of mother calcareous materials were studied. Irons were examined with three methods, and expressed as Fe_o, Fe_d and Fe_t. These were calculated as iron activity and iron crystallinity. The analyzed results of both factors show big difference under the different climate. The soils show high iron activity and low crystallinity in the Mediterranean areas, and low iron activity and high crystallinity in subtropical Monsoon areas. The crystalline iron of Mediterranean red soils are mainly type of Hematite. The crystalline iron shows mainly Goethite type in the humid subtropical Monsoon areas. Even the soils have reddish color and heavy clay in the both areas, the soil properties and the mineralization are different in the both areas.

GROUNDWATER RESEARCH FOR THE GROUNDWATER VULNERABILITY MAP OF THE "ŽUMBERAK-SAMOBORSKO GORJE" NATURE PARK

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There are 19 protected areas in Croatia: 8 National Parks and 11 Nature Parks. «Žumberak-Samoborsko gorje» Nature Park was established in 1999. on the grounds of the richness of its natural and cultural heritage. It covers approximately 333 km^2 of mountainous karstic terrain, rising from 180 to 1178 m above sea level with its highest peak–Sveta Gera (Trdinov Vrh in Slovenia). It is situated in the central western Croatia next to the border with Slovenia, between the Kupa and Sava rivers.

"Žumberak-Samoborsko gorje" NP is border part of the Dinaric karst. The main part of area is covered with carbonate rocks–mainly Triassic dolostones. There were investigated over 130 speleological objects with estimated total number of around 150.

There have been recorded 337 springs with very few data about their discharge and chemistry in the Park's GIS database. The Park's Authority started comprehensive hydrogeological research of its area at the beginning of the year 2007. It will be done in the next few years with a few stages to collect input data for the groundwater vulnerability map.

The first stage-groundwater recognition started and finished in the year of 2007. It resulted in 825 recorded mainly permanent springs. The following data were collected and measured through the field research: spring ID, usage, location, x ,y, z coordinates, lithostratigraphic description, type of the spring, discharge (l/s), water temperature (^{o}C), pH, ORP (mV), conductivity (µS/cm), TDS, oxygen concentration (mg/l), oxygen partial pressure (hPa), oxygen saturation (%), photographs. The data were stored within GIS database (ArcGIS).

The second stage started in February 2008 and will last for the next 2 years. It includes monthly groundwater sampling of 14 representative springs for stable ^{2}H and ^{18}O isotopes analysis, for chemical analysis of major cations and anions and field measurements of parameters as were in the first stage.

Groundwater tracing and tritium analysis should be included in the third stage if we find a way to solve financial matters.

The final stage will comprise all collected data through their analysis and vulnerability assessment.

UNSATURATED ZONE ABOVE THE OCHOZSKA CAVE (THE MORAVIAN KARST): TRACER TEST AND HYDRAULIC IMPULSE PROPAGATION

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A tracer test trough 70 m thick unsaturated zone above the Ochozska Cave was realized in 2007. Four tracers were used: fluoresceine, pyranine, sulforodamine B and rylux NT. About 50 sites in the cave were sampled manually and 6 automatically during one year. Two tracers (fluoresceine and pyranine) were detected, both in a very small amount (recovery about 0,01 % of injecteted fluoresceine).

Tracer test enabled to delineate the catchment area of the dripping site "E" and showed that subvertical flow prevailed in unsaturated zone (the highest deviation from vertical direction was 30^{0}). Concentration peaks of two detected tracers revealed two main period of epikarst saturation in 2007: March and July. Different tracer concentration records of two neighbouring dripping sites pointed out the complexity of the system. This tracer test clearly marked out the catchment area of the main dripping sites in the Ochozska Cave and brought new detailed information on the flow in unsaturated zone above.

SEDIMENTS IN CAVES OF THE TAQUISARA VALLEY: KARSTIC EVOLUTION, PALAEOCLIMATOLOGICAL AND PALAEOGEOGRAPHICAL IMPLICATIONS: A PRELIMINARY REPORT

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The karstic Taquisara valley is situated S of the Gennargentu mountains in the central-eastern part of Sardinia (Insular Italy). It flows from NE to SW and is developed between the altitudes of 780-700 m a.s.l.. The valley dissects the Jurassic carbonate table mountains Tacco of Ulàssai and Taccu Arba and almost reaches the Palaeozoic basement.

Many caves are known along the borders of the valley, mainly characterised by sub-horizontal passages often partially occupied by stream sediments. These fossil river caves are situated at different heights along the valley borders, especially at elevations of 775 m, 815-830 m , 850-870 m and 930-950 m a.s.l. on the SE side and 900 m and 950-955 m a.s.l. on the NW side.

In Genna'e Ua cave (952 m a.s.l.), on the NW flank of the valley, the impressive main passage has a length of 60 meters and is characterised by the presence of two underground collapse sinkholes that give access to an underlying cave level. The walls of these sinkholes reveal a >4 meter thick section of quartzite conglomerates intercalated with flowstone levels and overlying a 1 meter thick sequence of clayey sands. This sedimentary sequence is fossilised by an important flowstone. In two places this flowstone shows a thickness of more than 2 meters and is extremely corroded.

At Taquisara cave (954 m a.s.l.), 500 meters SW of Genna 'e Ua, the underground river passage shows important cave sediments and a complex geomorphological history with an active cave level 70 meters below. Cave sediments are represented by quartz conglomerates with minor phyllite fragments sometimes occupying entire rooms, successively eroded and transported to lower levels.

On the opposite side of the valley the big Serbissi cave (938 m a.s.l.) represents another underground river passage, most probably related to the same karstic cycle that generated the Genna'e Ua and Taquisara caves.

In the underground stream passage of the Sa Bulverera cave (901 m a.s.l.), located 50 meters below Genna'e Ua, concretions are corroded and sediment relics occur along the walls at heights of almost 2 meters, testifying that the passage was almost entirely filled with quartz conglomerates, successively removed during a re-activation period. The dimensions of this cave are less important and probably reflect a shorter period of formation than the one that was responsible for the huge passages of Genna'e Ua, Taquisara and Serbissi.

In the meandering Su Coloru cave (816 m a.s.l.), on the opposite side of the valley, the sedimentary sequence is more articulated, with alternations of quartz conglomerates and flowstones demonstrating cyclic erosion and depositional events. Dimensions are similar to those of Sa Bulverera suggesting a comparable time span of formation. At the same altitude another 5 interesting caves are known close by, documenting a stable base level.

Nearby, the active Cabudu Abba resurgence (800 m a.s.l.) hosts several sumps at 15 meters below the actual Taquisara valley floor, and sediments are characterised by quartzite-carbonate sands deriving from the Genna Selole Formation.

An analysis of valley morphology did not reveal distinct river terraces, but the cave floors testify to base level still stands.

Cave sediments have been carefully mapped and samples for cosmogenic nuclide burial dating with ^{26}Al and ^{10}Be were taken in the summer of 2005. Samples were collected from Su Coloru, Genna 'e Ua, Sa Bulverera, and Serbissi. All of the cosmogenic nuclide concentrations in the sediments were very low, indicating relatively high erosion rates in the sediment source area. Uncertainties in the burial ages are thus quite large. Of the four caves, the sediments at Serbissi proved undatable due to insufficient burial depth below the surface. Resulting ages are shown in Table 1.

Table 1. Cosmogenic $^{26}Al/^{10}Be$ burial ages of cave sediment

Cave	Burial date (My)
Genna 'e Ua	2.82 ± 0.50
Sa Bulverera	2.46 ± 0.53
Su Coloru	2.76 ± 1.17

The cosmogenic results indicate that all of the cave levels have similar ages, and date approximately to the early Quaternary. The regional geomorphology suggests that the four main cave levels almost certainly correspond to distinct Quaternary climatic periods during which the Taquisara river slowed its incision, enabling the development of horizontal cave passages, but the cosmogenic nuclide dating did not achieve sufficient precision to distinguish these various stillstands. The whole geomorphic evolution of these caves seems to be related to the beginning of formation of the Taquisara valley, which is believed to have occurred since about 3 million years ago

Further U/Th dating of speleothems and a more precise chronological placement of Pliocene basalts will allow a better delineation of the geomorphological evolution of the area.

RIVER INCISION BASED ON CAVE SEDIMENT ANALYSIS ALONG THE EASTERN ALPINE OROGEN – PANNONIAN BASIN SYSTEM TRANSITION ZONE

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Dating cave deposits via the Terrestrial Cosmogenic Nuclide (TCN) method allows a lower limit estimate of absolute cave ages and consequently an upper limit of relative incision rates of an adjacent river system. This study focuses on the area around Graz along the Mur river, which is located at the transition from the mountainous region, the so-called Highlands of Graz as part of the Eastern Alps to the Styrian Basin, being the western-most part of to the Pannonian Basin system.

First results of age dated cave deposits as well as geomorphologic manifestations using digital terrain modeling show a strong evidence of much recent (Pliocene and younger) actual drainage system characteristics. In this work various cognitions will be merged to emphasize the role of tectonic activity versus erosion driven incision in this area, particularly focusing on the karstified domains. This will provide an insight to further constrain the landscape evolution and the complicated uplift history respectively of that marginal area in space and absolute time in relation to ongoing basin inversion processes.

ARAGONITE IN SLOVENIAN KARST CAVES

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Aragonite is the high temperature polymorph of calcium carbonate $CaCO_3$ with the same chemical composition as calcite but crystallizing in a different crystallographic system. Aragonite has orthorhombic symmetry; single crystals are either short or elongated needles, steep bipyramids or flat prisms. It also occurs in a kidney-shape or is stalactitic. Aragonite properties derived from its atomic structure: the hardness on Mohs scale is 3.5-4, specific gravity 2.95, pearly lustre, colourless, white, pale yellow, translucent to transparent, cleavage unclear, fracture sub-conchoidal, brittle. Compared to calcite it is harder and with higher specific gravity. Aragonite is much less stable than calcite and with time its crystal structure internally changes to that of calcite while externally keeping its shape. It occurs in strictly defined physico-chemical conditions with alloys of Mg, SO_4 and Sr ions.
The most important factors influencing the aragonite dissociation before calcite are:

- Magnesium ions (Mg^{+2}) in solution (the impact of evaporation) solution acts as an obstacle at the growth of calcite crystal nuclei thus giving enough super-saturation to solution and enabling the aragonite dissociation;
- Strontium ion (Sr^{2+}) accelerates the formation of an aragonite crystal nucleus.

Aragonite is the second the most common cave mineral after calcite in Slovene caves. The most frequent shape are needle-like clusters found in major quantities in Ravenska jama near Cerkno, Kamniška jama, Jama pri Sv. Treh kraljih, Tajna jama near Polzela, Bevkova jama etc. In Ravenska jama there are especially nice clusters with even 10 cm long needles in clusters. Some of these needle-like crystal clusters in this cave have unusually thickened points which are a rarity for such clusters. Bevkova jama, discovered in 2005, near Ravenska jama is the richest finding-site of aragonite in Slovenia. The cave is 375 m long and it is formed in black Ladinian (Middle Triassic) limestone with dolomite breccias. In times past this cave was entirely filled up by clastic sediments with traces of paragenesis on the roof. The pebbles in the cave consist of keratophyre, porphyre, dolomite and limestone. Aragonite clusters, stalactites and stalagmites are located in the 80 m long passage. The most common shape of aragonite crystals in karst caves are fragile, snow-white tiny crystal coatings and aragonite flowstone in form of stalactites and stalagmites which may in the same speleothem alternate with calcite.