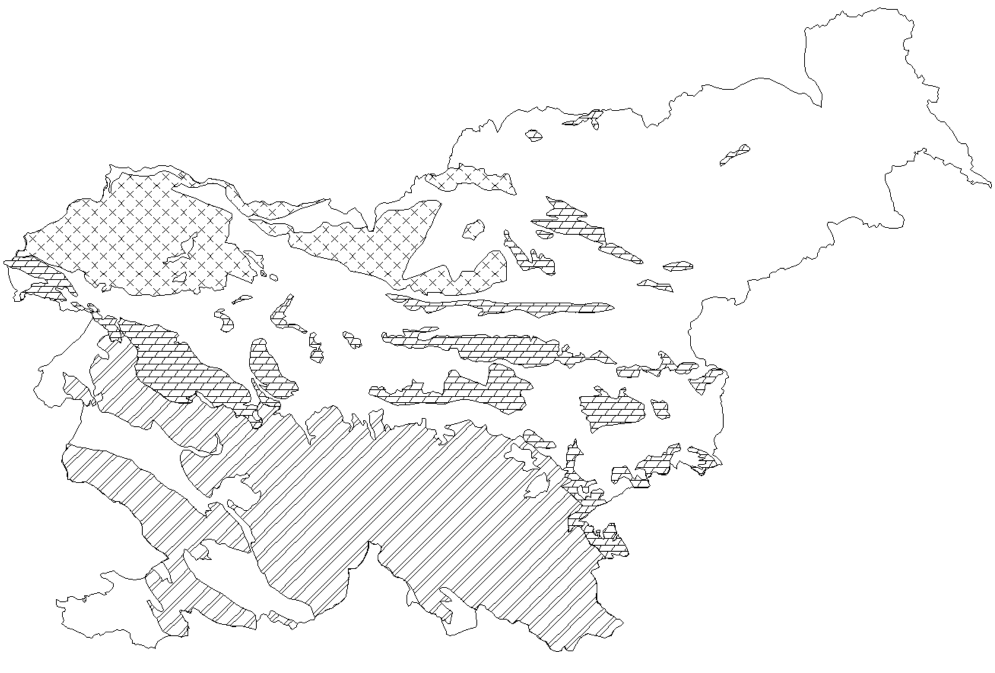
SLOVENIAN NATIONAL COMMISSION FOR UNESCO
SPELEOLOGICAL ASSOCIATION OF SLOVENIA
and
KARST RESEARCH INSTITUTE ZRC SAZU

10th INTERNATIONAL KARSTOLOGICAL SCHOOL
CLASSICAL KARST

TYPES OF KARST



GUIDE BOOKLET FOR THE EXCURSIONS
POSTOJNA, JUNE 2002

Organiser:
Karst Research Institute
Scientific Research Centre of the
Slovenian Academy of Sciences and Arts

By the financial support of the
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Guide booklet is only for the use at the Karstological School 2002.

PROGRAM

Tuesday, June 25, 2002

19.00–21.00 Registration

Wednesday, June 26, 2002

8.00–12.00	Registration
8.30–9.30	**Opening**
9.30–10.30	**Lectures**
10.30–11.00	Break
11.00–13.00	**Lectures and instruction for the excursions**
13.00–15.00	Break
15.00–17.00	**Lectures**
17.00–17.30	Break
17.30–19.30	**Lectures, poster presentations and slide–show presentations**

Thursday, June 27, 2002

8.30–19.00 **Whole day excursion**: Postojna – Bistra – Verd – Pokojišče – Begunje – Velike Bloke – Bločice – Loško polje – Dane – Zelše – Rakov Škocjan – Postojna.

20.00 **Solemn reception** is sponsored by the Slovenian National Commission for UNESCO and Commune of Postojna. Our scientific fellow Trevor Shaw PhD will be awarded by the National Speleological Society since he was selected as the 2002 Honorary Member Recipient. People attended all past nine Karstological Schools will be also announced. Mayor of the commune of Postojna will express his welcome to all the participantes.

Friday, June 28, 2002

8.30–18.00 **Whole day excursion**: Postojna – Grosuplje – Radensko polje – Lučki dol – Krka river spring (Krška jama) – Vir pri Stični – Dobrnič – Žužemberk – Ambrus – Podpeška jama – Požiralnik Raščice – Tentera – Postojna.

PROGRAM FOR THE WEDNESDAY, JUNE 26, 2002

8.00–12.00	Registration
8.30–9.30	**Opening**
	TADEJ SLABE, Head of the Karst Research Institute ZRC SAZU
	LUCIJA ČOK, Minister of Education, Science and Sport
	ZOFIJA KLEMEN–KREK, Secretary–General of the Slovene National Commission for UNESCO
	ANDREJ KRANJC, Karst Research Institute ZRC SAZU
9.30–10.30	**Lectures**
	FRANCE ŠUŠTERŠIČ, Basic types of karst in Slovenia viewed from the point of the pure karst model
	JURIJ KUNAVER, On the methods of classification of the types of the high mountain karsts, the case of Slovenian Alps
	JAROSLAV KADLEC, Amatérská and Demänovská caves: two largest fluviokarst systems in Czechoslovakia
10.30–11.00	Break
11.00–13.00	**Lectures**
	JIŘÍ BRUTHANS, Sediment load transport via cave systems in limestone and salt karst and related features of exo– and endo–karst
	MAŠA SURIĆ, Submarine karst of Croatia
	PAVEL BOSÁK, Blow hole cave: Unroofed cave on San Salvador island, the Bahamas, and its importance for detecition of paleokarst caves on fossil carbonate platforms
	GABRIEL LEŠINSKÝ, Some morphological microelements of karst relief detecting unopened caves in Slovak karst in relation to the mechanisms of thier natural and /or artificial opening to surface
	MILAN MARUŠIN, Geological conditions – factor of origin of two different cave system in two adjacent valleys (The Demänovská Valley and the Jánska Valley, the Low Tatras, Slovanika)
	Instruction for the excursions
13.00–15.00	Break
15.00–17.00	**Lectures**
	AUDRA PHILIPPE, Artesian caves in Provence (France). Specific morphologies and sediments

	SIMONA ŠUŠTERŠIČ, Two phase development of the upper Cerkniščica basin
	TIMOTEJ VERBOVŠEK, Cave forms and origin of the cave Pečina v Zjatih (Matarsko Podolje, Slovenija)
	PAVEL BOSÁK, High resolution magnetostratigraphy of speleothemes from Snežna jama, Kamniško-Savinjske Apls, Slovenia
	TIBERIU TULUCAN, Study about dolinas from Codru Moma Mountains (Romania)
	ALEKSEY BENDEREV, Development and characteristics of teh karst and karst processes in Vratsa Mountain (West Balkan, NW Bulgaria)
17.00–17.30	Break
17.30–19.30	**Lectures, poster presentations and slide–show presentations**
	CUCCHI FRANCO, Gypsum karst over karst in Iran (Zagros Mountains)

NOTES AND HINTS FOR THE PARTICIPANTS

- Meeting point for the excursions is at the parking place in front of the Business centre Primorka – PTC Primorka (No. 2 on the map).

- For the field trips suitable field shoes and clothes are needed. Personal lamp is also advisable.

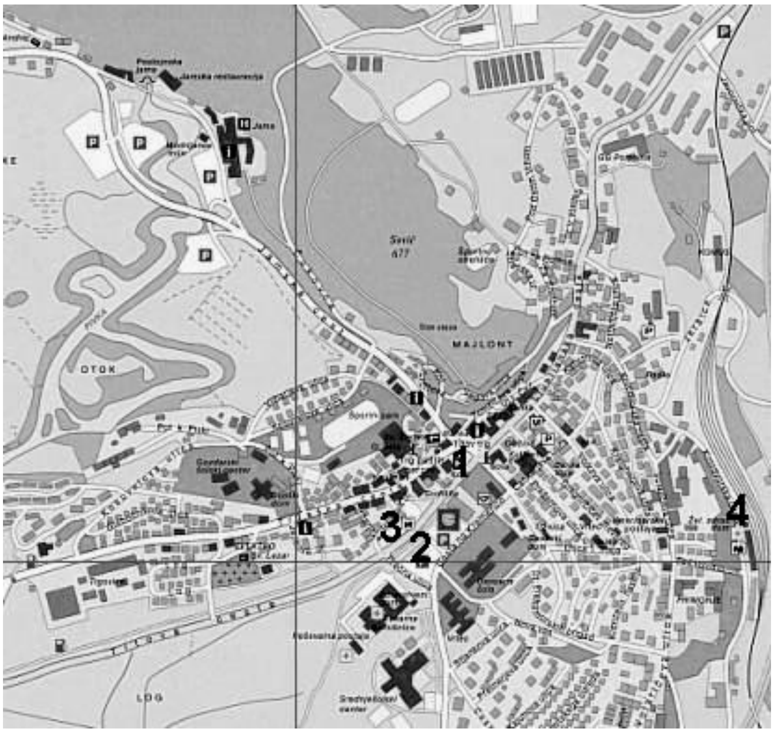
- Organiser will supply some beverages for the field trips. Take some additional beverages with you as well as some food. Time for lunch is also planned during the excursions.

- There is a possibility to have an evening slide–show presentations in the Institute's hall. Those of you who are interested, tell as soon as possible at the registration desk. Time and place are reserved on Wednesday, June 26, 2002. These slide–show presentations will be announced during regular lecture programme.

- **IMPORTANT**! The areas of field trips are populated by the infected ticks. Use repellent. Do not forget to check yourself carefully for the presence of ticks after the excursions!

- Do not hestitate to ask Institute's staff for more information.

POSTOJNA WITH SOME PLACES YOU MIGHT NEED



1-Karst Research Instite
2-Parking Place: Meeting Point for the Excursions
3-Bus Station
4-Train Station

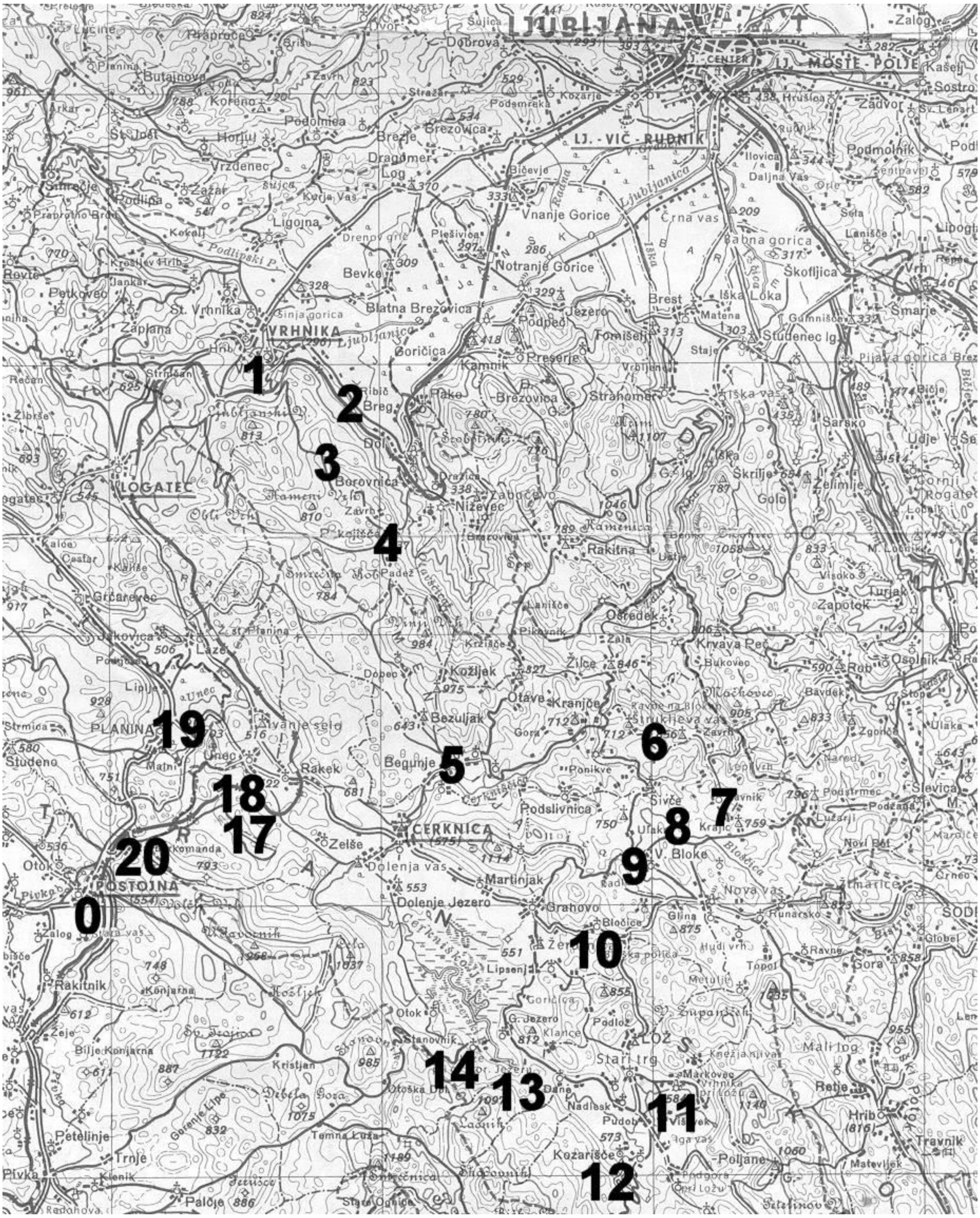


Fig. 1. Plan for the excursion on Thursday.

Legend: 0. Postojna, 1. Močilnik, 2. Bistra, 3. Temna Luža, 4. Pokojišče, 5. Begunje, 6. Štruljeva vas, 7. Andrejče, 8. Bloke/Berinjek, 9. Velike Bloke, 10. Bločice, 11. Loško polje/Vrhniški Obrh, 12. Loško polje/Mali Obrh, 13. Škrilje/Dane, 14. Čela gora, 15. Velika volčja jama, 16. Pogreščaki, 17. Zelške jame/Mali naravni most, 18. Veliki naravni most, 19. Planinska jama/vhod, 20. Mladika.
M 1: 200 000

TYPES OF NOTRANJSKA KARST
Thursday, June, 27 2002

Postojna – Bistra – Verd – Pokojišče – Begunje – Velike Bloke – Bločice – Loško polje – Dane – Zelše – Rakov Škocjan – Postojna

OVERVIEW

The area of the classical Karst in Slovenia is best considered as a triangle (Fig. 2.) with vertical that encompass the cities of Ljubljana, Rijeka and Gorica. One of its gravity lines runes from Ljubljana to Trieste and the present centre for karst studies, Postojna, lies close to triangle's centre of gravity. Traditionally, the area is subdivided into the karst or the Lower Karst, which lies SW of line of Gorica through Postojna to Rijeka, and High Karst, which covers the rest of the triangle.

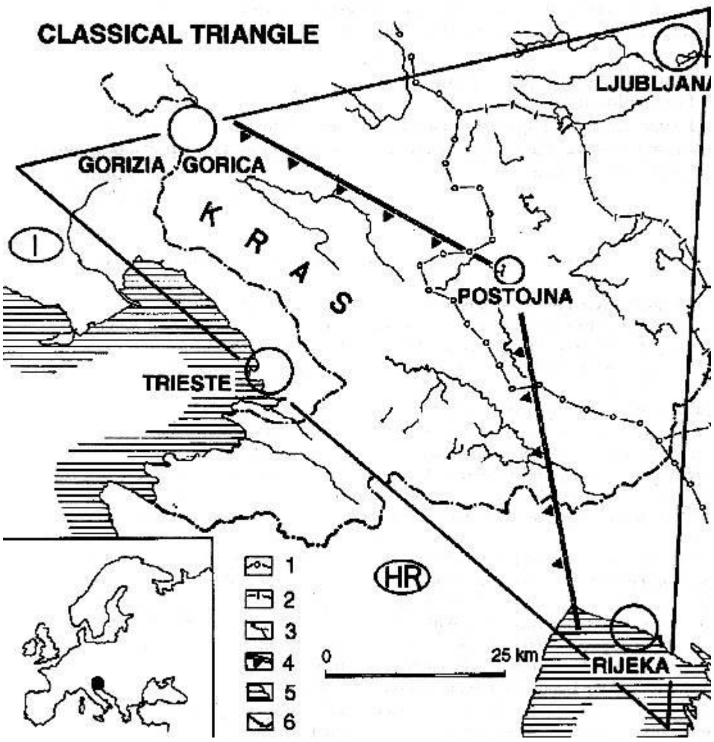


Fig. 2. The Classical Karst Triangle.

1 is the Adriatic – Black Sea divide. 2 is the karstic Ljubljanica basins limits within the Black Sea watershed. 3 is the sinking river and ponor. 4 is the southewest border of the High Karst. 5 is the Adriatic Sea coast. 6 is the international boundary (Klimchouk et al., 2000).

The eastern part of the High Karst is known popularly as Notranjska. It approximates to the catchment area of the sinking river Ljubljanica, which is the backbone of the area that drains into the Danube and onward to the Black Sea. The Ljubljanica (Fig. 3.) is widely known as a string of surface and underground stream segments, with the streams emerging onto closed basins that more or less fit the traditional view of poljes.

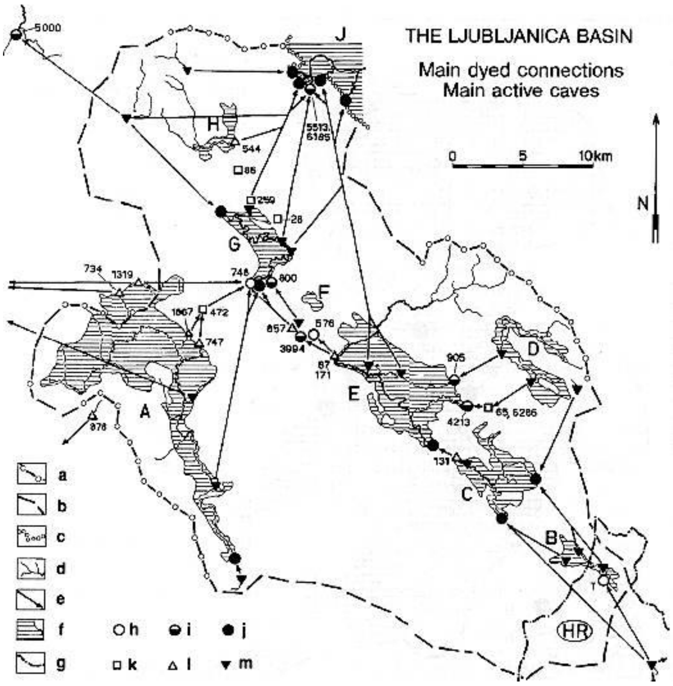


Fig. 3. The Ljubljanica Basin.

Main dye-traced connections, main active caves. **a** is well determined border of the karstic Ljubljanica catchment area. **b** is the approximate border of the karstic Ljubljanica catchment area. **c** is the outflow border of the karstiv Ljubljanica catchment area. **d** is the main surface streams. **e** is the traced connections. **f** is the alluvial floors of major poljes and the lower part of the Pivka Basin. **g** is the international boundary. **h** is accessible spring cave. **i** is the siphon spring cave. **j** is impenetrable karst spring. **k** is major water cave accesible inside the system **l** is accessible ponor cave. **m** is inaccessible ponor. A is the Pivka Basin. B is the Babno polje. C is the Loško polje. D is the Bloke (Bloško) polje. E is the Cerkniško polje. F is the Rakovško polje. G is the Planinsko polje. H is the Logaško polje. J is the Ljbljansko Barje (Ljubljana Marsh). Number of registered caves are also shown (Klimchouk et al., 2000).

The identification criteria for poljes arose primarily as descriptive terms and have related to a poplar classification since the very beginning. Later evolution of the poljes concept has been bound closely to a single genetic theory, rather than to observed facts and processes.

The connection between polje formation and Dinaric tectonics must be reconsidered in the light of modern knowledge of tectonics.
Horizontal caves (or fragments of them) appear in a well expressed clusters, up to several kilometres in length, a few kilometres in width, and some hundreds meters in depth. This pattern fits the notion of flow corridors with the a single tier, as defined by S.R.H. Worthington (Fig. 4.).
Features of at least two strings of clusters on both sides of the Idrija Fault can be correlated, and their displacements match the apparent displacement along the fault. This means that either the flow corridors were torn apart after formation, or similar structures, highly prone to similar karstification effects, had been established on both sides of a subsequent fault, and later activated.

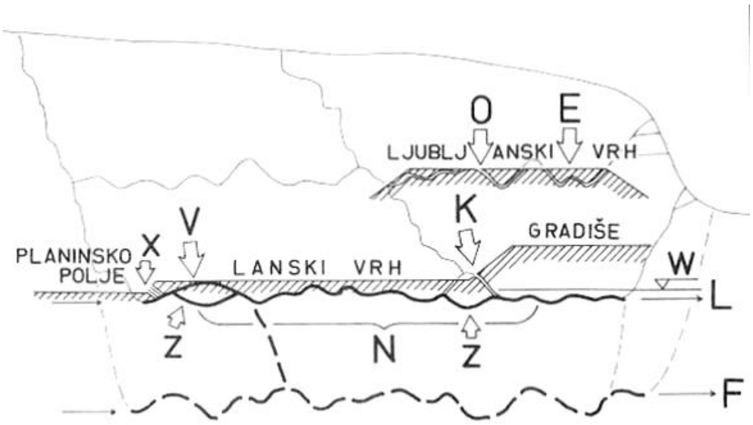


Fig. 4. Position of the caves north of Planinsko polje within Worthington's scheme.

V – Vranja jama, N – Najdena jama, K – Kloka jama, O – Koševelc, E – Lenarčič's cave, L – direction towards the springs of the Ljubljanica, F – direction towards the Furlanove toplice warn spring, X – secondary break from the polje into the tier, Z – added phreatic loops, W – the highest water level within the system (Šušteršič 1994).

The spatial orientation of these clusters only vaguely mirrors the present hydrogeological situation and the polje locations. There is evidence that present waterflow makes use – as much as possible – of older voids, inherited from different conditions, and is only partly influenced by the poljes position.
Caves within a given tier were forth under phreatic conditions and reworked in vadose ones, in hydrogeological sense. There are no traces of epiphreatic shaping, except in the ponor caves, where fluvial gravel is transported.
The phreatic passages are concentrated along a small number of bedding planes. In some cases it is evident that their directions do not follow any current structural framework, and that and penetration into joints was secondary. This bedding plane partings play the exact role of inception horizons, as defined by D.J.Lowe (1992). Joints and smaller faults are really important only as master structures to guide the formation of phreatic jumps within a tier, and they play an important role during its adaptation phase. More highly tectonically disrupted zones defines areas of

significant cavern collapse, or local slab spalling, during the subsequent decay of the cave.
Except in the direct ponor caves, where water flows on a bed of its own sediment and extensive adaptations by coarse bed load material appeared (I.Gams, 1959), no traces of fluvial organisations of the underground karst exist. Consequently, the input of fluvial bed load, rather that the position within the string of poljes, controls the further developments of caves.
The lack of genetic connection between the poljes and their karst input/output pattern makes the idea of a previous fluvial phase, which should bring about the large mass removal, unneeded. The poljes are just oases of non – karst within the karst (J. Roglić, 1957), in the true sense of the word. Just as the appearance of ground water at the surface in the desert is unrelated to the arid conditions, the existence of poljes within the karst has nothing to do with the karst itself.

SHORT DESCRIPTION OF THE SITES

Note different geomorphological realisations of High Karst Plateaus during the excursion on Notranjska karst. During the field work we will face these different types to The Pure Karst Model (Šušteršič, 1996) and we will show these features within this model. On the excursion we will follow outflow of the “karst” water on non – karst area and inflow on non – karst area as well. Please follow further discussion on the field trip.

Table 1. Location and topics of the Thursday’s field trip

No.	Location	*Topic*
0	Postojna	Start point (see Map for details)
1	Močilnik	General problems of Ljubljanica karst river **(Fig. 3.)**
2	Bistra	Subsurface karstification of dolomite & tectonics **(Fig. 5.)**
3	Temna Luža	Cave entrances, Maroltov kevderc cave **(Fig. 4.)**
4	Pokojišče	Non-karstified dolomite, cease of the karstification precess in the Otavščice case
5	Begunje	Begunjščica ponor area, karstification process under the weathered material **(Fig. 6.)** Čopcova jama cave (roofless cave)
6	Štruljeva vas	Young dolines in dolomite **(Fig. 7.)**
7	Andrejče	Outcrop of the bauxite
8	Bloke/Berinjek	Panorama of the low non-karst relief in dolomite
9	Velike Bloke	Artificial ponor Bloščice, problems of Bloke outflow
10	Bločice	Cone karst, problems of the Pleistocene closed depressions

11	Loško polje/Vrhniški Obrh	Karst poljes in the Pure karst/without Gams effect
12	Loško polje/Mali Obrh	Influence of the Idrija fault for regional hydrogeology
13	Škrilje/Dane	Vertical ponors of Obrh and Golobina **(Fig. 8.)**
No.	***Location***	***Topic***
14	Čela gora	Cerknica periodic lake **(Fig. 9., Fig. 10.)**
15	Velika volčja jama	Problems of the inherited cave systems **(Fig. 11.)**
16	Pogreščaki	Consequence of the Cerkniščica overflow
17	Zelške jame/Mali naravni most	"The third" natural bridge in Osja jama cave as the phreatic jumps, poorly modified phreatic system **(Fig. 12.)**
18	Veliki naravni most	Panorama of the classical karst
19	Planinska jama/vhod	Planinska jama cave system **(Fig. 13.)**
20	Mladika	Inflow into the karst area, realization of the " transenvironmental effect" in karst

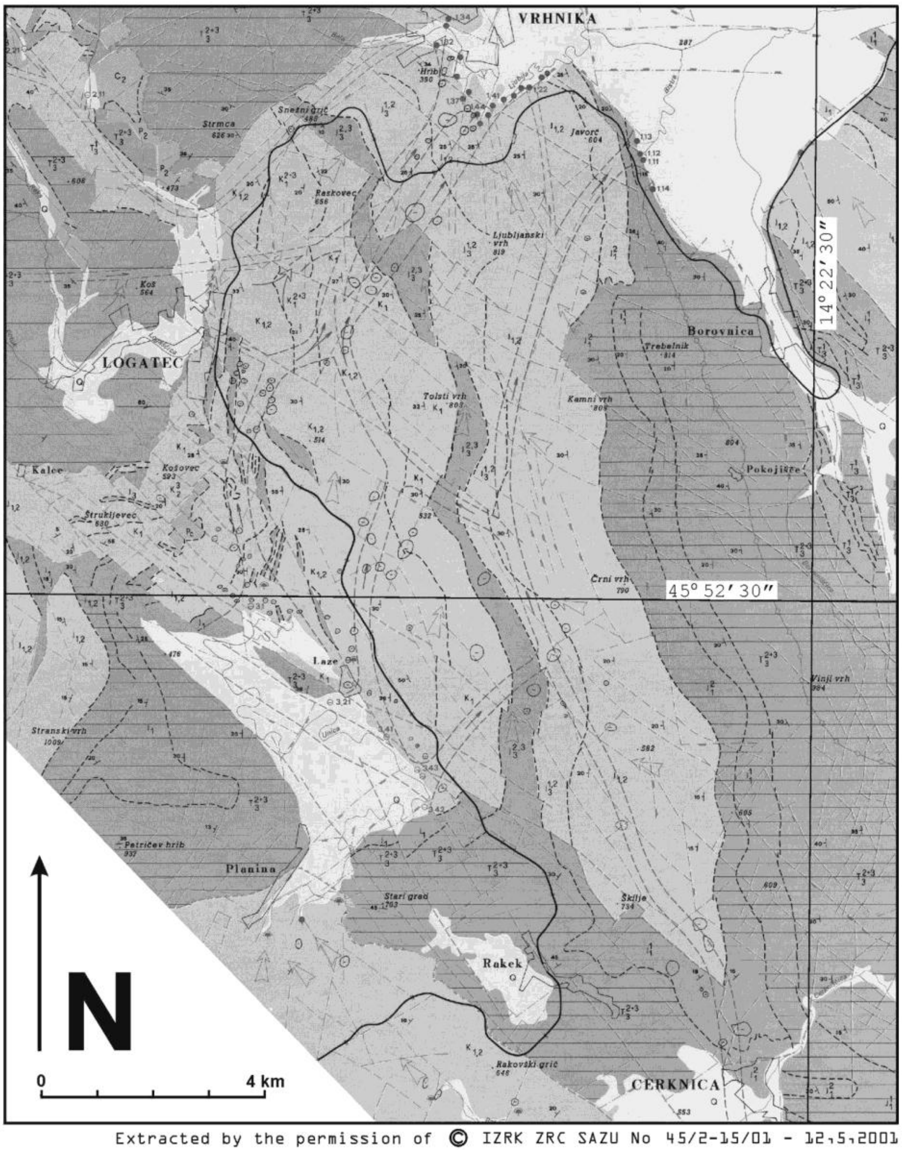


Fig. 5. Hydrogeological map of the Bistra area.

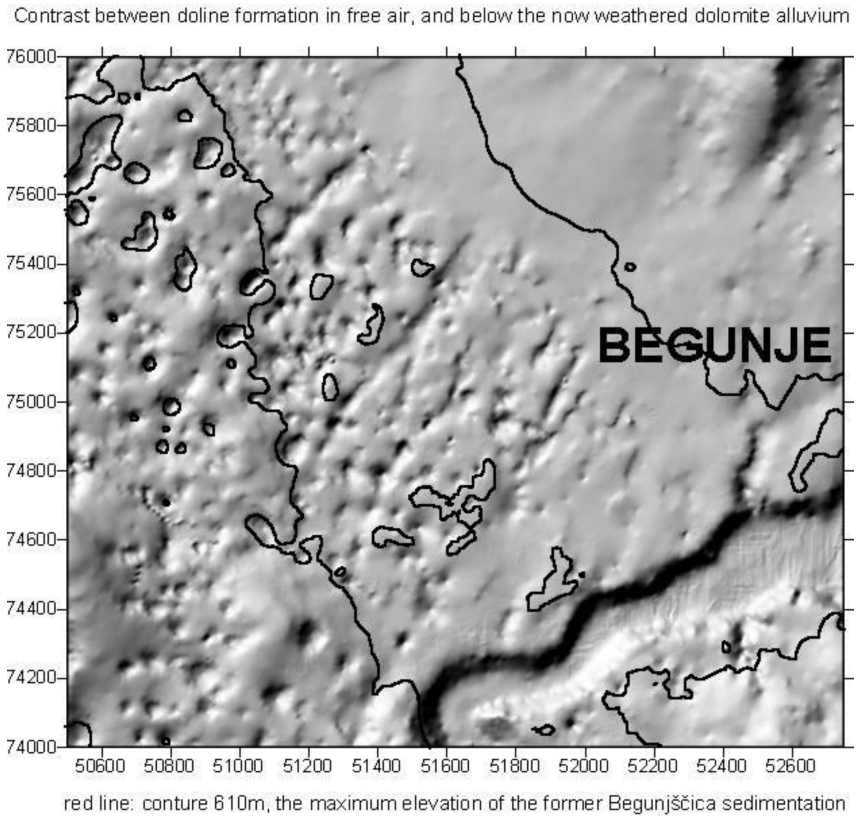


Fig. 6. Dolines near Begunje area.

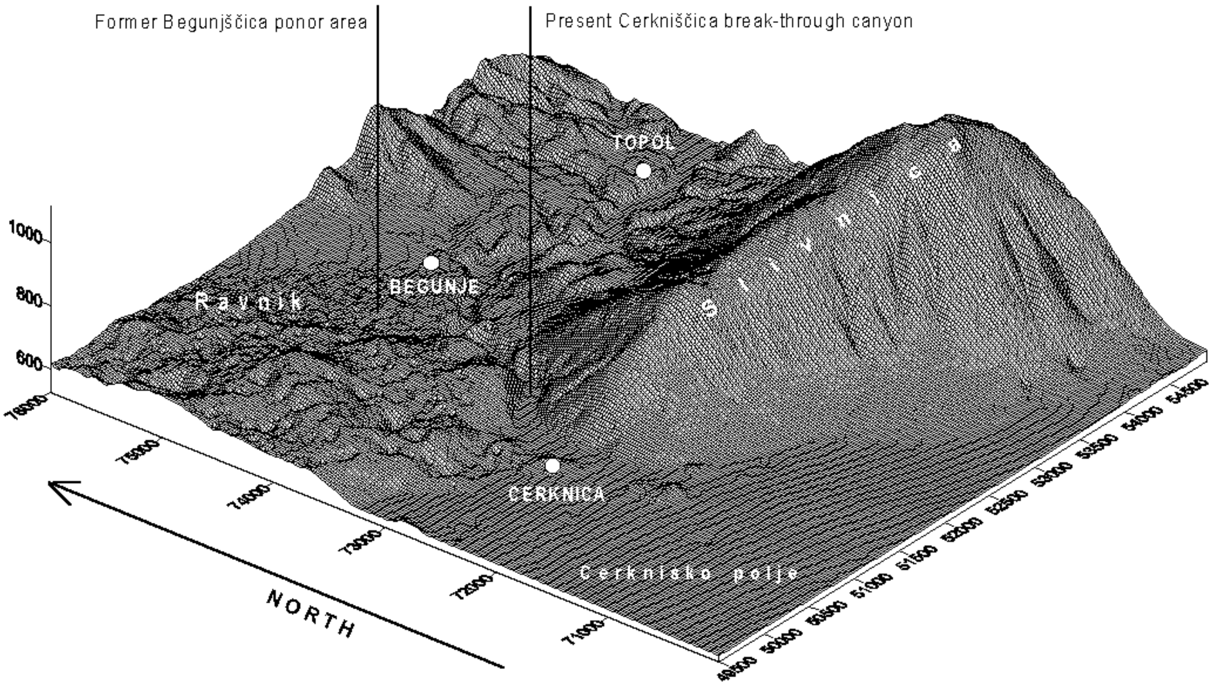


Fig. 7. Cerkniščica break – through.

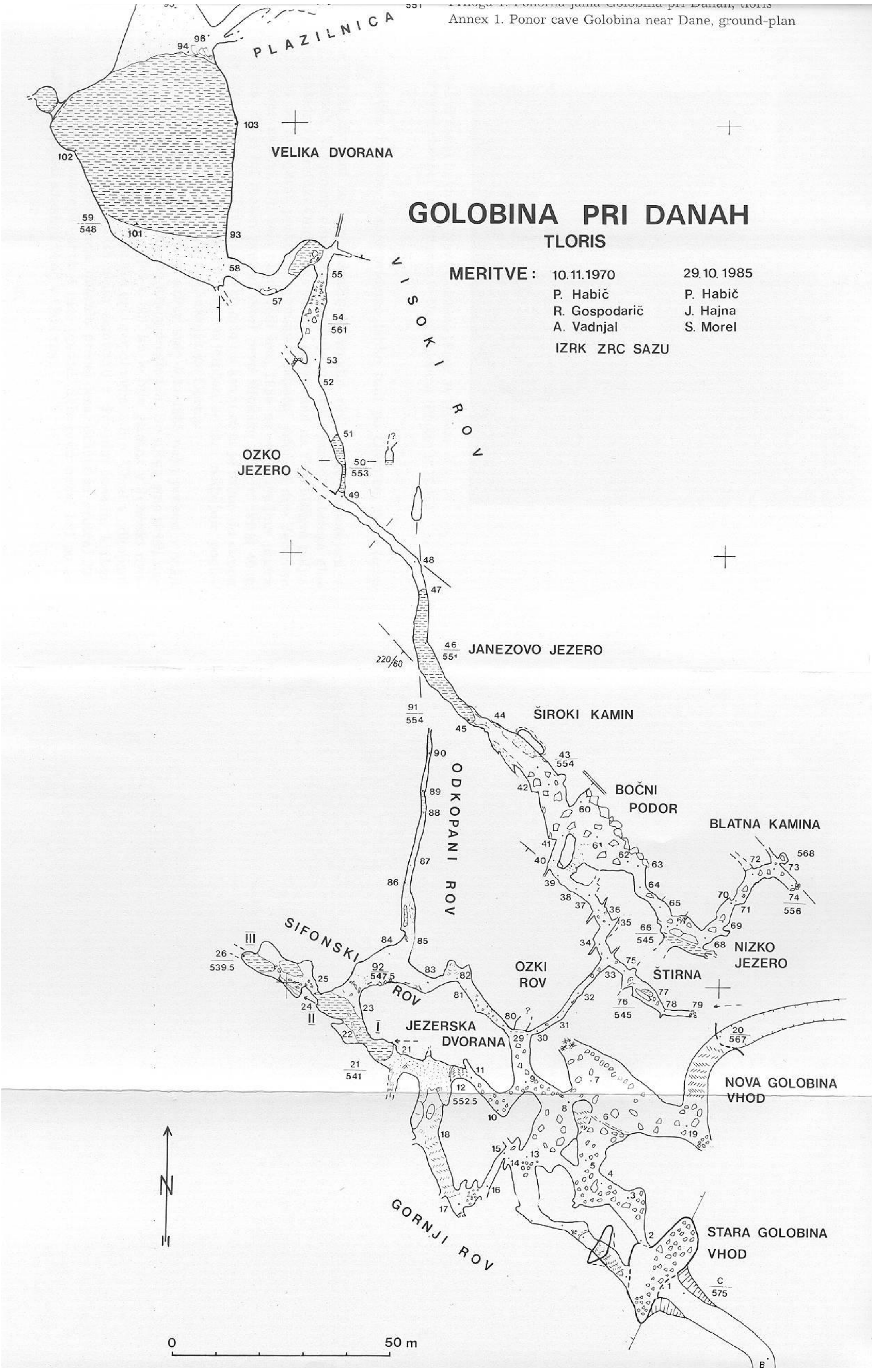


Fig. 8. Golobina pri Danah cave

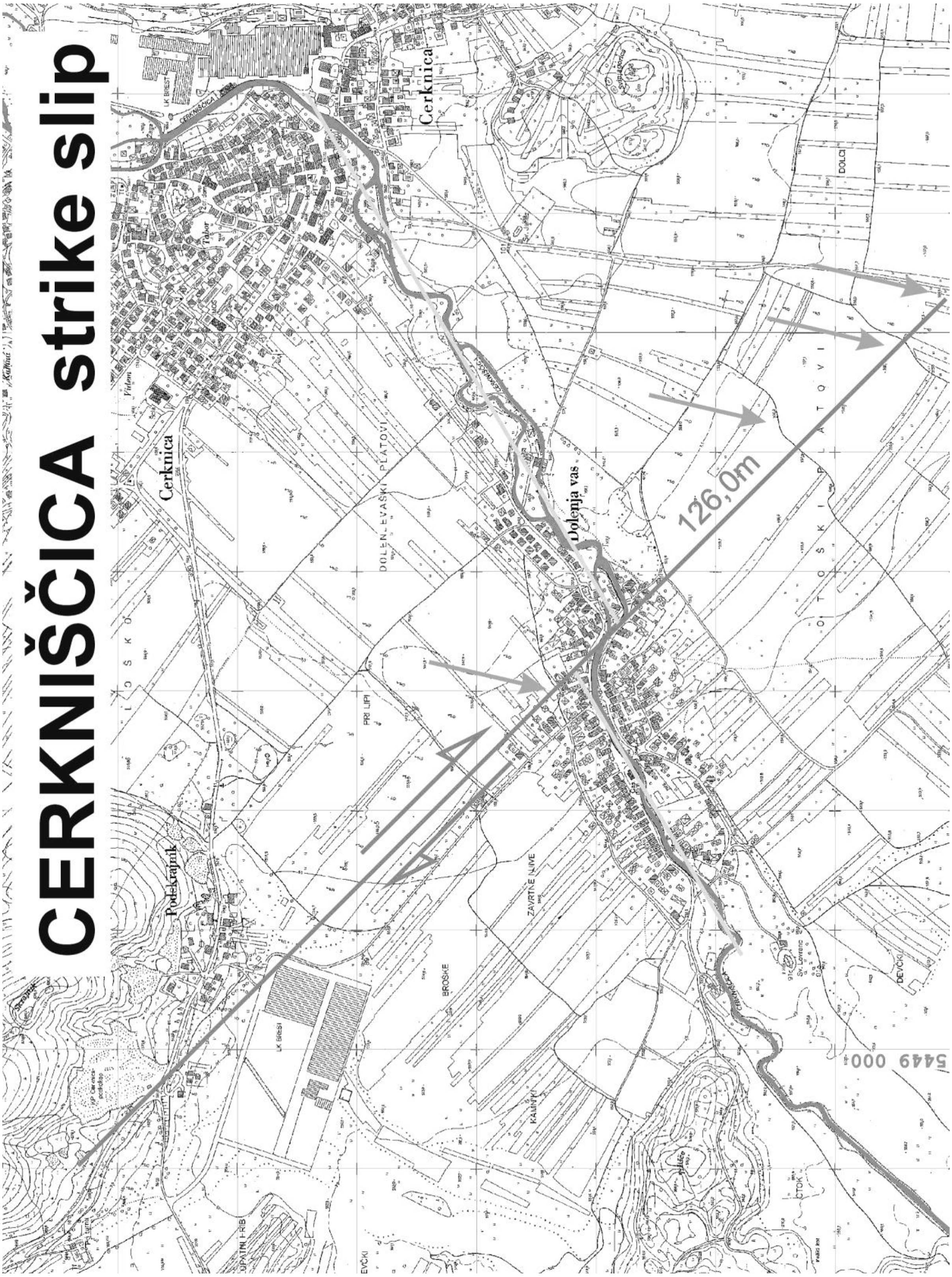


Fig. 9. Cerkniščica strike slip fault.

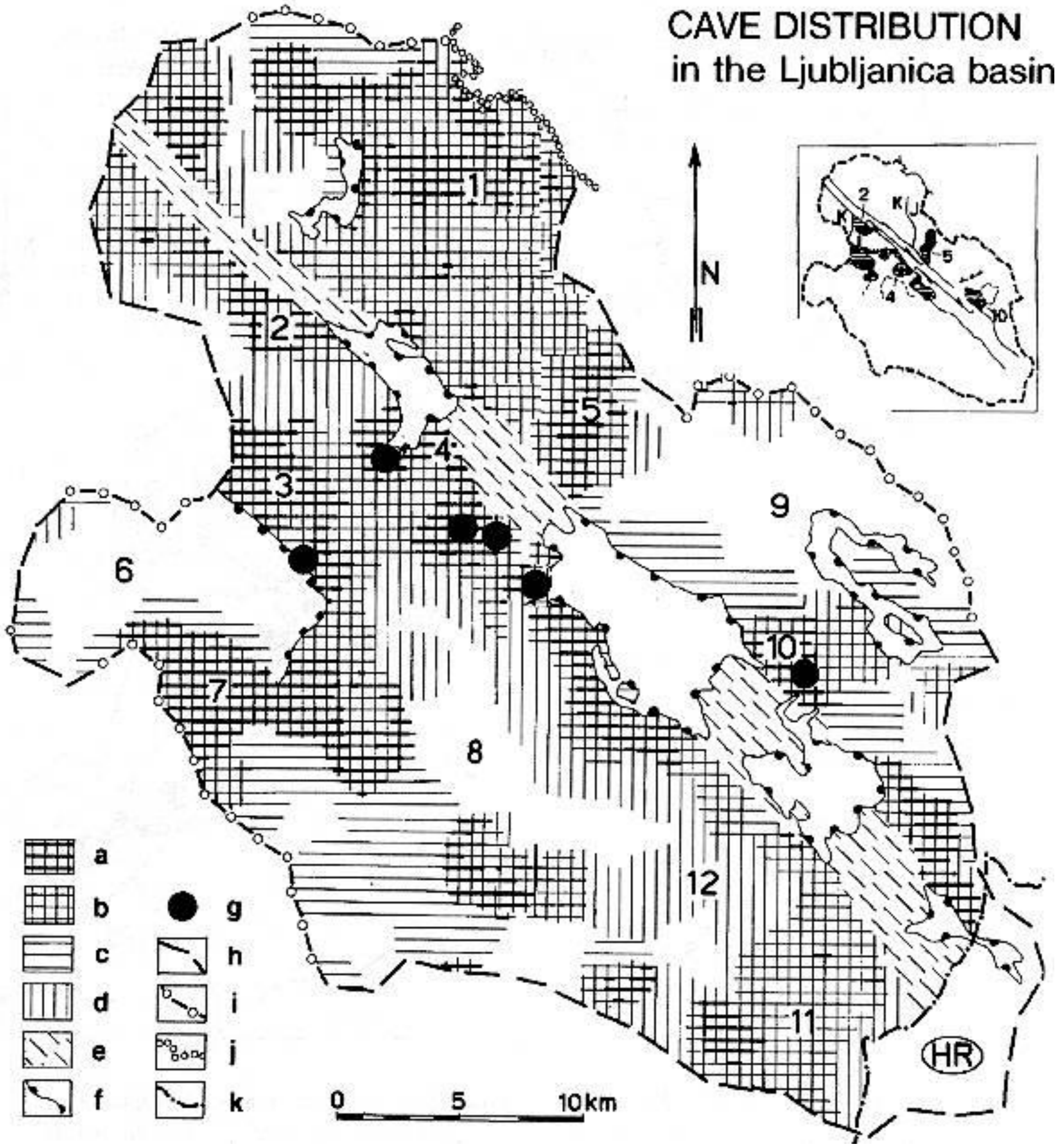


Fig. 10. Cave distribution in the Ljubljanica Basin.

a is horizontal caves ≥ 4 and vertical caves ≥ 4 and horizontal/vertical ≥ 1. **b** is horizontal ≥ 4 and vertical ≥ 4 and horizontal/vertical < 1. **c** is 1≤ horizontal < 4. **d** is no horizontal caves. **e** is Idrija Fault Zone. **f** is the borders of the alluvial floors of major poljes and the lower part of the Pivka Basin. **g** is major river caves. **h** is approximate border of the karstic Ljubljanica catchment area. **i** ist he well determinable border of the karstic Ljubljanica catchment area. **j** is the outflow border of the kartic Ljubljanica catchment area. **k** is the international boundary (Klimchouk et al., 2000).

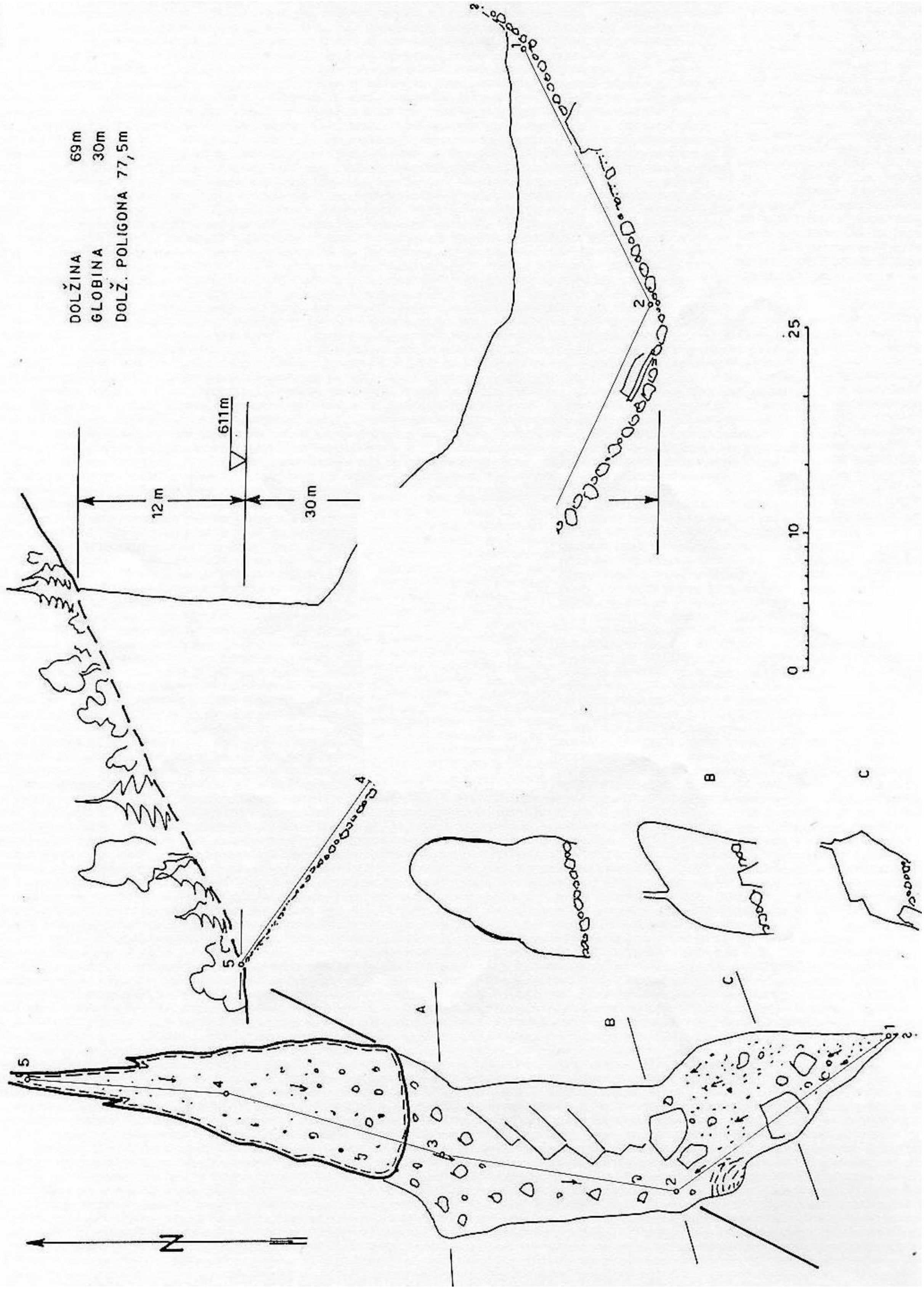

DOLŽINA 69m
GLOBINA 30m
DOLŽ. POLIGONA 77,5m
12 m
30 m
611m
0
10
25
A
B
C
N

Fig. 11. Map of the Volčja jama cave

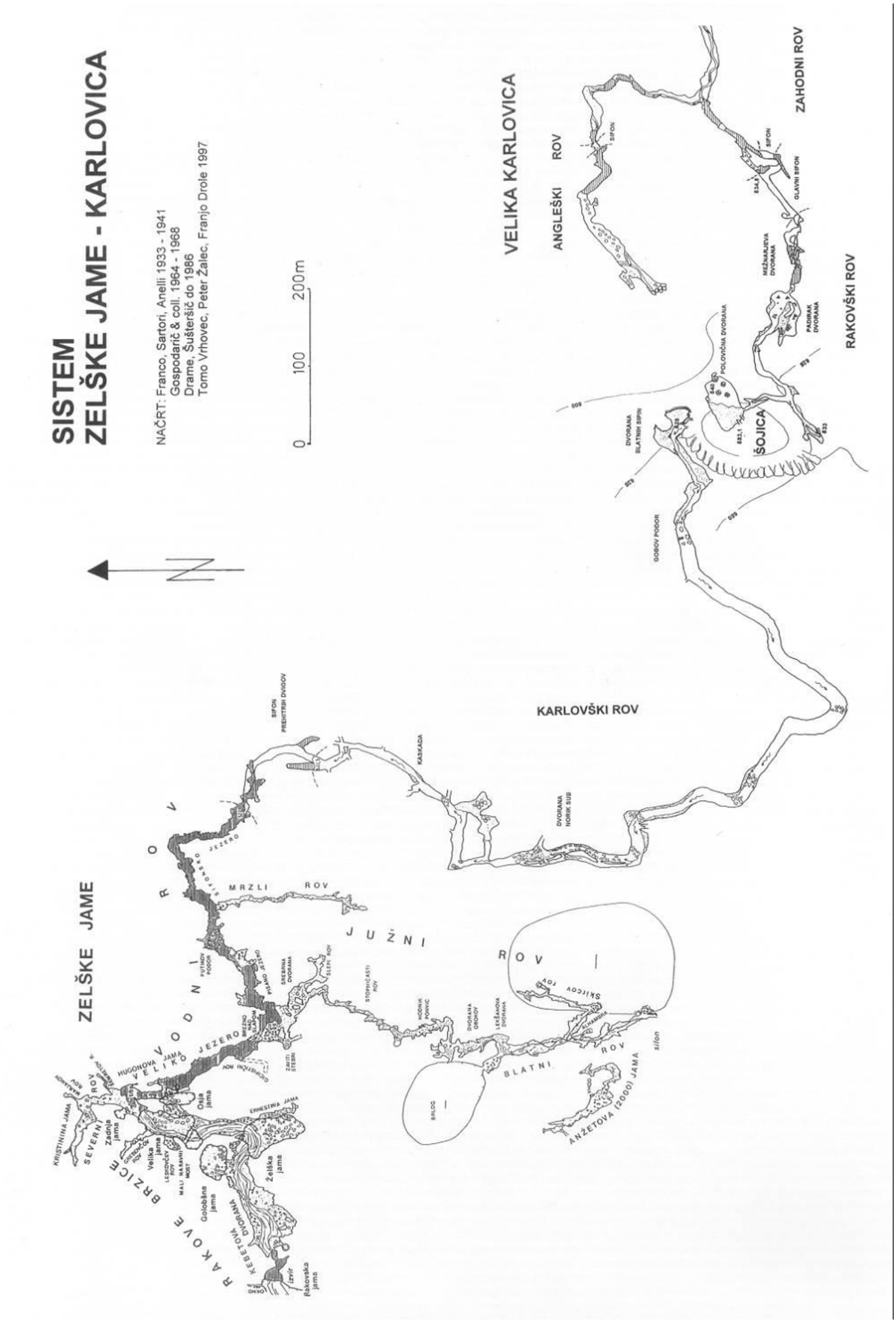


Fig. 12. Zelške jame cave system

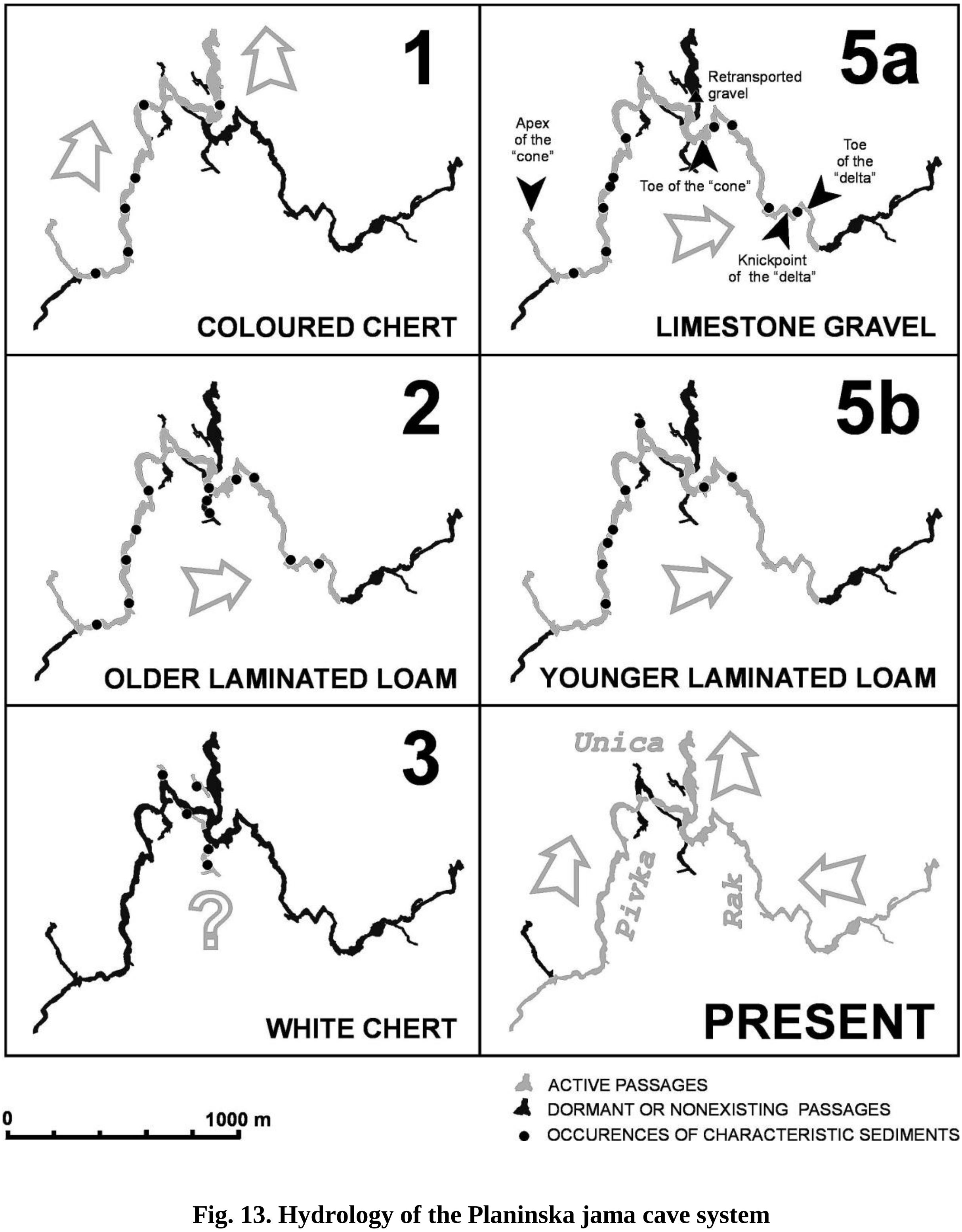


Fig. 13. Hydrology of the Planinska jama cave system

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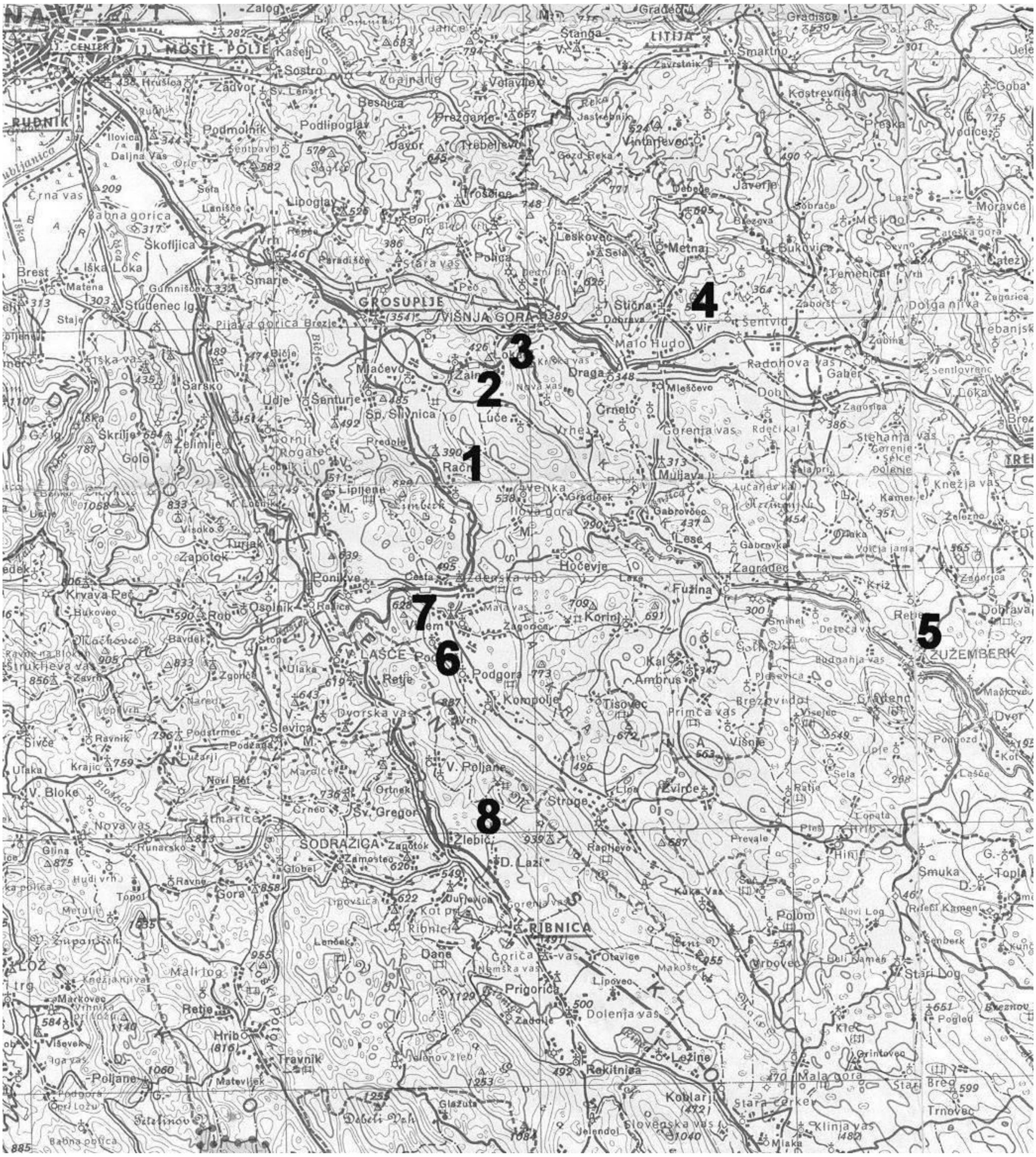

Fig. 14. The plan for the excursion on Friday, June, 28th

1. Radensko polje, 2. Lučki dol, 3. Krška jama, 4. Vir pri Stični, 5. Žužemberk, 6. Podpeška jama, 7. Raščica ponor, 8. Tentera ponor cave

KARST OF DOLENJSKA

Friday, June 28, 2002

Postojna – Grosuplje – Radensko polje – Lučki dol – Krka river spring (Krška jama) – Vir pri Stični - Dobrnič - Žužemberk – Ambrus – Podpeška jama – Požiralnik Raščice – Tentera - Postojna

OVERVIEW

Dolenjsko (Lower Carniola**) is a historical country, a part of former duchy of Carniola (Kranjska), lying between Ljubljansko Barje in the NW, the Sava river in the N and the river Kolpa and Croatian border in the SE and S. To the W high karst plateaux including Bloke, are the transition belt to Notranjsko (Inner Carniola). Tectonically Dolenjsko mostly belongs to Outer Dinarids. There are some larger overthrust nappes, landscape is crossed by faults and dissected to different tectonic units. They have been either uplifted or subsided.**

From the karst point of view the SW part, belonging to the Dinaric system, is more important. There is also the highest mountain of the region, Goteniški Snežnik (1289 m). Specially the Suha krajina plateau and the valley of the Temenica river have the main relief lines in Dinaric direction (NW – SE) and are well karstified. There are high karst plateaux (Velika gora, Mala gora, Rog, etc.) and karst poljes in-between (Ribniško polje, Kočevsko polje, Dobrepolje, etc.). Karst is mainly drained by the Krka river. The climate is a transition between that of the middle Slovenia and the subpannonian one. Precipitation decreases from the W (Kočevje 1500 mm) towards the E (Brežice 1050 mm). But bare karst surface is very rare at Dolenjsko. Soil and other weathered deposits cover rock and sediments of red or brownish red loam can be very thick. In the limestone and in the weathering products there is iron ore. Man started to use it, together with the charcoal from the forest in the Old Iron age (Hallstatt) already. Lower karst plateaux of Dolenjsko became cultural landscape and the inhabitants reached protourban stage of civilisation.

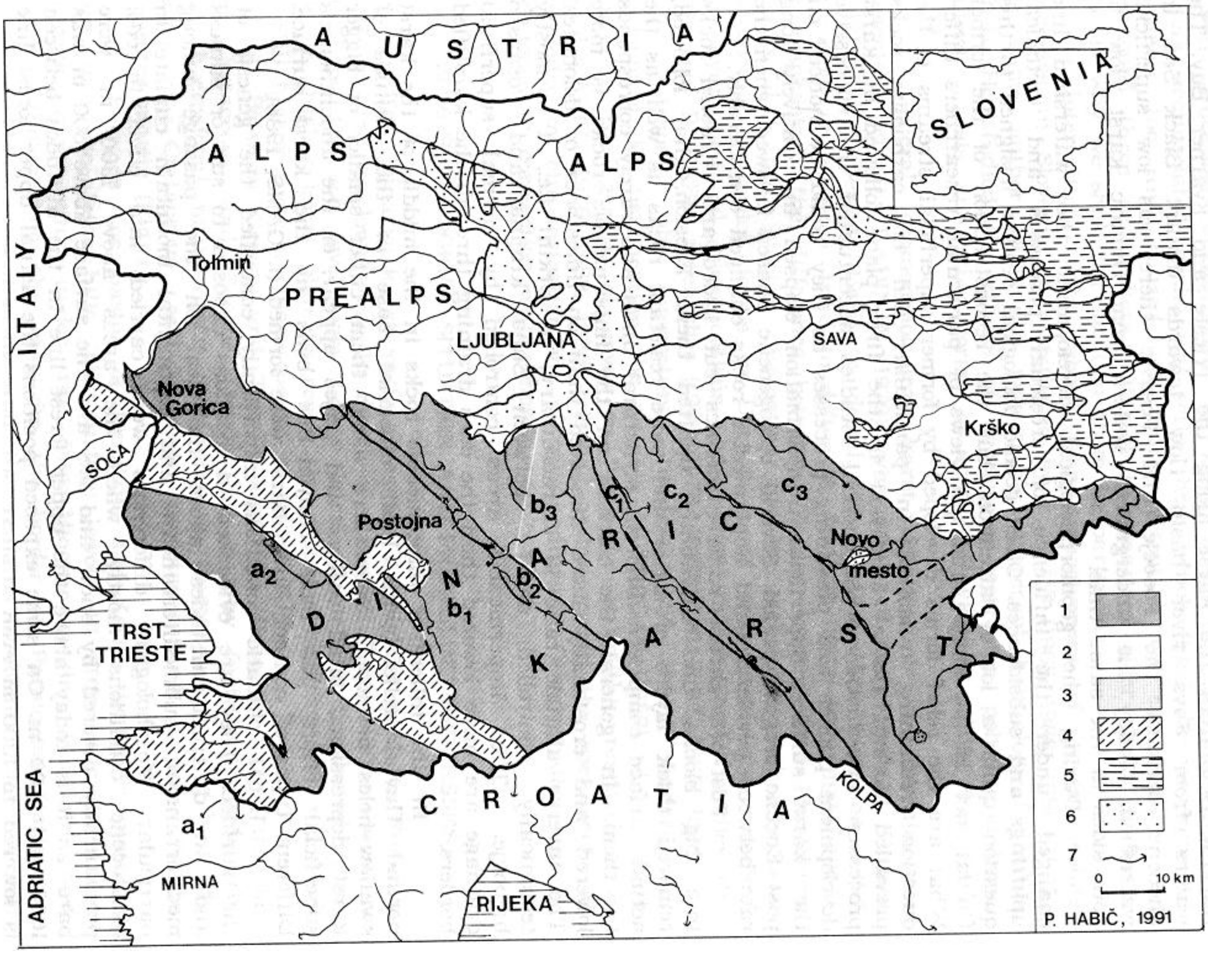

Fig. 15. The situation of Dinaric karst in Slovenia (Habič, 1991)

1 – NW Dinaric karst, Mespzoic carbonate rocks
2 – Pre-alpine mountains with isolated karst, Paleozoic, Mesozoic and Cenozioc rocks
3 – Julian and Kamnik Alps with High Karst, Mesozoic and Cenozioc carbonate and noncarbonate rocks
4 – Eocene flysch
5 – Oligomiocene beds
6 – Plioquaternary sediments in the basins
7 – Sinking rivers

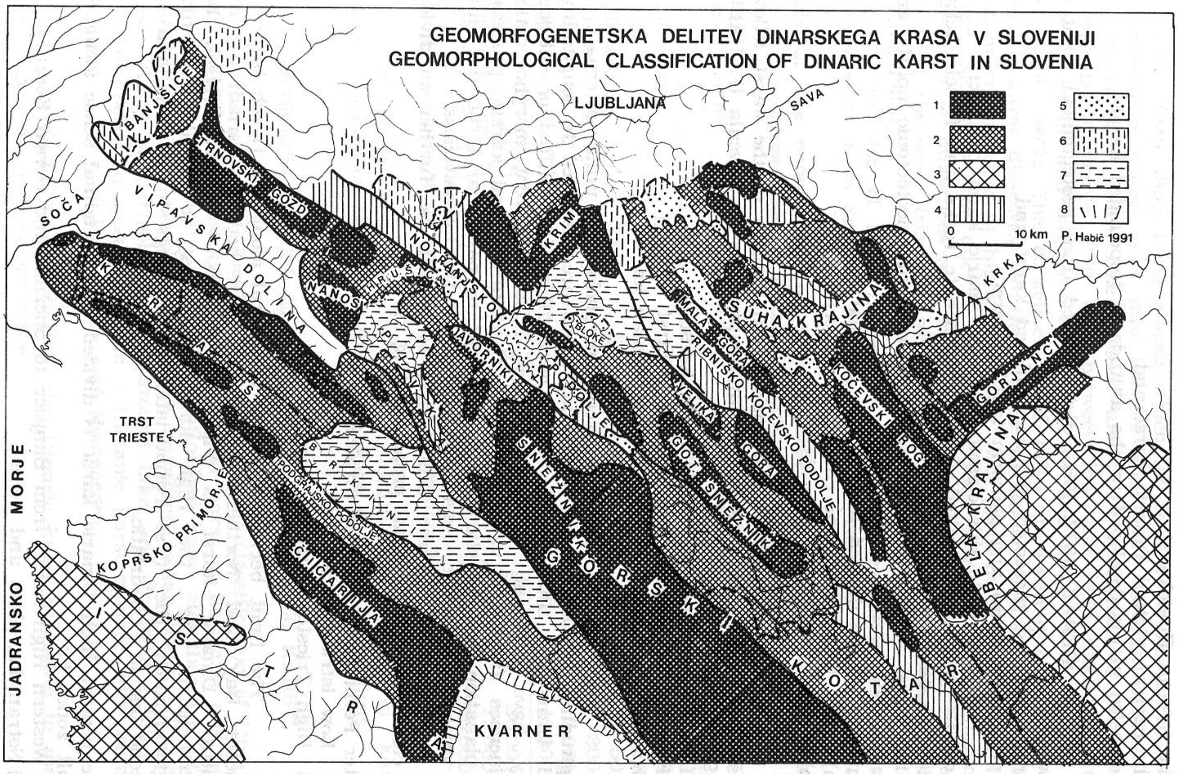

Fig. 16. Geomorphological classification of NW Dinaric karst (Habič, 1991)

1 – higher conical karst
2 – karst margin plains and pediments
3 – lower karst plains
4 – lowered surface with karst plains
5 – karst poljes
6 – contact fluviokarst
7 – fluvial relief encircled by karst
8 – littoral tectonic karst scarp

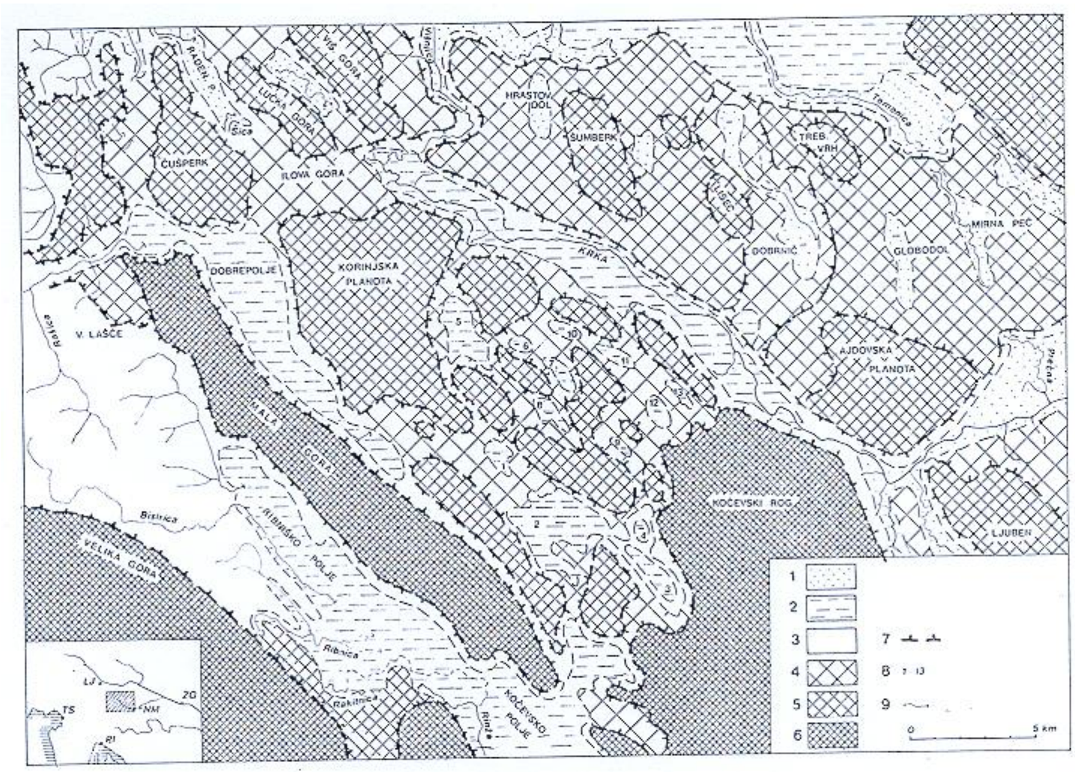

Fig. 17. Geomorphological sketch of western Suha Krajina and its border

1 – alluvium in basins and karst “dol”
2 – karst plain
3 – fluvial surface
4 – low karst plateaus (300 – 500 m)
5 – medium karst plateaus (500 – 700 m)
6 – high karst plateaus (above 700 m)
7 – border of karst plateau
8 – signs of “dol” – ouvalas in the central Suha Krajina
9 – superficial streams and sinking streams

Grosupeljsko polje (Polje of Grosuplje) is not a typical karst polje SE of Ljubljana in the transition belt between Alpine and Dinaric relief units. It lies 310-340 m a.s.l. and is similar to nearby Ljubljansko Barje 40-50 m lower. Grosupeljsko polje has normal tributaries from the N, from non-carbonate surface, and karst springs in the carbonate border. All the streams flowing over Grosupeljsko polje are collected in its SE “bay” Radensko polje (type of polje opened partly towards Grosupeljsko polje, or just a part of it). There are ponors and ponor caves and water flows underground to the springs of the Krka river. The bottom of Grosupeljsko polje is wet and has been often flooded. After 1965 it was nearly completely drained and changed into meadows, partly into fields. Higher parts of the bottom and foot of the border slopes are covered by thick deposits of carbonate red and brown-red loam and soil. On such positions there are settlements.

Žalnsko polje (Polje of Žalna) is 2 km long and up to 1 km large karst depression E of Grosupeljsko polje, separated from it just by a low pass. It is also non-typical karst polje, by some authors it is not polje, but uvala. N part of its border consists of little karstified Triassic dolomites while most of the bottom and the S border are in Jurassic limestones. Žalnsko polje is a closed depression in the altitude of 320-330 m with lightly undulated bottom covered by Quaternary sediments deposited by the streams from the N. Maybe it was a valley of some tributary of Grosupeljsko polje. There are three surface streams running to the polje sinking separately at the beginning or in the middle of it. After heavy rains the bottom can be flooded for few days. The streams belong to the Krka river basin. In the S slopes there are some small caves too. Ponors and new-formed sinkholes (specially in the streambeds) are the proof that nowadays the karstification (evacuation of surface sediments underground) prevails over the sedimentation. Considering the above properties Žalnsko polje can be classified as a small border karst polje.

Lučki dol: This work brings new knowledge about karst features in karst of Dolenjsko. Area Lučki dol is located in karst area between Grosuplje basin and the springs of Krka river. The area is very poorly explored, what is to conduct from the scarce literature. The work discusses geomorphological and hydrological features of the area Lučki dol discussed, that point out, that Lučki dol is a small baselevel “karst” polje. From the relief features in the area of Lučki dol the most distinctive are presented as dolines (corrosion), colapse dolines, flat floor, passes, slopes, peaks, small scale solution sculptures and caves. Based on geological, geomorphological and hydrological conditions the formation and development of polje Lučki dol is presented. Lučki dol is situated in the catchment area of the Krka springs. That played na important role in his geomorphological and hydrological development. Today Lučki dol is a part in the decantation of the waters towards the springs of Krka during high waters, as there a surface stram appears in Lučki dol.

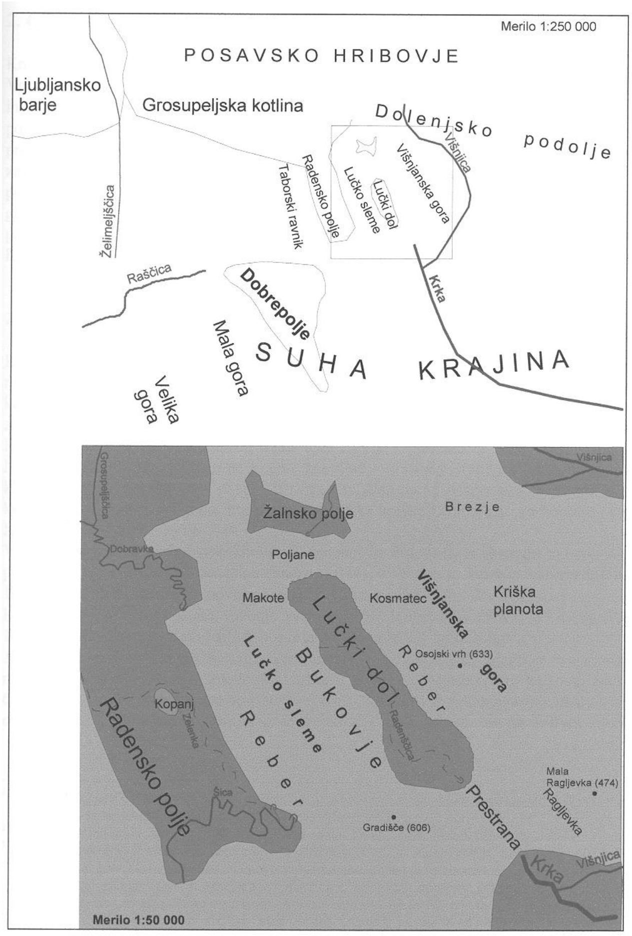

Fig. 18. Situation of Lučki dol (Frelih, 2001)

Proteus anguinus **(močeril, človeška ribica** in Slovene), amphibian, the only real cave dwelling vertebrate in Europe. With the length of 25-30 cm it is the biggest cave animal at all. It is endemic for the Dinaric karst. First alive examples of Proteus have been brought to Ljubljana naturalist A. Scopolli by local people from the karst spring **Vir** near the village of the same name in the vicinity of the Stična monastery. He has sent them to some friend naturalists, among them to Žiga von Hochenwart at Klagenfurt too. Scopolli intended to prepare and to publish a detailed study of it. Certainly Dr. Laurenti saw the curious animal at Klagenfurt and got the Scopolli's picture of the animal. He hurried to publish (1768) a few lines together with the illustration, made after the Scopolli's one and gave the animal the scientific name *Proteus anguinus.* Serious scientific description was published by A. Scopolli in 1772. During the 18th century Proteus was an interesting trade item too. In Slovenia it was protected in 1922 and in 1982 it was put to the list of rare and endangered species (Washington Convention). The Vir spring is a small one, usually disappearing underground after few 100 m of flow. But after heavy rains this a flood overflow spring, gushing from all the fissures and small openings nearby and water often ejects Proteus.

The Krka river, 111 km long right tributary of the Sava river takes its karst spring in the NW part of Suha krajina (275 m a.s.l.). It consists of the main spring of Vauclusian type, some springs coming from fissures in limestone and Krška jama cave, about 300 m long. There is a siphon at the end of the cave but the cave is functioning as an overflow just after heavy rain, when the poljes in the background are flooded. The Krka river basin covers 2284 km^2. In the upper part (in Suha krajina) the Krka river flows through relatively deep valley. Its bottom is in Triassic dolomite, while the slopes are in limestones. The valley formed in two phases: at first relatively large valley in carbonates was formed and in it a narrow valley, at some places a real gorge was cut more recently, 10-20 m deep. The terrace – the rest of the first phase valley bottom – is well karstified today. In this part the Krka river is practically without surface tributaries but it is receiving water from many strong karst springs, mostly immediately at the river bank. Two phase development can be seen from the situation of springs too. They are in the bottom of the gorge, above them are periodically flooded caves. At extremely high waters some periodical springs may appear on the higher carbonate terrace. Tufa deposits are typical of the upper part of the Krka stream. On the karst terrain the watershed with the Ljubljanica river is not well defined and not stable. There are more examples of vertical bifurcation. For example, low waters from Ribniško polje flow underground towards the Krka river, but when the polje is flooded, water flows underground to the Kolpa river too.

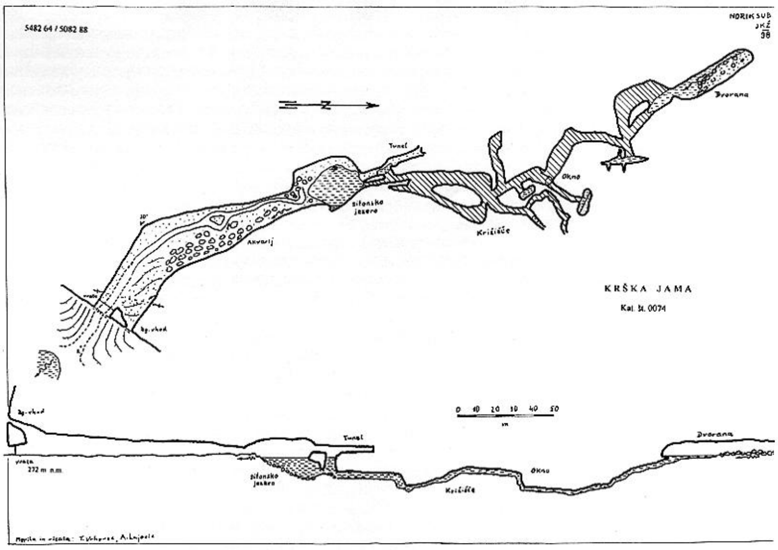

Fig. 19. Sketch of Krška jama (Cave register of IZRK)

The Temenica river, the left tributary of the Krka river, covering slightly more than 300 km^2 of the recharge area with mean annual discharge of 4.6 m^3/s at the outflow to Krka. The source of the Temenica lies in the fluvial relief of Posavsko hribovje (N of karst of Dolenjsko) and it flows along the border between non-carbonate Posavsko hribovje and karstic Suha krajina. It sinks underground two times. The last spring is from the cave Luknja (Lueg – there has been a castle under the arch too) and after flowing 6 km on the surface, the Temenica is named Prečna there, joins the Krka river.

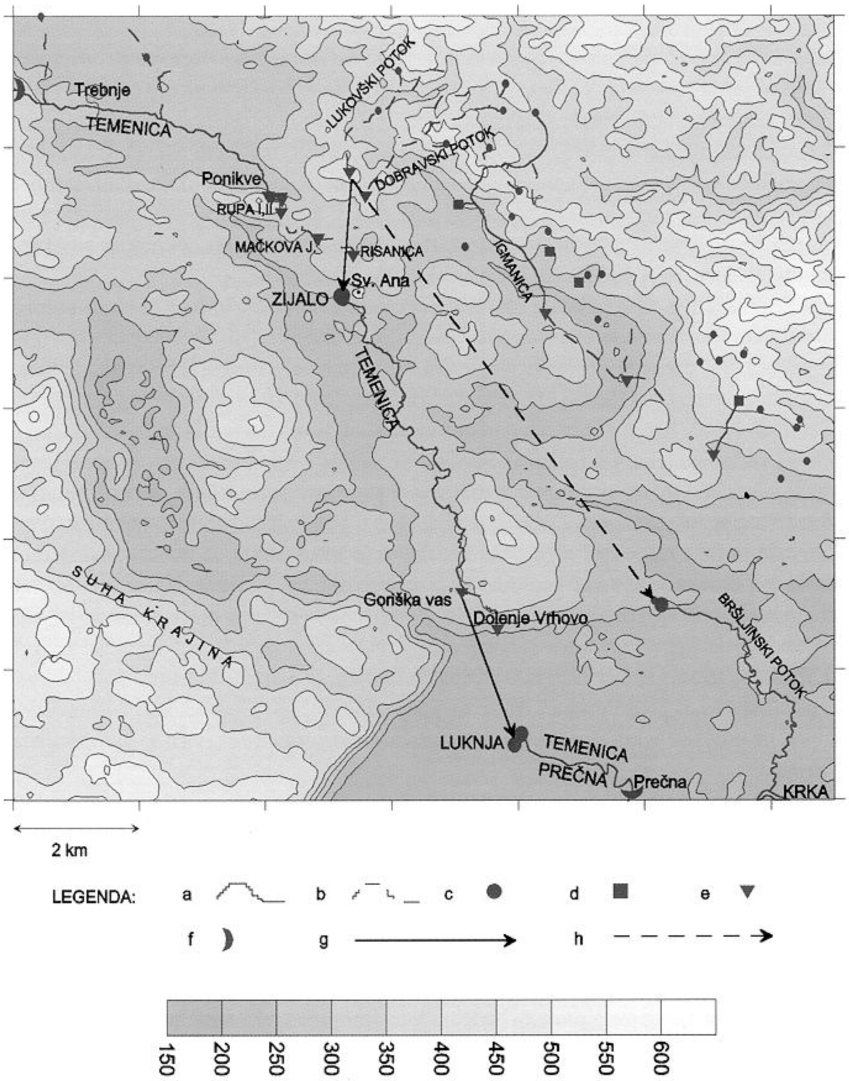

Fig. 20. Hydrological map of water flow of the Temenica river (Kogovšek, 1998)

a – permanent superficial flow,
b – temporary superficial flow,
c – spring,
d – captured spring,
e – ponor,
f – gauging station,
g – proved underground water connection,
h – supposed underground water connection.

Suha krajina (meaning dry country) is about 430 km^2 large karstland in the central part of Dolenjsko. It lies on the Mesozoic limestones, partly dolomite. W and E parts of Suha krajina are two low plateaux with the Krka river valley in-between. Plateau is dotted by dolines, uvalas and dry valleys all in the Dinaric direction. There are three karst poljes in Suha krajina too: in the centre of E part is polje where the village Dobrnič is lying (Dobrniško polje), on the S border is the polje of Globodol and on the W one the polje called Dobrepolje. All belong to so-called dry poljes. The brown carbonate soil of uneven thickness prevails there, often the rock are jutting out. There is a lot of relatively small dry caves and shafts, the deepest is -150 m deep. Suha krajina has about 1300 mm of precipitation per year. Except the Krka river, flowing in the deep valley in the middle of Suha krajina, there are no other surface streams. The whole country belongs to the Krka river basin. There is a regional water supply from the Globočec karst spring and from the spring near Žužemberk. Globočec, several sources at the beginning of a deep steep-head valley flows after a kilometre the Krka river. It has a large catchment area, even the fluvial relief W of Suha krajina, which was the cause of severe pollution by mineral oils. Before the regional water supply was established the inhabitants used rain water. During the drought they had to carry water from karst springs, from water caves or from the Krka river. People of some villages in the middle of the plateau had to transport the water as far as 8.5 hours in extreme cases. In 1890 Suha krajina had the most of inhabitants (about 20 000) while nowadays the number is halved. This is the reason that once cultivated land, meadows and pastures are now overgrown by forest. Today the forest covers more than 50 % of the land.

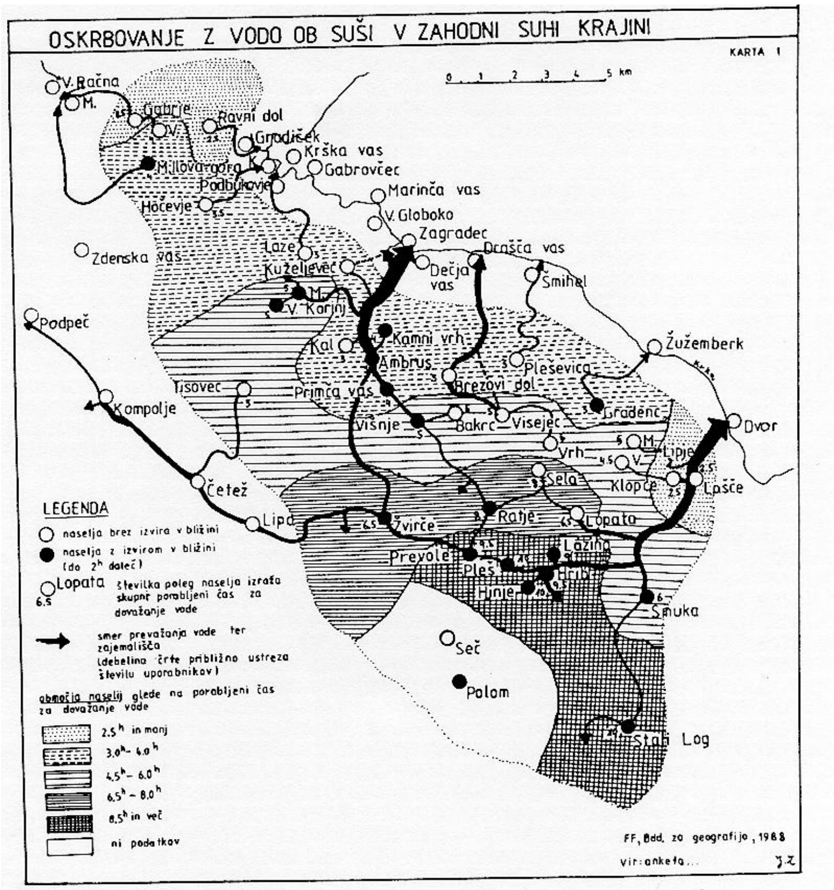

Fig. 21. Water supply during drought in the W Suha Krajina (Zupančič, 1988)

Mala gora, a Cretaceous and Jurassic limestones ridge between Suha krajina on the E and high Dinaric plateau on the W, that is between karst polje of Dobrepolje and karst polje of Ribnica (Ribniško polje). It stretches in Dinaric direction along the major fault lines. It is 45 km long and up to 4 km large. The highest summits reach 963 m. It is well karstified and many streams running from western impermeable terrain sink in the foot of Mala gora and flow underground either directly towards the springs along the Krka river or reappear on the E side of Mala gora thus adding to flooding of **Dobrepolje karst polje.** Further SE the streams from Ribniško polje and Kočevsko polje run under it towards the Krka river. Therefore on the W side there are ponor caves and on the E one spring caves, the biggest one is Podpeška jama.

Dobrepolje is a dry karst polje at 420-450 m a.s.l. W border forms Mala gora and E one plateau Suha krajina. It is elongated in Dinaric direction. Bottom is covered by alluvium and weathering material, border is of limestones with a small patch of dolomite in the middle of the polje. There is no surface water on the polje. But under the extreme conditions the Raščica stream, normally sinking few km upstream of Dobrepolje, runs to the polje itself and floods it. Water running from the caves Podpeška jama, Kompoljska jama, Potiskavška jama in the foot of Mala gora and from karst springs adds to flooding. The water accumulated in the SE, the lowest part of the polje, where it can flood houses even. Such flood can last for a few weeks. Before the organised water supply people have used the water from karst springs and from the caves.

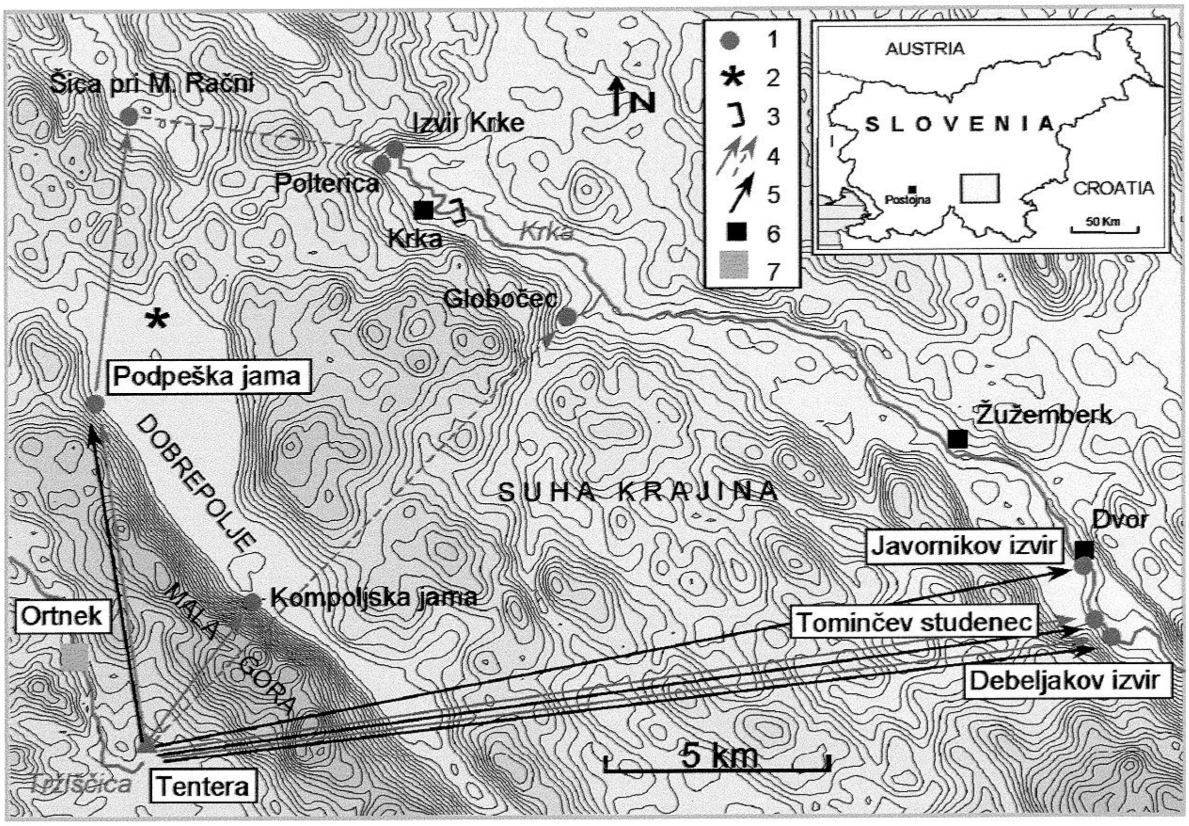

Fig. 22. Repository of oil derivatives near Ortnek and stated underground water connections (Kogovšek, 2002)

1 – sampled spring,
2 – precipitation station Zdenska vas,
3 – gauging station Podbukovje,
4 – proved and uncertain water connections,
5 – proved water connection by tracing test in April 2000,
6 – village,
7 – repository of oil derivatives.

Podpeška jama**, a karst cave in the foot of Mala gora, in the karst polje of Dobrepolje, in the village of Podpeč. It is a horizontal cave in Lower Cretaceous dolomitic limestone. A stream is running through it,** at extremely high waters it flows out through the entrance and through the village over the polje. Water comes from the opposite (W) side of Mala gora and in the streambed non-carbonate pebbles can be found. From the cave the underground stream continues towards the springs of the Krka river. The first part of the cave is known from old as people were using water from the underground stream. Valvasor compared the water levels at Podpeška jama and Kompoljska jama and the results have been used to confirm his theory of underground lakes. Therefore in his first article on Cerkniško jezero (Lake of Cerknica) (1687) the plan of Podpeška jama was added. In 1876 the stream was dammed and wooden pipes have been installed to bring the water to the drinking trough under the entrance porch. Later they changed wooden pipes with iron ones and water was installed in the houses. In 1971, when regional water supply was organised, the village stopped to use the water from the cave. In 1928 Zoological Institute of Ljubljana University organized an underground laboratory in a part of the cave. Today the length of the cave is about 4.5 km thank to speleodivers who started to dive the siphons in 1997.

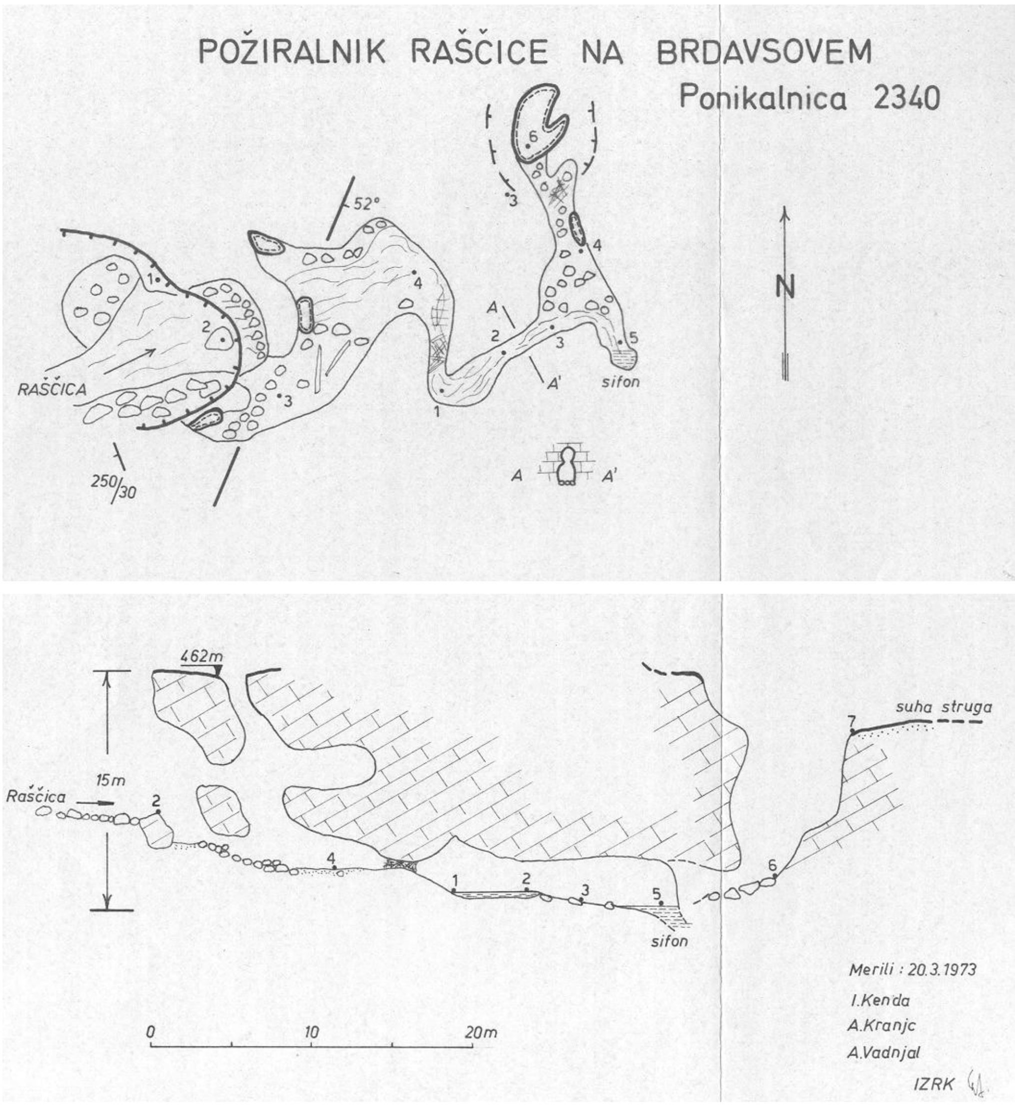

Fig. 23. Sketch of the Raščica ponor (Cave register of IZRK)

Lašče dolomite karst – is approximately 1 x 2 km big part of surface on the Upper Triassic dolomite. But the part of $CaCO_3$ can reach up to 70 %. This dolomite patch is partly surrounded by normal fluvial relief. Small streams coming from the impermeable rocks sink at the contact with dolomite and reappear on the other side. One such small stream is the Predvratnica sinking into ponor cave Predvratnica, nearly 400 m long. 800 m away in straight line is a small collapse doline Zajčjak with a stream at the bottom. In 1987 the tracing test was performed: water from Vratnica cave needed to reach Zajčjak 12 hours and another 6 hours from Zajčjak to the spring Peči, of 350 m far away. This dolomite karst is also an example of shallow karst. The water streams and caves are between 5 and 20 m under the surface only.

Bloke is about 10 km long and 5 km large dolomite (Triassic) high Dinaric plateau (700 – 750 m a.s.l.), between the fluvial terrain round Lašče on the E and Cerkniško polje (Polje of Cerknica) on the W. The border consists of limestone too and the streams flowing over the plateau, forming a shallow non-typical karst polje, sink there. Most of the water flows underground into the springs at Cerkniško polje, including the stream flowing through well known Križna jama. Bloke are known by harsh, cold and snowy winters. The autochthonous skis have been developed there by the natives, first reported by Valvasor (1689).

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ABSTRACTS OF THE PRESENTATIONS

Papers of the presented lectures and posters will be published in Acta Carsologica and available at www.zrc-sazu.si/izrk/carsolog.htm

KARST TYPES IN BULGARIA

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The karst in Bulgaria occupies an area of 26 170 km^2 or 22.7 % of the territory of the country. The karst water resources are estimated to be 2.3 billion m^3 or 11.6 % of the total water resources of the country. The interest in karst in Bulgaria has become greater during the last years because a number of practical problems had to be solved. There is a great diversity of karst in the country due to the complex combination of the factors (geological, tectonic, geomorphological, hydrological and hydrogeological, climatic, etc.) and to the geodynamic development of this part of Europe. This work presents a new zoning of karst in Bulgaria. The following types have been distinguished: plain karst (the Danubian Plain); marine and transformed marine karst into plain and plain-marine one (Black Sea subaqual and subareal plain); plateau-like karst (the Fore Balkan) and mountain and mountainous karst. The karst wetlands and karst phenomena provoked by paleoearthquakes are separately outlined as well as sample models for the different karst types, genesis, dynamics, lithostructural control, relations, etc.

PALEOSEISMIC PHENOMENA IN KARST TERRAINS IN BULGARIA AND MOROCCO

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During the recent years there is a growing interest in recording and investigating the effects of paleoseismic events in surface and underground karst in almost all countries. Karst represents a reliable reference benchmark for understanding the potential seismicity in regions with instrumentally established low to moderate seismicity. The karst terrains in Bulgaria and Morocco occupy considerable areas. The disturbances in surface and underground karst had been usually provoked by catastrophic one-act events or by repeatedly activated structures by the earthquakes. The catastrophic seismic events had disturbed the naturally interrelated karst ecosystems and were the reason for rejuvenation, reactivation or attenuation of karst

processes. The natural surface and underground relief had been partially or entirely destroyed; a new type of relief with specific outlook had been formed; the geological environment had been disturbed; changes occurred in the flowrate and direction of surface and underground karst water; wetlands of the gravitation type had been formed; natural caves, local grabens, rock-falls and landslides collapsed partially or entirely and terrains were subjected to subsidence and destruction; the ecological comfort in the urbanized territories had been disturbed. The present work considers the different types of paleoseismic phenomena in the karst terrains in Bulgaria and Morocco. The sites have unique nature and are protected by the legislation in both countries or by international conventions. The impact of the contemporary tectonic movements is studied and recommendations are given for the protection of these unique areas.

CAVE AND CAVE TYPE SYMBOLS

Stephan Angsüsser

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This poster deals with various possibilities of visualising the position of caves or cave entrances in maps. All experts are familiar with the omega shaped symbol, but of course there exist numerous different symbols depicting the same phenomenon. To get an idea about variety and use of such symbols it is necessary to collect and classify them systematically. Naturally this leads to several questions like: Why is there such a great range of different symbols? What kind of symbols are preferred by users? Are there differences depending on cultural background? Are there time-dependent differences? ...

According to this year´s focus of the Karstological School, several possibilities presenting different cave types are shown. This subgroup of cave symbols is especially interesting because in this field some symbol systems have been developed as well.

STRUCTURAL AND FORMAL FEATURES OF CULTURAL LANDSCAPE IN THE KARST AREA

Landscape in transition

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During a long historical continuity in the Karst area a specific landscape type has evolved due to varied climatic, geomorphological, topographic as well as socio-economic conditions. This is characterized by great typological diversity based on authentic features both of natural and cultural origin. These have occurred as a consequence of balanced economic land-uses from early periods on.

The main quality of these landscapes is derived from unique agricultural land-use patterns, which constitute one of the most valuable spatial heritages in the entire

Mediterranean. However, the recent evolution, mainly in the socio-economic sphere, generated far-reaching impacts in the rural areas which largely affect the integrity and traditional harmony the Karst countryside in general and the landscape in particular. The basic intention of the paper is to outline these transformations as a serious threat and immense loss of the national cultural heritage and to emphasize the great responsibility of this generation in these processes.

ARTESIAN CAVES IN PROVENCE (FRANCE). SPECIFIC MORPHOLOGIES AND SEDIMENTS

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Two dry caves from French Provence (grotte de l'Adaouste, grotte des Champignons) were up to now considered as "normal" caves having evolved under meteoric water flow conditions. A first approach gives evidence of a different setting: they originate from deep water uprising under artesian conditions. Specific morphologies and sediments associated to this hydrology are discussed.

BLOW HOLE CAVE: UNROOFED CAVE ON SAN SALVADOR ISLAND, THE BAHAMAS, AND ITS IMPORTANCE FOR DETECTION OF PALEOKARST CAVES ON FOSSIL CARBONATE PLATFORMS

Pavel Bosák & John E. Mylroie & Jindřich Hladil & James L. Carew & Ladislav Slavík

The comparative studies on Quaternary carbonate platform (San Salvador Island, the Bahamas) and Devonian Carbonate Platform (Krásná Elevation, Moravia) indicates a great parallel in karst evolution during unconformities. Both sites show similar tectonic/paleotectonic setting at passive margins of continents, high thickness of cyclically arranged carbonate sequences and influences of glacio-eustatic sea-level changes. On both platforms, preserved stratigraphic sequences record less than 10 % (the Bahamas) and about 5 % (Moravia) time of evolution. Nevertheless, there is difference in the character of subsidence and rank of unconformities. The Great Bahama Bank has subsided with relatively constant rate since Cretaceous, but the Krásná Elevation was typical by minimum subsidence during the whole Paleozoic. Breaks in Quaternary of the Bahamas can be compared with unconformities of the 4th order (parasequence boundaries) while hiatuses on the Krásná Elevation are unconformities of the 3rd to 2nd order (regional unconformities and superunconformites). Also time of sediment accumulation differs, on Bahamas sediment was deposited during periods lasting 10^1 ka, in Moravia depositional events had 10^2 to 10^3 ka in duration. Nevertheless, the evolution model of carbonate platforms and karst/caves is philosophically easily comparable.

The alternation of deposition and nondeposition led to creation of the freshwater lens during gaps. The concentration of caves in boreholes along fossil shoreline of the Krásná Island and their fill indicate the origin as phreatic flank margin caves, which easily developed

during relatively short time of individual sea-level highstands. Complicated geomorphic agents (erosion, chemical denudation, abrasion) during periods of prolonged hiatuses led to cave unroofing. Unroofed caves contain preserved fill of minor marine ingressions.

The gamma-ray spetrometry (GSR) pattern of the fill of Quaternary Blow Hole Caves (Bahamas) shows striking similarity with the natural gamma-ray (GR) well-log from the Devonian Krásná site. The sedimentary fill of both caves is genetically comparable – beach and eolian sediments with bodies of breccias. The magnetic susceptibility study on the fill of the Blow Hole Cave indicates the dependence on the eolian delivery of fine-grained silt concentrated in trap of the cave and its combination with microbial production of magnetic minerals. Uranium data confirm the general idea that weathering and sedimentary carbonate cave fills would be co-indicated or directly indicated by relatively high uranium concentrations in rocks that otherwise show only generally low background values. An elevated radioactive signal forms broadened, head-shaped, peaks on the GRS or GR curves.

HIGH RESOLUTION MAGNETOSTRATIGRAPHY OF SPELEOTHEMS FROM SNEŽNA JAMA, KAMNIŠKE-SAVINJA ALPS, SLOVENIA

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The Snežna Jama Cave is located in Kamniške-Savinja Alps, Northern Slovenia, in a Raduha Karst Masif. The cave is huge, more or less horizontal representing fossil phreatic/vadose conduit. It is dissected by vertical shafts, which represent Quaternary invasion vadose conduits. Just in the entrance part of the cave, there is about 3 m high wall composed of speleothems. Speleothems are developed as complex sequence of flowstone with numerous breaks in deposition, six of them are principal. The lower part of the profile contains abundant terrigenous component (most probably clay of terra rossa-type). Stalagmites developed in several periods are completely buried by nearly horizontal younger sequences of flowstone. Some stalagmites were buried even broken. Approximately 2.4 m of flowstone were samples continuously in three successive profiles. The column of the rock was cut to cubes in the laboratory (2x2x2 cm) and studied both by thermal demagnetisation method (23 samples, 12 steps – 20 to 620 ^{o}C) and alternating field method (100 samples, 14 steps – 1 to 100 mT). Magnetic properties clearly identified the lithological boundary at about 85 cm of the profile, when brownish and highly porous speleothems changed into classical laminated compact type. The lower part of the profile shows both higher magnetic susceptibility and higher remanent magnetisation. Magnetostratigraphic results indicate the presence both of normal and reverse polarised magnetozones in a very complicated picture. There are 5 normal polarised subchrons and 4 reverse polarised subchrons. The age of the speleothem sequence was proved also by the U-series alpha-counting spectrometry. All samples studied were outside the method range, i.e. over 350 ka, U isotopic equilibria indicate the age over 1.2 Ma. The age of the fill is pre-Quaternary, clearly older than 1.77 Ma. The most probable correlation is about 1.8 to 3.5 or 3.1 to 4.9 Ma. Both possibilities indicate the growt time of speleothems for about 1.7-1.8 Ma, which can indicate the growth rate of speleothems about 1.3 m per 1 Ma.

SEDIMENT LOAD TRANSPORT VIA CAVE SYSTEMS IN LIMESTONE AND SALT KARST AND RELATED FEATURES OF EXO- AND ENDO-KARST

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Sediment load transport was studied in two different types of karst:
(a) Salt karst on five salt plugs in SE Iran: Hormoz, Namakdan, Kurgu, Kuh-e Jahani and Larak salt plugs. (b) Several limestone karst areas in Czech Republic (Moravian and Bohemian Karst, Javoříčko Karst, several karst occurrences of metamorphosed carbonates in southern Bohemia and Jeseníky Mts, etc.).

Significant difference exists between these two karst types. The extreme dissolution rate in salt karst enable the corrosional enlargement of caves to keep pace with large amount of sediment carried into cave by alochtonous streams. Predominant part of sediments can be trapped in karst environment. In carbonate karst, on the other hand, the corrosional enlargement of cave passage running from ponor to spring is too slow compare to the amount of sediment load carried by alochtonous stream into the cave. This can be simply demonstrated if we compare the volume of large blind valleys in non-karst rocks with volume of related cave systems, which drain such depressions. Commonly the volume of caves is at least several hundred times smaller than the volume of depressions above the cave. This means, that almost all clastic material carried into carbonate karst by streams must be transported via cave systems to the discharge point

There exist two end members of karst areas with respect to the sediment transport in the Czech Republic:

(1) Streams in the Moravian Karst are sinking in large closed depressions (i.e. blind valleys with volumes much larger, than the volume of cave system). Flow conditions in cave systems must be therefore capable to transport nearly all clastic load carried by stream into cave via recently active cave passages to the resurgence.

(2) The Bohemian Karst, Chýnov Karst and several other areas in the Czech Republic show different picture. Despite of long-term karstogenesis and existence of small streams traversing the karst areas for tens of millions of years, there is lack of concentrated ponors. Blind valleys are completely missing. Transport of clastic sediments via cave systems does not exist in such areas. There is even no turbidity in spring water after precipitation events. In such areas, the caves are often batyfreatic and the hydraulic gradient is too low even during floods to ensure sufficient velocity to enable sediment transport via existing conduit systems. It is also common in these areas that geological settings prevent shallow phreatic cave systems to develop in whole paths among recharge and discharge areas (carbonates occurs only in depths between the recharge and discharge area due to tectonic movements, etc.). In areas where the above-mentioned factors preclude transport of sediment load, common karst landscape with blind valleys will therefore never develop.

There is a significant difference in intensity of gradational processes between karst areas of (1) and (2) group. It was demonstrated by Ford and Ewers (1978), that sediments plays very important rule in paragenesis, bypassing and also in vadose entrenchments. In areas where sediment load transport in conduits does not take place, the caves remain mostly phreatic as the gradational processes are cut down.

A REVIEW OF TURKISH KARST WITH EMPHASIS ON GEOLOGIC AND CLIMATIC CONTROLS

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Turkey is among the Mediterranean countries that exhibit classical karst in large scale owing to the extensive carbonate rocks that form about one-third of the country (Milanovic, 1981). The country structurally is located in the Alpine orogenic belt and affected by strong orogenic movements involving the carbonate rocks, which is known as one of the basic reasons for the extensive karstification of most carbonate rocks in Turkey. The early stage of karst studies that included mainly comparison of different karsts to understand the phenomenon, has produced several classification schemes. Eroskay and Gunay (1979) defined the karst types in Turkey following the tecto-genetic approach classification of karst as proposed by Herak (1977). In their work, they divided the country into four tectonic based on the tectonic classification of Turkey by Ilhan (1954). As new works on tectonics, stratigraphy and karst morphology came out, this rather broad classification required a detailed revision so as to provide an insight into the karst of the Turkish Karst with emphasis on the processes controlling the phenomenon.

This paper re-evaluates the karst phenomenon in Turkey basing on the post-1980 works on tectonic, geologic, climatologic and morphologic characteristics. The information collected so far suggests that subdividing the country into four geographical regions in order to describe and understand the karst phenomenon in Turkey is quite insufficient and more importantly leads to erroneous conclusions. On the contrary, based on this voluminous works, the Turkish karst can be described and consequently classified basing on the factors controlling karstification processes, instead of subdividing the country into regions whose boundaries rather arbitrary and far from reflecting the essence of the phenomenon. In this context, the Turkish karst can be reassessed according to a) source of energy gradient b) lithostratigraphy (thickness and petrography), c) relation between the type of erosion base (sea or continental element) and the dominating tectonic regime (paleo/neo and compression/tension) and d) climate and soil conditions.

In the karst map that is prepared to demonstrate the history of the processes and the related controlling factors, two main karst types, including sub-types are described as follows:

1. Evolutionary karst which implies continuous karstification but at different stage of maturation. The rock masses form high-yield karst aquifers. Subclasses can be defined under this type of karst according to the source of energy gradient, e.g. a-Rapid uplift controlled juvenile karst (Taurus Mountain Belt). Climate changes have secondary role in karst development. b- Sea/lake level controlled juvenile karst (Weakly active Northern Province-Black sea zone). Climatic changes are pronounced in this type of karst. c- Relict karst which implies that the karstic features that have ceased to function hydrologically because the underlying impervious unit become shallower and/or the carbonate rock masses are dissected into small pieces due to regional slow uplift so that they do not form media for continuous flow. Also capture of karst features by drainage elements is resulted in relict karst. This is mainly due to the rapid incision of major rivers such as the Sakarya River in Central Anatolian Province and the Euphrates in the East Anatolia Contractional Province. Climatic changes are as important as the regional tectonics in development of this type of karst.
2. Rejuvenated karst form by reactivating a formerly (probably during paelotectonic episode) developed and subsequently ceased karst structure either by an uplift and/or a drastic decline

of erosion base. Recently developed karstic features can be recognized within older and mature karst features are common. This type of karst is common particularly at the Anti-Taurus belt, as well as some parts of the Central Anatolian Province. Climate and tectonics has a sequential influence on the rejuvenation.

FROM DOLINE DISTRIBUTION TO TECTONIC MOVEMENTS EXAMPLE OF THE VELEBIT MOUNTAIN RANGE, CROATIA

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The influence of tectonic forces on the karst relief development has been studied using dolines as geomorphological markers. The strain and stress orientations have been calculated from the doline distribution applying the centre to centre method (Ramsay, 1967 ; Fry, 1979). 623 local results have been obtained which were later injected into a 2D finite element model created in Castem 2 000 software. As the observed deformations are the consequence of the tectonic displacements, the numerical model tends to simulate the tectonic conditions which produce the observed deformations. A special fault block model of the Velebit mountain range has been done. The results from the centre to centre method were interpolated on the 1 085 nodes of the mesh created in the model. Some blocks without initial data were added on the east and west side of the model to avoid edge effects. The boundaries are fixed and no displacement added because the aim of the model is to obtain pure results inferred directly from doline measurements. The program proceeds toward the resolution until the necessary displacements are obtained which equilibrate the imposed values. In this way the distribution of the principal stress and shear stress have been obtained over the whole studied area. The strain and displacement trajectories were constructed to facilitate the analysis. Finally the results were correlated with the GPS measurements and a great coincidence was observed.

AMATÉRSKÁ AND DEMÄNOVSKÁ CAVES: TWO LARGEST FLUVIOKARST SYSTEMS IN CZECHOSLOVAKIA

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The Amatérská Cave located in the Moravian Karst (Czech Republic) was formed by subsurface streams in dependence on the morphology of karst valleys representing a local base level before the Badenian (Middle Miocene) marine transgression. During the Quaternary, stream activity in the caves alternated with speleothem deposition. Fluvial sediments deposited in the Early, Middle and Late Pleistocene are preserved mainly in ponor passages of the cave system. However, fluvial sediments filling the caves near resurgences of subsurface streams were deposited only in the Late Pleistocene. The age of cave deposits was assessed by paleomagnetic record, U-series, radiocarbon and cosmogenic isotope datings. Filling of cave corridors with sediments was induced by blockage of passages caused by local events in many cases (e.g., the collapse of cavities). As a result, bodies of fluvial sediments in the Amatérká Cave system cannot be correlated with fluvial terraces formed by surface streams.

The Demänovská Cave system located in the Low Tatra Mts. (Slovak Republic) consists from 8 levels filled by fluvial sediments deposited during the Late Tertiary and in the Early, Middle and Late Pleistocene. Cave passages were filled with deposits in dependence on gradual lowering of valley bottoms representing local base level. Sediment transport by local streams dominated in the Tertiary, while meltwaters fed by mountain glaciers transported sediments into the cave passages during the Quaternary. The age of cave deposits was assessed by paleomagnetic record and U-series datings. Deposits preserved in the Demänovská Cave system allow to correlate subsurface fluvial processes with Pliocene and Pleistocene river terrace system of the Váh River flowing 10 km north.

DEFORMATIONS OF SPELEOTHEMS AS INDICATORS OF PALEOSEISMICITY: EXAMPLES FROM BULGARIA

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The caves represents environment that is favorable for recording and conservation of damaging evidences caused by earthquakes. The broken and deformed speleothems in the caves are accepted by many researchers as a good tool for paleoseismic reconstruction. The speleothems potentially broken by a seismic event can be dated by various geochronology methods (U/Th, C14, etc.) and offer possibilities to obtain the age of the paleoearthquake that caused the collapsing. The study of the paleoseismicity on the base of speleoinformation (fallen speleothems, breakdowns, etc.) is a new type of research in Bulgaria. Deformations of speleothems are established in the Lepenitsa Cave and Shepran Cave, Rhodopes Mts, South Bulgaria, Troana Cave, Fore-Balkan, North Bulgaria, etc. The detailed geomorphologic study and the statistical analyses of the orientation of the deformed speleothems proved the possible coseismic origin of the deformations.

DEVELOPMENT AND CHARACTERISTICS OF THE KARST AND KARST PROCESSES IN VRATSA MOUNTAIN (WEST BALKAN, NW BULGARIA)

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Vratsa Mountain is one of the most interesting and representative mountain karst massifs in Bulgaria. It is situated in the West Stara Planina (Balkan) and attracts the attention with numerous karst forms and complicate orographic, lithostratigraphic and tectonic conditions. Here are established about 400 caves and potholes. The lithologic and structural control are the main geologic preconditions for intensive karstification. The fault zones determine the borderlines of the region and some of the lithologic boundaries between carbonates and unpermeable rocks determine the location of some of the deepest caves in Bulgaria (Barkite 14 Cave - 356 m, Belyar Cave - 282 m, etc.). The tectonic stress-field analysis permit the commitment of the directions of the preferred karstisification in this area. The Vratsa Mountain is characterized by high annual rainfall with considerable dynamics during the year -- precondition for high activity of the karst processes. The drainage of the karst waters is accomplished completely by springs at the base of the massif. The antropogenic presence in the region influence on the environment and the quality of karst water.

ON THE METHODS OF CLASSIFICATION OF THE TYPES OF THE HIGHMOUNTAIN KARSTS, THE CASE OF SLOVENIAN ALPS

Jurij Kunaver

The geomorphological classification is a systematic approach to the variety of landforms which at the end have to be either classified as morhologicaly separate phenomena or could be treated as the constituent parts of certain geomorphological systems. If they reflect the whole geomorphological development and the conditions for it their study could help as a tool for the comparative and sintetic geomorphology. In the past some syntetic and comparative studies on the classification of the Perimediterranean and Alpine highmountain karst were already successfully written, although they are quite rare on the whole. The final result of such an approach is a review of the types of the highmountain karsts in different areas, explained either in a text or in a table, or shown on the geomorphological map. Although some types of the Slovenian highmountain karsts have been partly already included in the upper mentioned syntetic studies, some further efforts in this way will be explained in this paper.

SOME MORPHOLOGICAL MICROELEMENTS OF KARST RELIEF DETECTING UNOPENED CAVES IN SLOVAK KARST IN RELATION TO THE MECHANISMS OF THEIR NATURAL AND/OR ARTIFICIAL OPENING TO SURFACE

Gabriel Lesinsky

An observation of karst relief in detail, especially searching for microelements (e. g. the initial depressions) scattered in it has led in last six years in Slovak karst to very interesting discoveries of predominantly juvenile vertical caves but also other forms of different morphology, speleogenesis and development stage. Symbiosis of correct recognizing these microelements and the way how these unopened caves are displayed to surface in winter enable spelunkers to work efficiently and overrun a nature openig mechanisms by artificial penetration. Dozens of caves discovered in such a way belong to (until discovery) practically untouched underground forms in which the dominant natural opening factors are recognized very well. Several cases are presented in the contribution and relative preliminary teoretical aspects are discussed.

GEOLOGICAL CONDITIONS – FACTOR OF ORIGIN OF TWO DIFFERENT CAVE SYSTEMS IN TWO ADJACENT VALLEYS (THE DEMÄNOVSKÁ VALLEY AND THE JÁNSKA VALLEY, THE LOW TATRAS, SLOVAKIA)

Milan Marusin

The Demänovská Valley is the most famous karst valley in the northern slopes of the Low Tatras. There is developed more than 30 km long Demänovská cave system. The similar karst valley, the Jánska Valley with dozens of underground karst phenomena is situated ten kilometers eastwardly. Total length of these caves exceeds 20 km. The geomorphological, hydrological, and karst conditions of these two valleys are similar nevertheless there are several outstanding differencies between two cave systems developed in these valleys. The whole current of the Demänovská cave system is developed within eastern slope of the Demänovská Valley. On the contrary in the Jánska Valley significant caves are situated on both sides of the valley. Besides this difference the Demänovská Cave system is permeable in its whole length whereas cave system of the Jánska Valley is not permeable although connection of underground spaces was proved by varios methods. Described state is caused by different geological conditions in these valleys. Both cave systems are developed mostly in the Middle Triassic Gutenstein limestones. But the Demänovská Valley is situated at the area which is built by monocline of the Krížňanský nappe. In the territory of the Jánska Valley there is the Chočský nappe which is tectonically very complicatedly framed.

Key words : geological conditions, cave system, Gutenstein limestones, Demänovská Valley, Jánska Valley, Slovakia

MORPHOGENETICAL KARST TYPES OF THE TRANSYLVANIAN MOUNTAINS (MT. APUSENI)

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The most well developed karstic forms in the whole of the Carpathians emerged in the Transylvanian Mountains (Mt. Apuseni) situated between the Transylvanian basin and the Great Hungarian Plain. This phenomena correlates with the diversity of structure and rock formation, and to the multifold nature of denudation processes. Carstified rocks occur in the Transylvanian Mountains on such a large territory and in such a great variety that to show all is impossible in the scope of this paper. My intention is to present a survey and morphogenetic systematization of the most interesting karstic regions (karst plateaus of Padis, Scărişoara, Padurea Craiului [Királyerdő], Codru-Moma [Béli], Trascău [Torockó[Mountains, Transylvnian Ore Mountains [Munţii Metalliferi]).

The development of the nappe structure of the Transylvanian Mountains ended essentially during the nappe formation of the Upper Cretaceous period. In the later periods, only the uplift and sinking of the area took place, accompanied by important levelling processes. In the last decades, Romanian geomorphologists described three such planated surface remnants, formed via levelling. These can be found at different heights, due to tectonic movements. The strikingly flat peaks rising highest in the Transylvanian Mountains were formed by tropical surface planation taking place in the Cretaceous and the end of the Oligocene. The peaks of the Gilau and Bihor Mountains and Vlădeasa, rising between 1600-1800 m, are assumed to be the remnants of tropical peneplain surfaces. The 1000-1400 m high surfaces embracing the three highest mountains developed by a levelling process taking place under Mediterranean weather conditions in the Miocene epoch. Lastly, the researchers identified a third, lower pediment surface as well, formed in the Pliocene. These three surfaces form a step-like relief in the Transylvanian Mountains. The differently aged and structured limestones also appear ordered to the above mentioned geomorphological levels.

The ophiolite-flysch zone in the Trascău (Torockó) Mountains the Upper-Jurassic reef limestone appears on a larger area and plays an important role in the formation of the landscape. Almost on the whole of the 70 km long mountains, in a number of parallel ranges, the so-called Titon (or Sramberg) Limestone runs through. This appears in the most variable forms such as nappe, klippe, patch reef and olistolith. Titon limestone makes up the highest peaks, around 1300 m, the Ciumerna (Csumerna) plateau (or Vârful C.), and the Bedeleu (Bedellő) Mountains. The somewhat lower Piatra Cetii and Vârful Plesii belong to a smaller-sized klippe. An Upper Jurassic limestone range is settled on basalt rock of a submarine volcanic ridge, and runs from Trascău (Torockó) towards Tureni (Tordatúr). Blocks (olistoliths) of varying sizes of the same limestone rise by the hundreds. The embedded Cretaceous flysch surface and individual cliffs or spectacular peaks "hover" above the environment. The most beautiful are the Piatra Craivei, the Sfredelasul (1132 m) and the Bulz (939 m).

SMALL KARST FEATURES (KARREN) OF LONG ISLAND AND KORNATI ARCHIPELAGO COASTAL KARST

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Long Island and Kornati archipelago islands are characterized by karst morphology. Small karst features are particulary well developed along the coast in the swash-zone, and significant differences can be observed due to different interaction of wave action, bedding attitude, bed thicknesses and lithologies. Among the other karren types, fissure- and network-type karren are particulary interesting, both of which start developing from initial pot karren which at the small distances of just several meters turn into debris-karren.

The age of some of these small karst features can be estimated by their occurrence in ancient quarries, and we suggest their historic age.

We can envisage the future development of these small coastal corrosion features, and estimate future intensity of the corrosion.

QUANTITATIVE CHARACTERISTICS OF DOLINES IN SLOVENIA

Mitja Prelovšek in Miha Staut

The students of the subject Geography of karst at the Department of geography (Faculty of Arts, University of Ljubljana), have under the mentorship of prof. Andrej Mihevc (Institute for the research of karst) and prof. Karel Natek (Department of geography) decided to make a detailed morphometric analysis of dolines in Slovenia. The purpose of the research was to find out whether there are any differences in the shape of dolines in an area as small as slovenian karst. At five characteristically different sites (Gropajska gmajna, south of the village Povir, near Vrhnika, Žužemberk and Stojna-Velika Kočevska gora) sample areas of 1 km^2 were taken. Sixteen parameters were taken to be measured: average elevation (a.s.l.) of the surrounding surface, surrounding surface inclintation, azimuth of the surrounding surface inclintation, elevation (a.s.l.) of the bottom of the doline, min, max and avg depth of the doline, min, max and avg inclination of the doline slope, the length and azimuth of the long axis, width, the inclination and azimuth of the beds dip. In the light of newer views of the karst geomorphic system development also some other diagnostic features were taken into account: the length of dry walls, surface occurings of speleothemes and other signs of denuded caves, rounded peaks, lime-kilns etc. Analysis and evaluation of the collected data was performed with the help of programmes Microsoft Excel™, Surfer™ and Idrisi for Windows™. On the basis of this year measurements and measurements performed (provided) by the following year students, maybe in the spring 2003 some more comprehensive results will be achieved. Meanwhile it was decided to bring out some preliminary results.
(™: all the programmes are trade marks of their respective companies)

KARST TYPES AND TERMINOLOGY IN SOUTH CHINA

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Good knowledge of terminology in different languages is indispensable to be able to present correctly the results of scientific work, for international cooperation of experts and for translating professional texts. Purpose of the present poster is to represent the typical Chinese karst landscape, it's subtypes and to explain the terms used in the country. Although the author was striving after as high professionalism as possible, she tried to find a proper professional term in English language for each karst phenomenon. In cases where a foreign word is possible to replace some more descriptive English words or if there are no English words in use yet, it is much more appropriate to use such foreign words. Since due to characteristically geological, climatic and other geomorphological factors the karst landscapes in the South China are of unique character, violent translation into English language would be of more harm than benefit. Although karst researches in China are carried out separately from the karst-sciences of western countries, terms such as *fengcong*, *fenglin*, *shilin* are enforcing gradually into international karst terminology. Question how to introduce new terms into narrower professional public sphere with old terms already established, is still remaining open. Sometimes this is necessary since a new term is of somehow enriched meaning or is gathering more information and improving the understanding. Appropriateness of such decision should be estimated by further discussions, which should be based upon familiarity with the problem and not upon the sentimentality towards the terms, if these have born more general meaning up to this time.

THE KARST OF SALENTO REGION: CONSTRAINTS FOR MANAGEMENT

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The Salento peninsula is the southernmost emerged part of a plate which constitutes the foreland of both est-verging Apenninic and west-verging Dinaric orogens. It comprises a Mesozoic carbonatic sequence more than 6000 m thick - the *Calcari delle Murge* unit - overlain by thin deposits of Neogene and Quaternary age.

The landscape of Salento peninsula is composed of low sediplains interposed to narrow ridges, NNW-SSE trending and up to 200 m a.s.l. high. A polyciclic karstic landscape was produced by main phases of karst development linked to late-Cretaceous, Miocene and Plio-Pleistocene tectonic phases and influenced by different climatic conditions.

The present evolution of Salento karst landscape raised numerous problems of management during last years. In this paper, two examples of sinkhole activity due to the large input of surficial waters are reported.

The first case has been recognized in a karstic landscape shaped on Miocene limestones and calcarenites and mantled by Upper Pleistocene sandy-silty colluvial deposits.

A large amount of water coming from a reservoir produced the prolonged flood of a broad depression and enhanced soffusion processes. These last ones induced the sinking of colluvial cover and the development of a small subsidence dolina which at present hosts a small lake fed by the reservoir surplus water.

A detailed morphological and geological survey reveals that a roughly elliptic depression (major axis of 140 m, minor axis of 80 m) is shaped directly on the bedrock and completely filled by colluvial deposits, up to 6.5 m thick. A narrow cone-shaped conduit, showing vertical axis about 7 m long and diameter ranging from 4 to 25 m, opens at the depression bottom.

The second example has been observed in a wide endorheic area placed in the central part of southern Salento. This area is placed between two narrow morphostructural ridges and characterized by unpervious marls and calcareous marls belonging to different sedimentary cycles of Middle-Upper Pleistocene age. These last rocks cover a basement composed of different units cropping out along two main depressions placed at the foot of the main border fault scarps.

An important karstic phase developed in response to the input of surficial water to the bordering depressions and to an Upper Pleistocene tectonic phase. This phase has been responsible for the development of numerous sub-cilindrical collapse sinkholes (locally named *Vore*) at the end of short, temporary streams. Land reclamation works realized in the area since 1930 have modified the path of major streams and the relative drainage basins.

The 13 March 1996 the collapse of a cave about 19 m deep and 20 m wide occurred in an area marked by two older collapse dolinas which receives the surficial water received by a drainage basin about 15.56 km2 wide. The collapse phenomena are most likely linked to the surficial and underground water circulation as well as to the particular lithostratigraphy of the area.

The described examples stress the necessity to realize a morphological survey of karstic landforms in the Salento region as a base for the correct landscape management and for risk assessment and its mitigation.

SUBMARINE KARST OF CROATIA

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During the last, Late Pleistocene-Holocene transgression, the rising sea flooded a vast part of Dinaric karst. Due to prevalence of carbonate rocks in the drainage area of most of the karst rivers on Eastern Adriatic coast, those rivers carry only 20% of particulates as suspended matter and the rest is dissolved. Consequently, many of typical karst features such as karrens, dolines, poljes, caves, pits, and river valleys and canyons as well, presently under the sea, can still be recognized. Beside these simply drowned features, some new ones were formed by the sea level rise. Those are submerged springs, so called vruljas, and marine lakes.

The most significant evidences of former subaerial conditions are speleothems in submerged caves and tufa deposits of drowned paleo rivers. Both of them could be used for determination of former low sea level stands.

Key words: submarine karst, sea level rise, Adriatic Sea, Croatia.

BASIC TYPES OF KARST IN SLOVENIA VIWED FROM THE POINT OF THE PURE KARST MODEL

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The karst is presented as a self-contained geomorphic system, including underground and surface morphology. The conceptual model is described in terms of eight basic axiomatic statements. True karst relief (surface) appears only when all eight conditions are fulfilled, while six of them suffice the underground karst to develop. Three main types of the karst in Slovenia, i.e. Dinaric, Alpine, and isolated karst, including some more local variations, are interpreted in the terms of the model. It comes out that the diversity of underground and surface types of the karst is due to varioable patterns of the axiomatic statements fulfillment.

TWO PHASE DEVELOPMENT OF THE UPPER CERKNIŠČICA BASIN

Simona Šušteršič

The Cerkniščica catchment area covers about 46.8 km^2, and the most of the area is built up of the upper Triassic dolomite. So, the diferences in the surface roughness are mostly not due to variable lithology, but to diffent degree of tectonically injuried rock. Reconstruction of longitudinal profiles of the main river and of its tributaries revealed that there do not exist multiple terraces, as belived before. Rather than, the river formed only two distinct levels. The older one is about 10-40 m higher, wide, well equilibrated valley. It was formed by the predecessor of the present Cerkniščica, at the time when the river sunk in the area of Begunje and continued its way towards Vrhnika springs, underground. The younger level is controlled by the inrush of the river into Cerkniško polje. Sudden lowering of the erosion base, by the end of Würm, provoked rapid incision into earlier surface, and formation of canyon-like entrenchment. Large amounts of gravel, brought by the river into Cerkniško polje, choked the vertical ponors and diverted the main stream in the direction of Rakov Škocjan. Consequences can be traced in Planinska jama and even in the caves on the other side of Planinsko polje.

STUDY ABOUT DOLINAS FROM CODRU MOMA MOUNTAINS (ROMANIA)

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Universitatea de Vest Vasile Goldis Arad

One of the most important Romanians karst region is situated in the Apuseni Mountains (Carpatii Occidentali). On his western side, as a consequence of a great geological diversity and intense fracturation Codru Moma Mountains represent a large area with underground and surface karstic features.

This paper illustrates a quantitative evaluation of some local specific tipes. Measurements and observations were focused about a few hundred of dolinas from Vascau Plateau.

CAVE FORMS AND ORIGIN OF THE CAVE PECINA V ZJATIH (MATARSKO PODOLJE, SLOVENIJA)

Timotej Verbovšek

Cave lies in Matarsko podolje, between Markovscina and Skadanscina. Surrounding beds are composed of limestones and limestone breccias, lower to upper cretaceous age. The cave was not yet scientifically documented, so we made an exact plan and studied cave forms. Then we were able to interpret the origin of the cave. In the vicinity there are many dolines and collapse dolines. The entrance and final part of the cave are situated directly under the big dolines. Because of the small doline, which can be found above the middle part of the cave, there are many flowstone features. Obvious damages due to the freezing and thawing are found along the most part of the cave; at the entrance there is a lot of cryoclastic gravel. Origin of the cave is typical for the contact karst, but the role of the underground streams from Brkini mountains is yet to be studied.
Key words: cave, Pecina v Zjatih, contact karst, dolines, speleology, Slovenia

PROPAGATION OF A FLOODWAVE IN KARST DURING ARTIFICIALLY GENERATED RECESSION

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During hydrogeological research of the area of north-eastern foothill of Mt. Suva Planina in Eastern Serbia, a borehole of 100 m of depth was drilled in the vicinity of a lukewarm spring Banjica. The borehole had an artesian discharge, which caused artificially generated recession in the adjoining spring Banjica. During this hydrodynamical test, great quantities of precipitation occured in the hinterland of the spring, with the effect of a floodwave.

In this area, presence of two types of karst is obvious in the field and from the geological characteristics of the terrain – confined karst and covered karst. However, the hydrogeological response to the mentioned artificially generated recession proved the presence of at least two more types of karst: deep-seated karst and paleokarst. This can be detected by comparative analysis of the hydrograph of the Banjica spring and the graph of pressures in the borehole. In this way, not only the presence, but also characteristics of various types of karst can be proved (e.g. dimensions and types of karst conduits, relative age of karst, size and extension of the aquifer, etc.).

LIMESTONE PAVEMENTS IN GREAT BRITAIN AND THE ROLE OF SOIL COVER IN THEIR EVOLUTION

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Soil has an important role in the evolution of karstic features. If it is needed to describe briefly the difference between forms which occur under soil and which develop in open-air conditions, it can be said that angular forms are produced directly by the dissolving power of rain, while rounded forms have formed under a soil cover. The role of soil cover in the evolution of limestone features depends on the pH of soil. In general, calcareous soils with high pH (pH of 7 to 9, calcium carbonate content is higher than 10 %) protect the underlying limestone almost completely from erosion, the soil water arriving at soil-bedrock interface is incapable of dissolving the bedrock. If the percolating water is not saturated, then solution will take place. Under acid soil limestone is extensively weathered. Erosion of limestone is most severe beneath deposits supporting acid vegetation and with a pH between 4 and 7 and a calcium carbonate content of 0 to 1 %.

Soil samples were collected on limestone pavement areas of North England. Samples are from runnels, grikes, foot of pavements, top of limestone, grass patches and dolines. During the examination the pH and carbonate content of soils were measured. The questions are the followings: whether there is a connection between solutional power of soil (so pH and carbonate content) and the deepness, smoothness, roundness of limestone forms and whether the proximity to limestone has an effect on the soils.

The results of the measurements verify that the soils with lower pH are related to deeper solution features, not surprisingly as their solvent power is greater than of the soils with higher pH. From the measurements it is also clear that the limestone also has an effect on the soils. Proximity to limestone causes a higher soil-pH, while the soils which do not have direct contact with limestone have a lower, acid pH.

OSOVNIŠKA JAMA, CAVE IN ISOLATED KARST IN THE EAST OF SLOVENIA

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Osovniška jama has been discovered in 2001 during the exploitation of the Middle Miocene limestone in Pijevci quarry in the E part of Slovenia. Isolated subpanonian karst is typical of this part of Slovenia. Karst developed on small isolated patches of shallow limestone. Subpanonian isolated karst is a special type of karst on Lithothamnian limestone, where the surface karst forms are very well developed but no long caves were known. Osovniška jama is the longest cave in this part of Slovenia. In this area the general dip of limestone beds is towards SE at dip angle 20^0. The main tectonic structures of the area are in NW-SE and E-W directions. In the quarry reef limestone is massive and fissured in E-W, NW-SE and N-S directions. Cave generally follows the NW-SE direction. The shape of channels still shows its formation in phreatic conditions; but mostly the transformation and formation of its channels in vadose zone is expressed. In some time of this cave development the allochtonous clastic sediments filled up upper parts of the cave, after they were almost entirely washed away. There are a lot of flowstone formations in this cave.