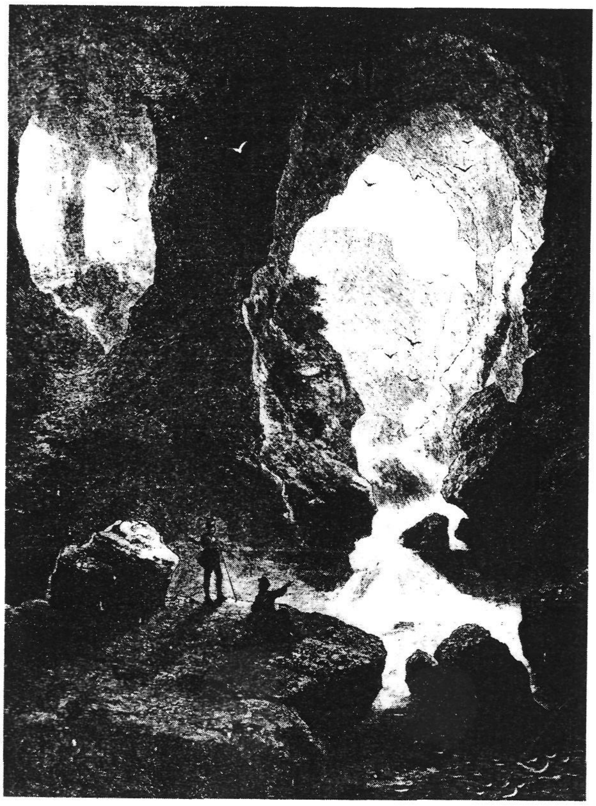
Speleological Association of Slovenia
and
Karst Research Institute ZRC SAZU

5th INTERNATIONAL KARSTOLOGICAL SCHOOL

Classical Karst



CAVES

Guide-booklet for the excursions
and abstracts of the papers

Postojna, June 1997

Organizer:
Karst Research Institute
Scientific Research Centre of the Slovene Academy of Sciences and Arts

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Postojna Commune
Postojna Cave Tourism p.o.
Škocjanske jame Caves

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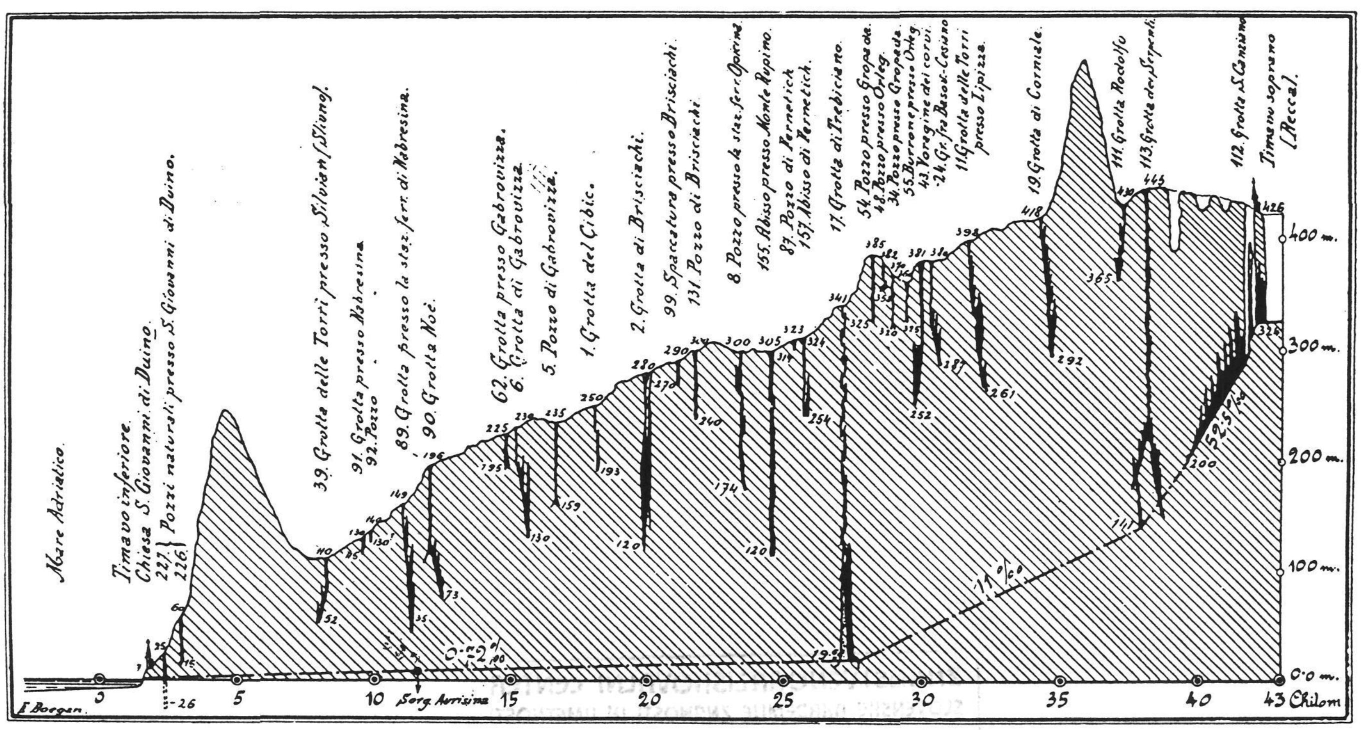
ŠKOCJANSKE JAME CAVES

Monday 30 June

Martin Knez



Authors:
dr. Martin Knez
mag. Janja Kogovšek
dr. Tadej Slabe
dr. Stanka Šebela

ŠKOCJANSKE JAME CAVES

Monday, June 30, 1997

Martin Knez

The Škocjanske Jame Caves are part of the Škocjan Karst. This south-eastern part of the Karst (Kras) borders in the south-east on the impermeable flysch rocks of the Brkini hill region, from which there flows the river Reka, which has hollowed out more than 6 km long system of Škocjanske Jame caves.

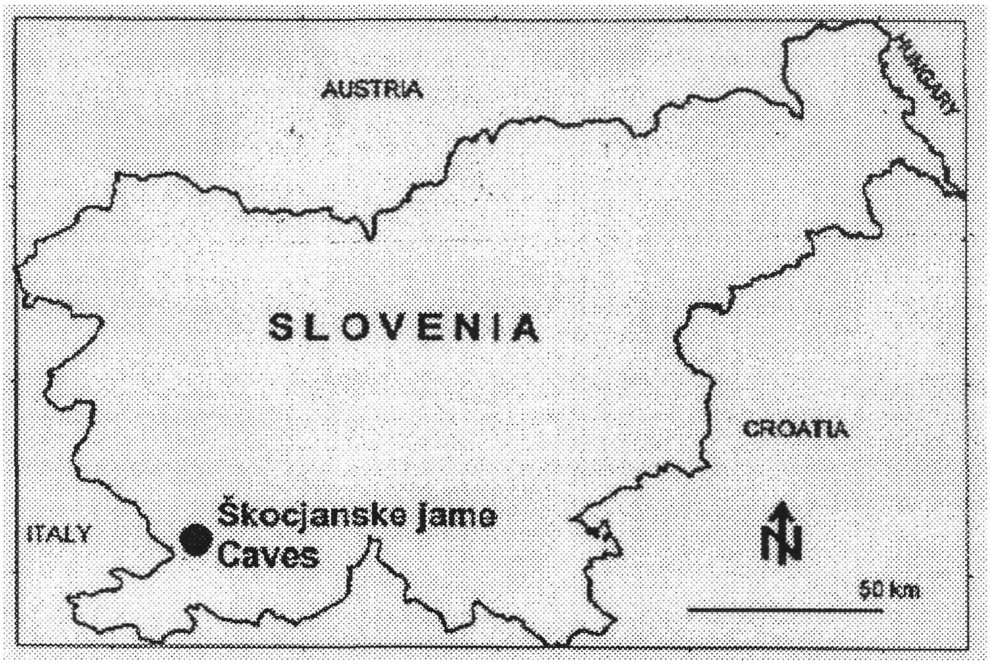
The surface of the Reka basin is 330.8 km^2, 2/3 of which is composed of impermeable rocks. In autumn when the Reka waters rapidly rise and flood, high overflow waters cause an increase in water amount by as much as 5 m/h (Rojšek 1983); the highest discharge is: Qmax = 387 m^3/sec (Gospodarič 1983; Kranjc 1986).

The elevation difference between the Reka ponor and the sources of the river Timavo (Italy, N of Trieste) is 327 m (Boegan 1938). For its 39 km long underground flow, the water needs 8 days at medium high waters. The velocity is approximately 0.056 m/sec. Due to a limited flow capacity, water in the cave can rise by about 50 m in high water conditions.

One of the reasons for the development of the contact karst (Gams 1987; Mihevc 1993) near the system of Škocjanske Jame caves in such a distinctive way is certainly the large amounts of water of the sinking river Reka, with an average discharge of about 11 m^3/sec. The Reka is the largest Slovenian sinking river. In the valley Vremska Dolina, the Reka formed the largest Slovenian blind valley. About 242 million m^3 of carbonates have been washed away from this area. In the Reka canyon in Vremska Dolina, shortly before the ponor to the Škocjanske Jame caves, about 20 million m^3 of limestone has been transported from its primary site by the river (Jakopin 1981).

Southern Slovenia is part of the Dinaric carbonate platform (Buser 1989; Drobne and Pavlovec 1991). According to Buser (1988), this territory belongs to the Outer Dinarides and according to Herak (1986), southern Slovenia is part of the Adriatic region.

Škocjanske Jame caves are one of the most important karst objects (Čelhar 1996; Knez 1996; Kogovšek 1994; Otoničar 1994; Slabe 1995; Šebela 1994; Zupan 1991) on the Classical Karst and in the rocks that are the most typical and widespread on the Karst. For 10 years it has been a UNESCO World Heritage site. Geological data indicate that the accessible passages in Škocjanske Jame caves developed in Turonian, Senonian and Maastrichtian limestone.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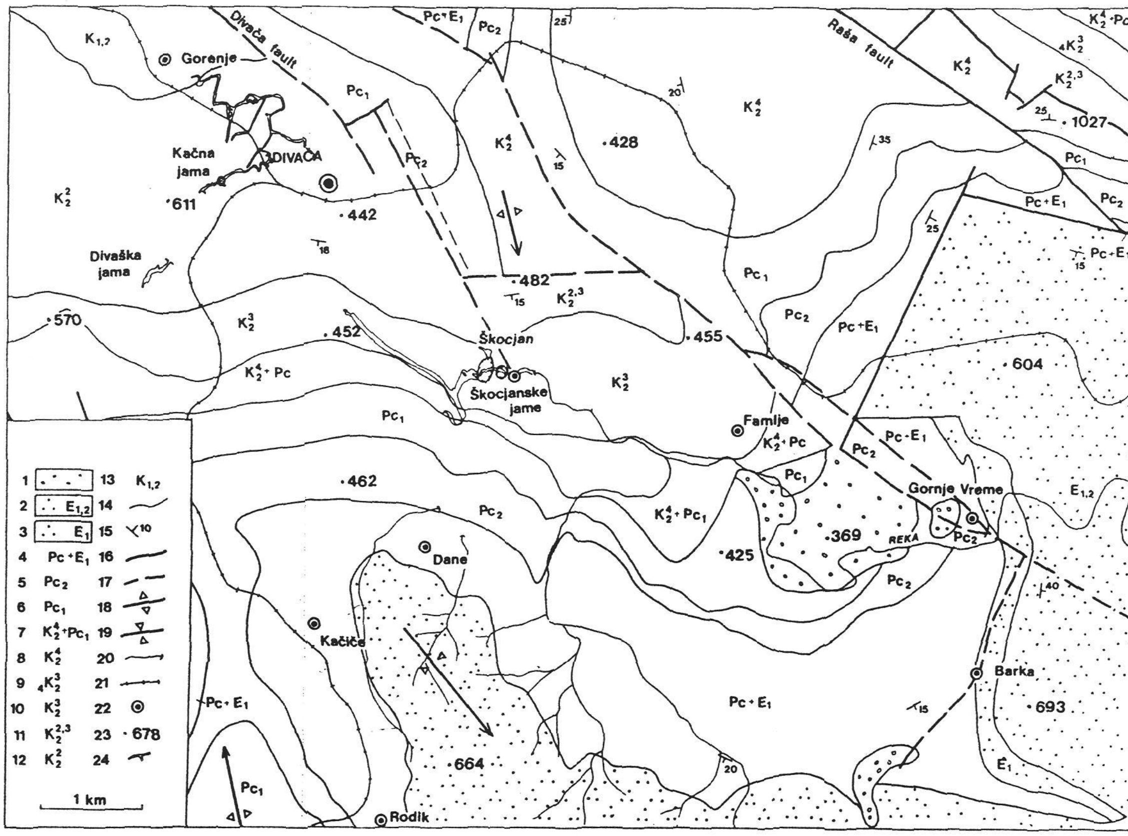
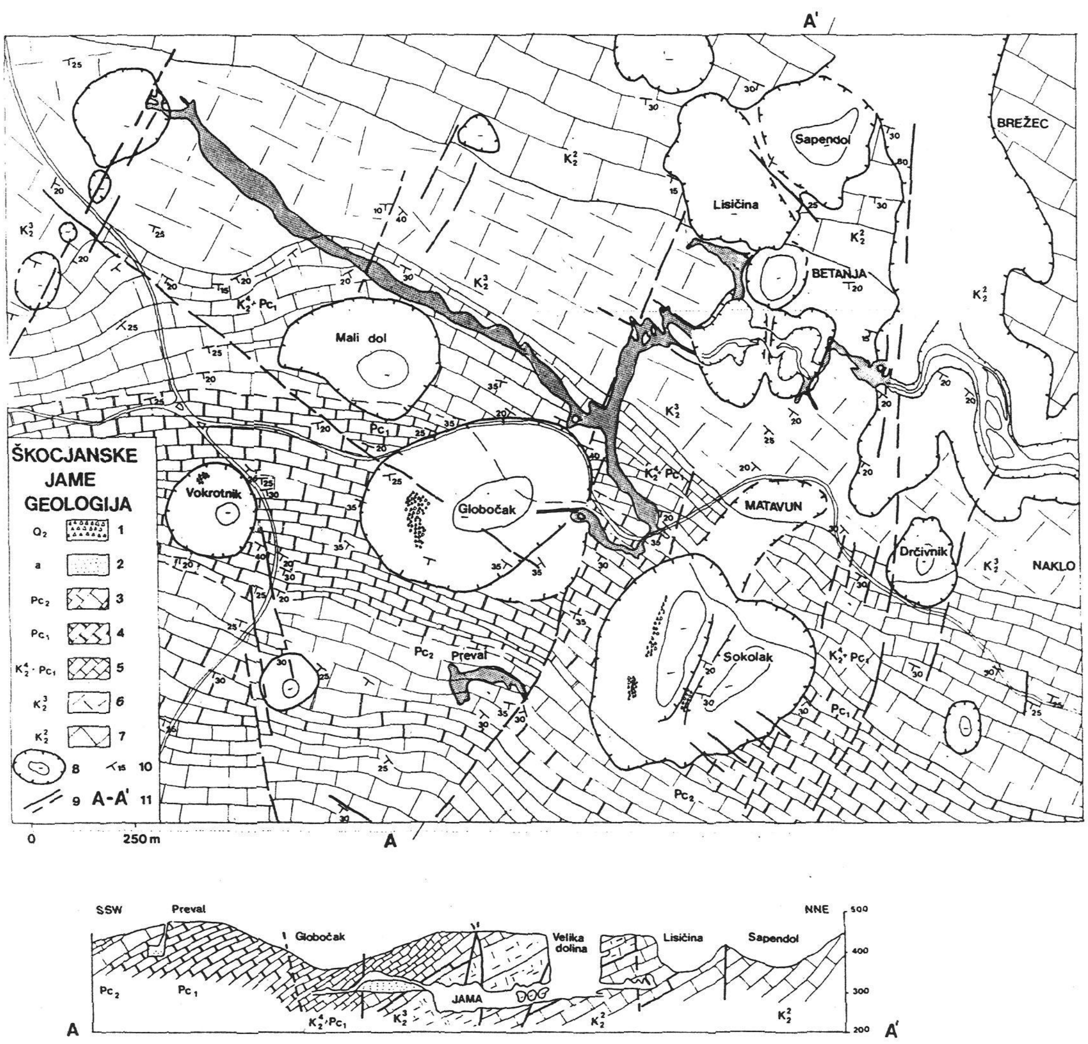
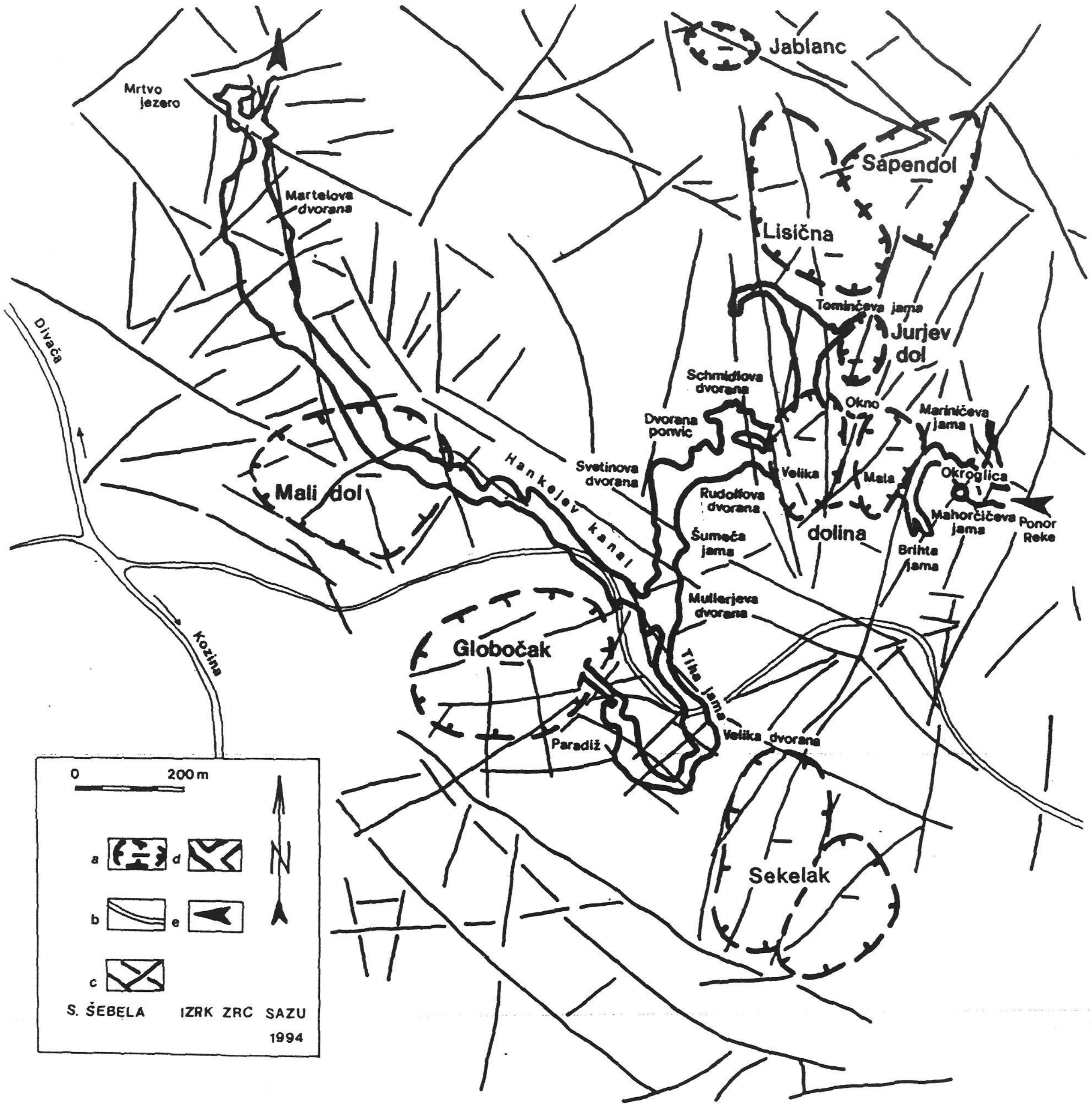


Geology of Divača Karst.



Geologic Map of Škocjanske Jame Karst.

HABIČ, P. et al., Škocjanske jame Speleological Revue.- Internat. Journ. of Speleology, 18, 1-2, 1-42, Trieste.



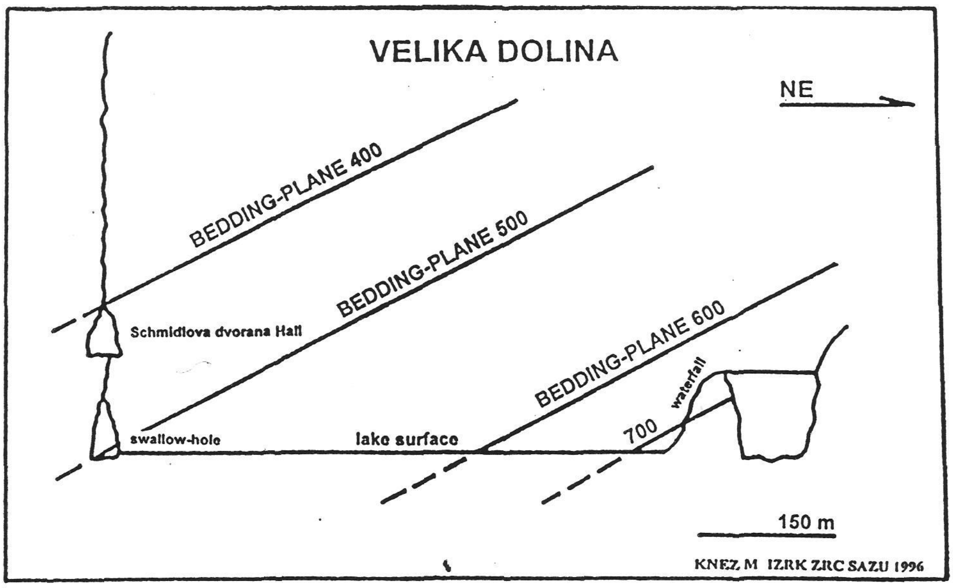
Determination of the Geological Structure of the Surface above the Škocjan Caves by Means of Aerophotography

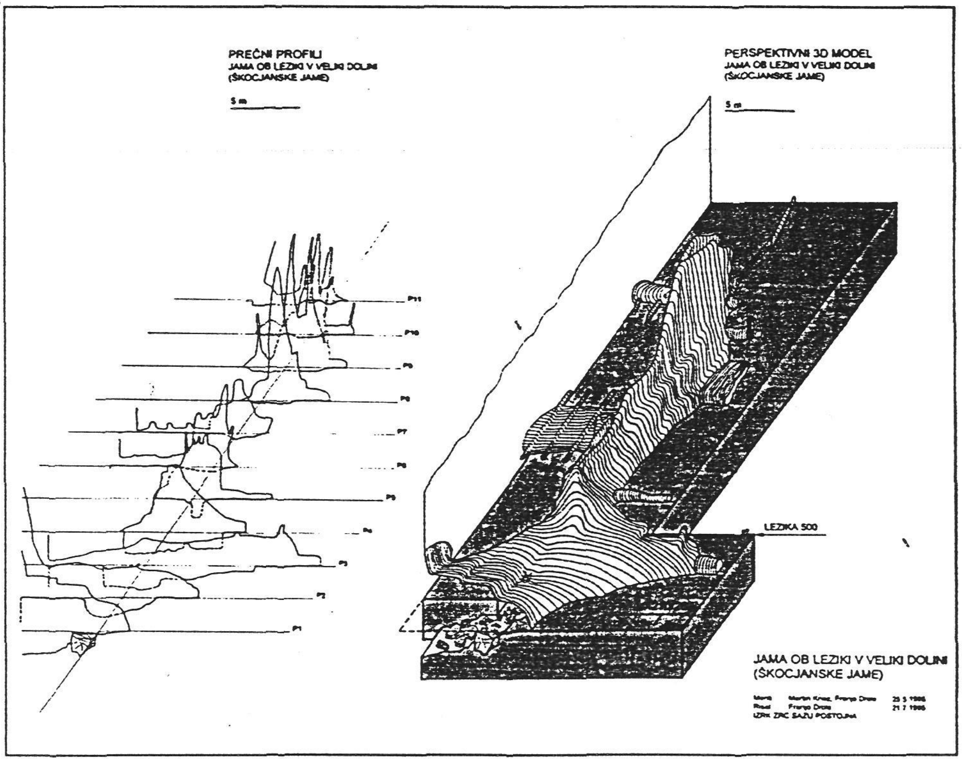
With the help of interpretation of aerophotographic pictures taken in the scale of 1 : 5000 about 39.5 km of tectonic lines were determined on the 3.8 km^2 of the surface above the Škocjan Caves. The most often direction of the underground passages of the Notranjska Reka corresponds to the most frequent direction of the tectonically cracked zones on the surface above the cave, which were determined by means of aerophotography.

ŠEBELA, S. 1994b, Določitev geološke zgradbe ozemlja nad Škocjanskimi jamami s pomočjo letalskih posnetkov.- Annales, 4, 183-186, Koper.

Karst Cave Development from the Bedding-plane Point of View (Škocjanske jame Caves, Velika dolina)

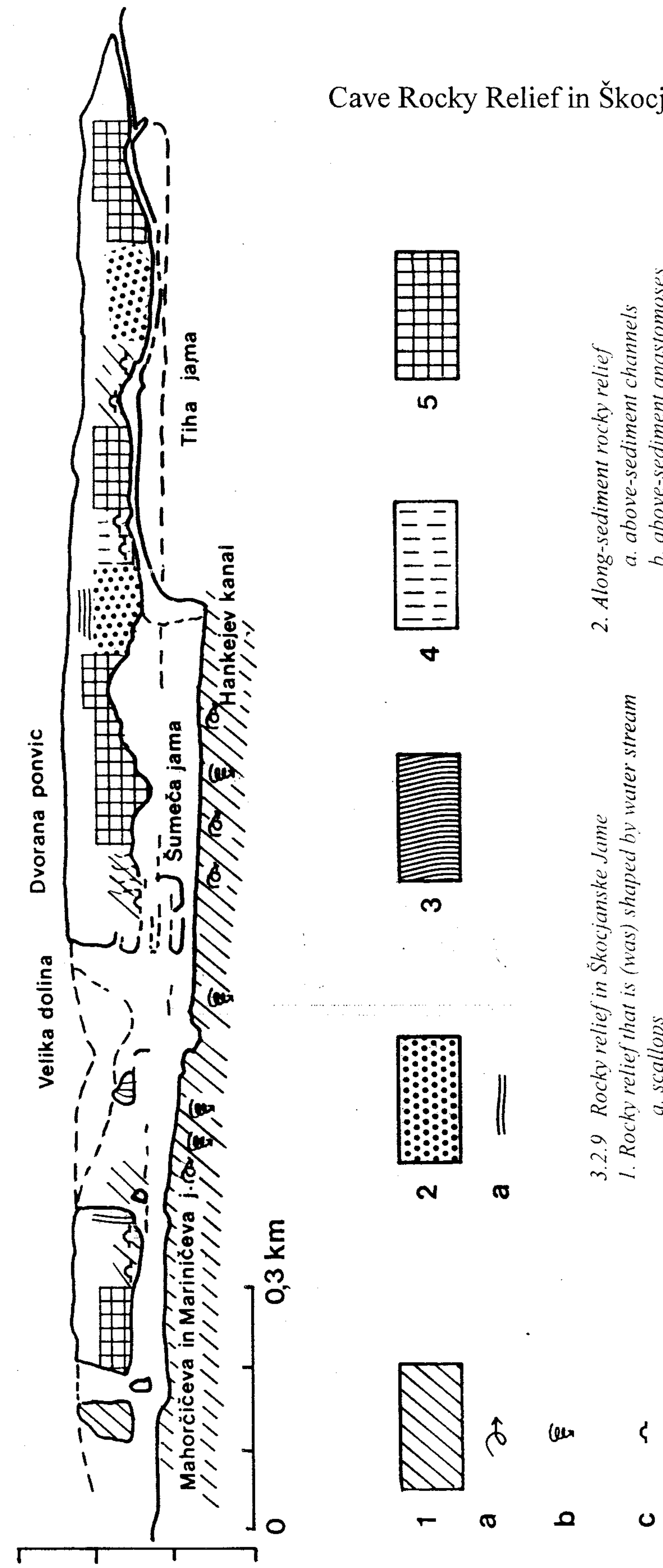
Since the beginning of speleological science the researchers focused the concern on the relation between geological properties (rock, structure) and passage development. The researchers of the Slovene karst underground for a long time register tectonic elements (faults and fissures) on cave surveys; however, lithopetrology and stratigraphy within the studies of cave passage development were underused. Single parameters were partially anticipated, mostly they are guessed. These questions achieved another importance when some researcers stressed the importance of bedding-planes in speleogenesis.





KNEZ, M., 1996, Vpliv lezik na razvoj kraških jam. (Primer Velike doline, Škocjanske jame): Znanstvenoraziskovalni center SAZU, 14, 186 p., Ljubljana.

Cave Rocky Relief in Škocjanske jame Caves



3.2.9 Rocky relief in Škocjanske Jame

1. Rocky relief that is (was) shaped by water stream
- *a. scallops*
- *b. potholes*
- *c. ceiling pockets*

2. Along-sediment rocky relief
- *a. above-sediment channels*
- *b. above-sediment anastomoses*

3. Rocky relief shaped by trickling water

4. Rock transformed by condensation corrosion

5. Rocky relief shaped by perimeter disintegration

SLABE, T. 1995, Cave Rocky Relief and its Speleogenetical Significance.- Zbirka ZRC, 10, 128 p., Ljubljana.

Vertical water percolation and sinter deposition

Rainfall with admixtures dissolves during its infiltration through 50 to 110 m thick roof of Škocjanske Jame up to 310 mg $CaCO_3$ /l. This percolation water appears in various tiny and permanent droppings and in larger trickles with varying discharge, some of them dry up during drought (Fig. 1). In most cases the percolation water is oversaturated and deposits flowstone. Out of 1 l of percolation water from 37 to 170 mg $CaCO_3$ may be deposited which is from 23 to 65% of all the contained carbonates (Fig. 2). Even a tiny drip may deposit half of kg of flowstone in one year. More abundant trickles, specially those that are permanent, deposit substantially more flowstone. The quantity of deposited flowstone is proportional to the quantity of water. As the rate of carbonates dissociated from the percolation water in Škocjanske Jame is considerably higher compared to the caves of Notranjsko, also the flowstone growth is bigger.

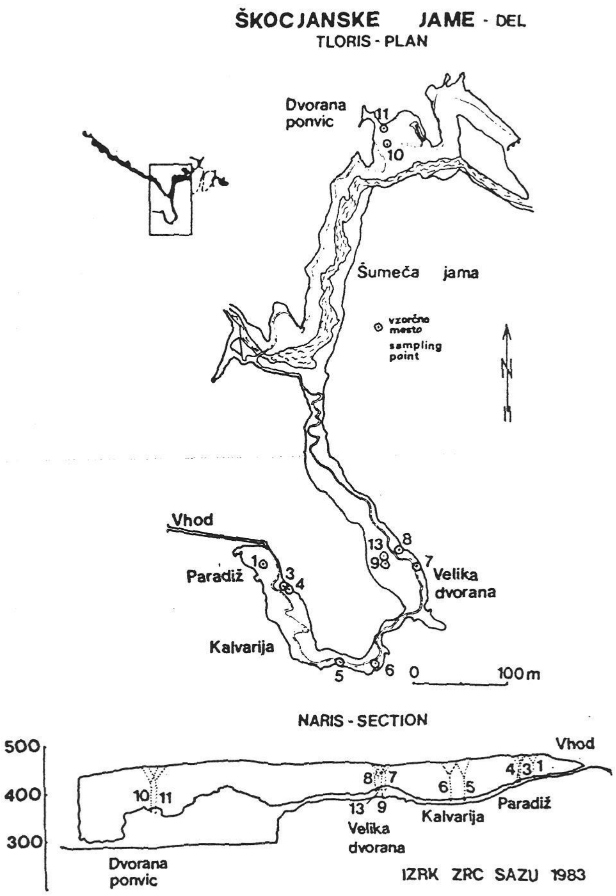
Water quality of percolated water and river Reka

In Tiha Jama increased nitrate levels were found at one point only while the percolation water in Mariničeva and Mahorčičeva Jama is much more polluted (Table 1). This fact additionally proves that waste waters of the Škocjan village must be treated and the surface above the cave must be bettter protected.

Due to progressive industrialization and urbanization in this century the pure Reka had to receive more and more untreated waste waters. The decrease of its quality was observed before 1960 already. According to the measurements from 1969 - 79 Reka was on section Ilirska Bistrica - Nova Sušica a virtual sanitary sewer, where intensive anaerobic processes of decomposition have taken place. Such decay is accompanied by gas and easy volatizable products causing an odour in the valley of Reka and Škocjanske jame which was unpleasend surprise for the visitors.

In autumn 1990 the production in the factory of the Organic acids was stopped and very soon the positive changes in the Reka river were seen. We have analysed Reka in Mahorčičeva jama several times after 1990 (Table 2).

In spite of considerable improvement of the Reka water quality one must be aware that also waste waters of industry and villages along the superficial flow need special treatment.



The situation of observed points Škocjanske Jame.

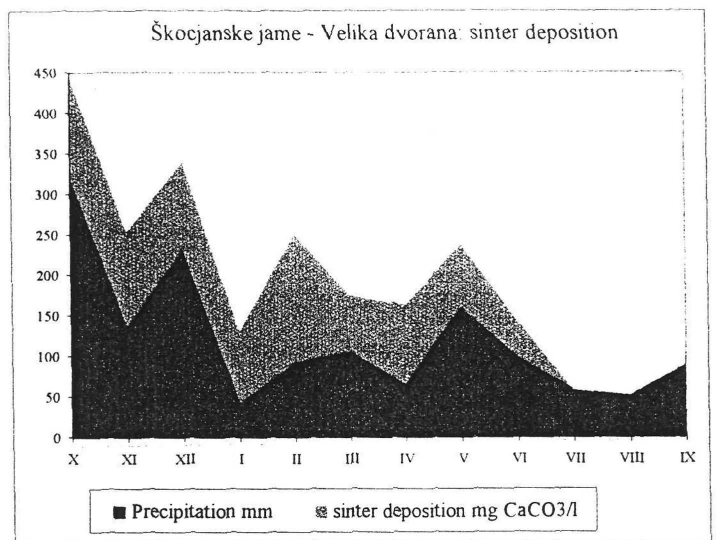


Fig. 2

Table 1

Percolated water in Mahorčičeva in Mariničeva jama

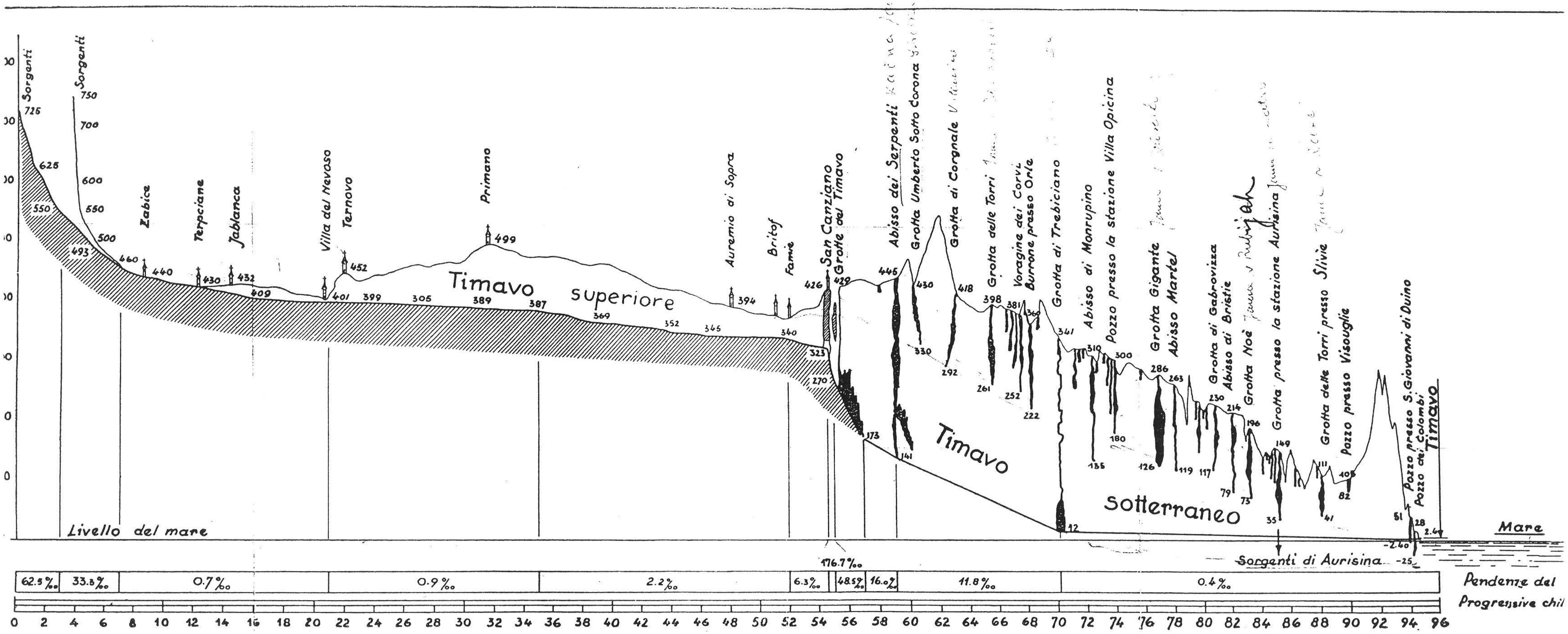
Conductivity	660 µS/cm
Chlorides	16 mg/l
Nitrates	85 mg/l
Sulphates	53 mg/l
Phosphates	5.5 mg/l
COD	8.7 mgO2/l
BOD	1.7 mgO2/l

Table 2 The Reka quality

	SEC	Cl^-	NO_3^-	PO_4^{3-}	SO_4^{2-}	COD	BOD	COD/BOD
Average values 1992-95	345	3,7	4,5	0,03	14,5	6,6	1,8	3,7
June 1993	341	4,0	5,3	0,01	12,0	12,0	2,0	6,0

T - *temperature (°C)*
SO_4^{2-} - *sulphates*
SEC - *conductivity (µS/cm)*
COD - *chemical oxygen demand*
Cl^- - *chlorides*
BOD - *biochemical oxygen demand*
NO_3^- - *nitrates*

KOGOVŠEK, J. 1994, Impact of Human Activity on Škocjanske jame.- Acta carsologica, 23, 74-80, Ljubljana.



Tav. 10 — Profilo longitudinale del Timavo con le varie pendenze del suo letto e le cavità naturali lungo il suo percorso

BOEGAN, E. 1938, Il Timavo. Studio sull'Idrografia Carsica Subaerea e Sotterranea.- Mem. dell'Istituto Ita Speleol., Mem. 2, 16, 251 p., Stabilimento Tipografico Nazionale, Trieste.

ZELŠKE JAME CAVES AND RAKOV ŠKOCJAN - A PART OF LJUBLJANICA CAVE SYSTEM

Tuesday, July 1, 1997

Andrej Mihevc

LJUBLJANICA RIVER SYSTEM

Ljubljanica karst river collects the water from NW part of Dinaric karst and belongs as right Sava affluent to Danube part of Black Sea water basin. The real watershed is placed somewhere in the underground, and the waters from karst plateau are flowing to all sides.

The Ljubljanica water basin is about 1100-1200 km^2. The mean annual precipitation is 1300 - 3000 mm, during 100 to 150 rainy days. The one day maxima amount to 100 mm, in extreme cases even 300 mm.

Most of the basin is formed on the Mesozoic rocks, mostly limestone. On these rocks the precipitations infiltrate directly into the karst and there is no surface rivers. Triassic dolomite is important, allowing some surface flow, forming bottoms of some karst poljes or forming hydrologic barriers.

The highest lying is the karst polje near Prezid (770 m), followed by Babno polje (750), Loško polje (580), Cerkniško polje (550), Rakov Škocjan and Unško polje (520), Planinsko polje (450), Logaško polje (470) and finally by Ljubljansko Barje (290-300m) where the Ljubljanica springs are at 300 m a.s.l.. On the poljes 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.

CERKNIŠKO POLJE AND KARLOVICA CAVE SYSTEM

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 is 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 bottom are filled with alluvia. Alluvium at altitude of 550 m is distinctive in all the ponor caves, its thickness is possibly the same as a thickness of alluvia in Jamski zaliv, 8 - 15 m respectively.

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

RAKOV ŠKOCJAN AN ZELŠKE JAME CAVE

A very specific karst depression, about 1,5 km long and 200 m wide valley of the Rak river is situated at heights 500 to 510 m at the northern foot of Javorniki, somewhere in the middle between the Planinsko and Cerkniško polje.

At the eastern, spring side, the valley is canyon like. The Rak river springs up from the Zelške jame at 520 m, bringing waters from Cerknica. Numerous collapse dolines are situated around the entrance to the cave. Downstream valley widens and several small karst affluent join Rak from south. Important spring is Kotliči, bringing water from the Javorniki mountains.

The wide flat along the lower course of the Rak is concluded after 800 m by the Great Natural Bridge and after Rak sinks into Tkalca jama. The distance from this point to the springs at Planinsko polje is about 4 km.

The water regime in the Rak valley is intimately bound to the regime in Cerkniško polje. When the Cerknica lake dries up, the course of Rak extinct too. The connections of Rak with the Cerkniško jezero and with the Unica springs at Planinsko polje are proved by watertracing.

Zelške jame are about 3000 long spring cave. There are 9 large entrances in the entrance part of the cave with important collapse and frost shattering forms. The main part of the cave are the water galleries in elevations from 510 - 520 m. Here water from Cerkniško polje flows. New research, mostly in sumps is still going on here. An artificial entrance from the large collapse dolina Brlog makes the visit to Južni rov easy. This gallery which is higher has no permanent water flow, but most of it is still regularly flooded.

PLANINSKO POLJE

Planinsko polje is 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 a geological structures.

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

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

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 being 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.

Bibliography

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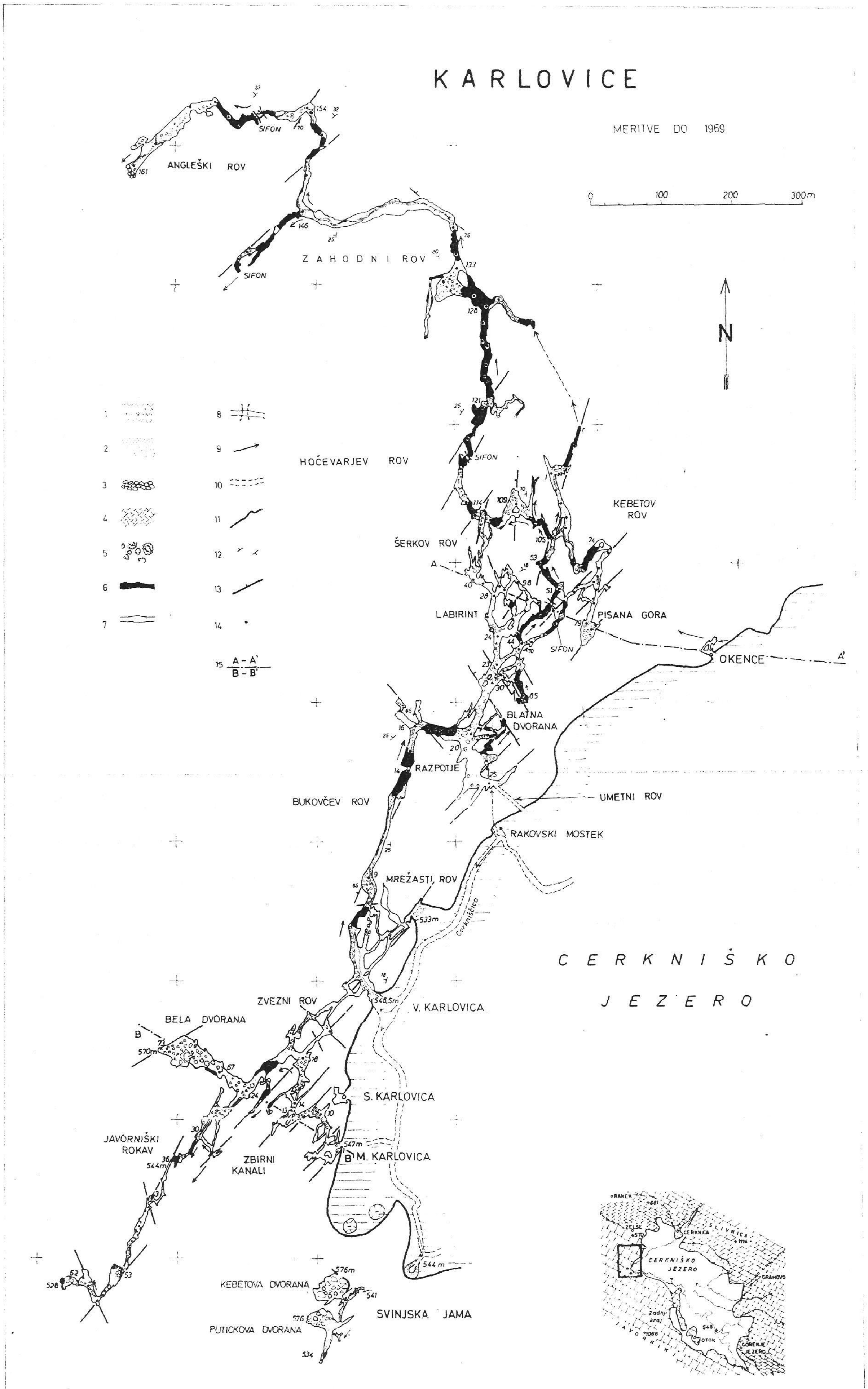
Gospodarič R., 1970: Speleološke raziskave Cerkniškega jamskega sistema. Acta carsologica, 5, 109-160, Ljubljana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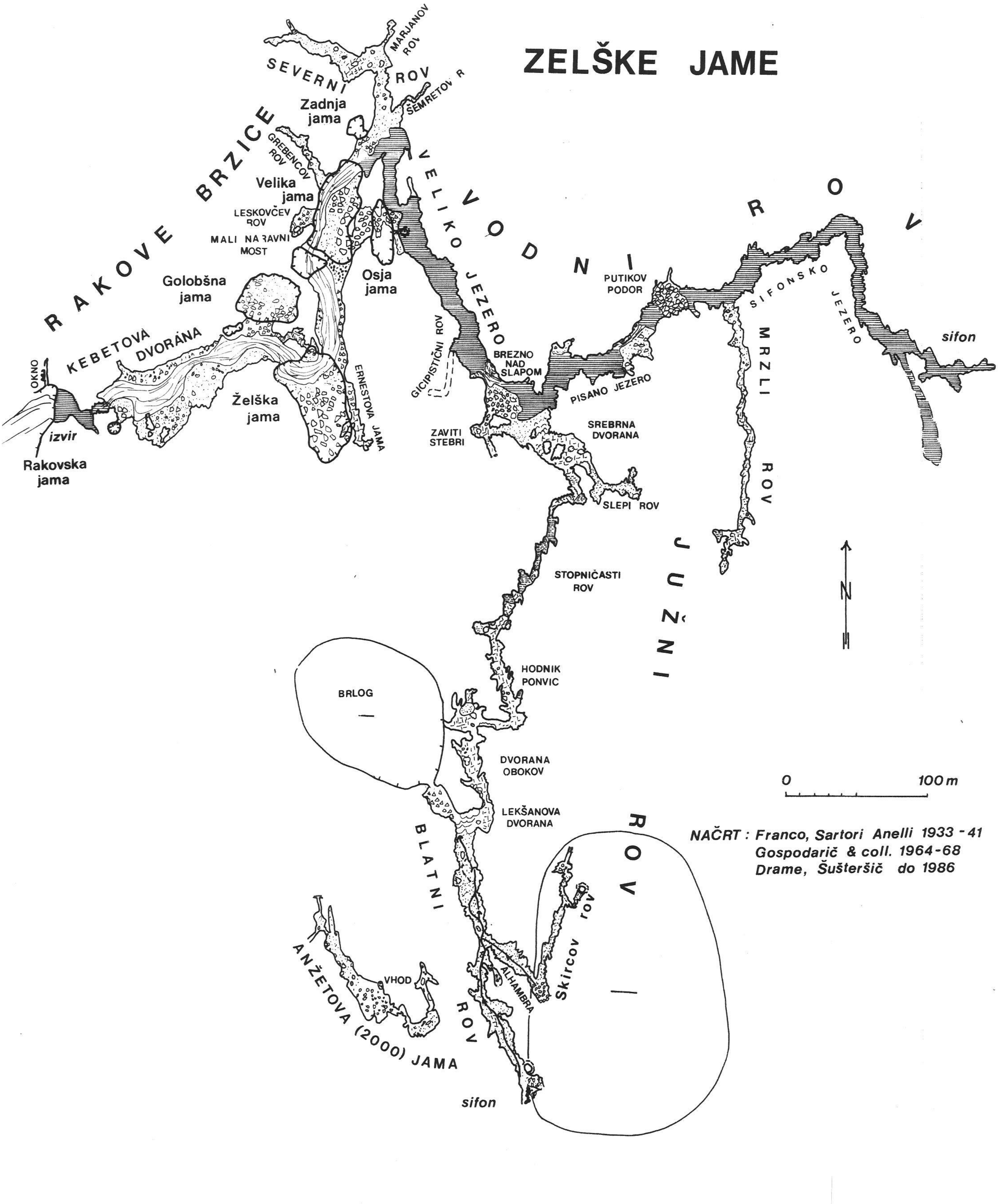
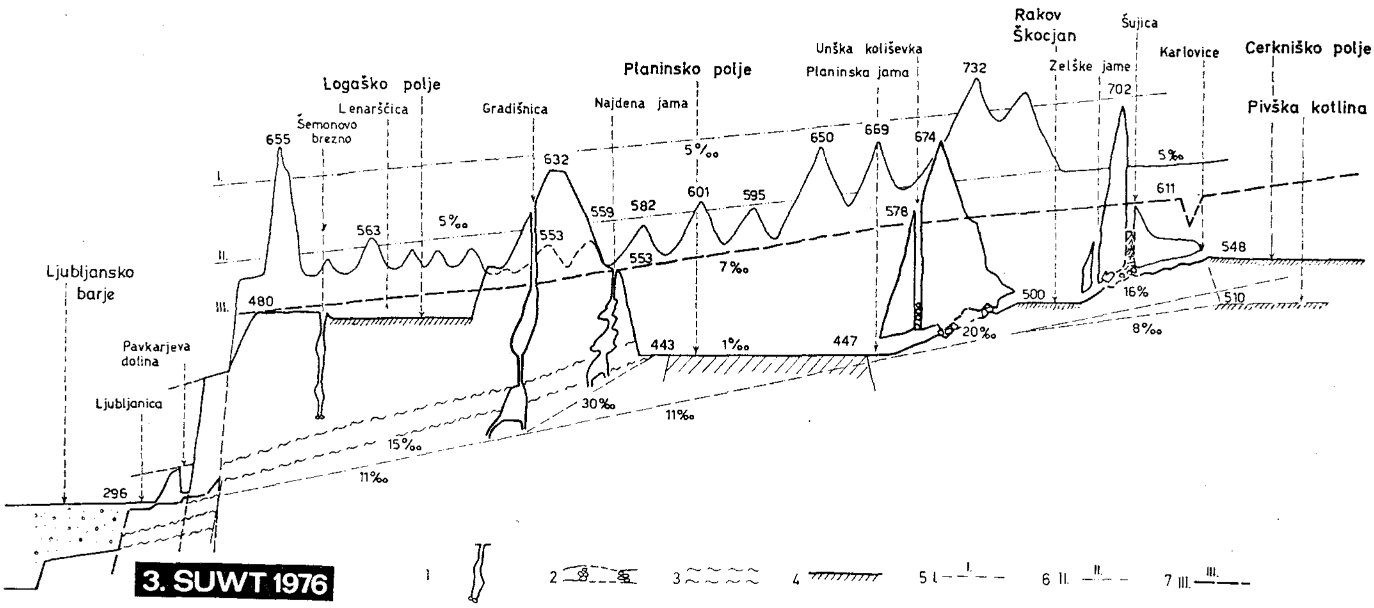
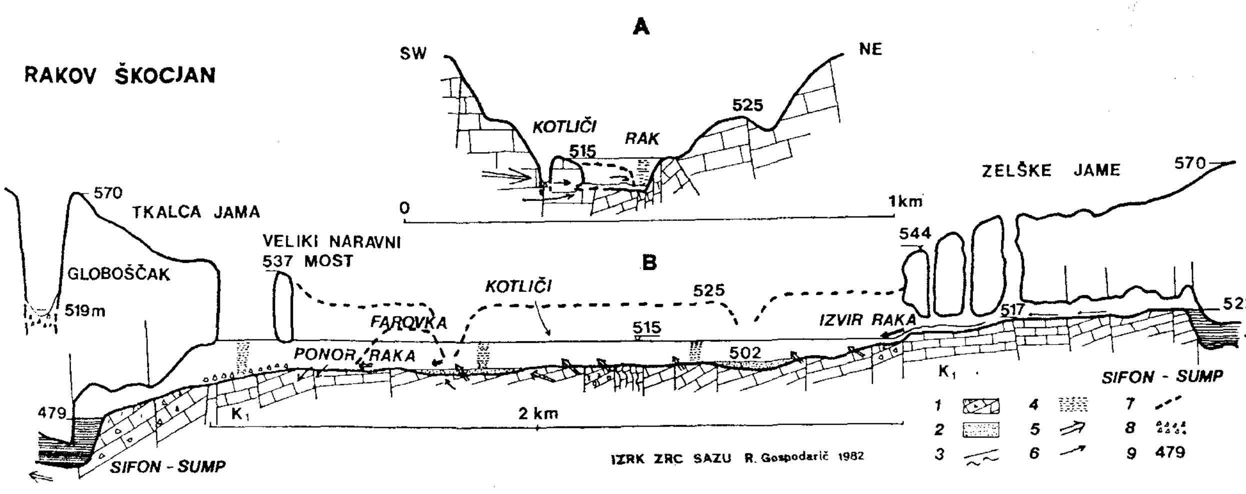


Fig.4.: Plan of Zelške jame



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.

Fig.1: Ljubljanica karst river basin.



Rakov Škocjan Depresion. A — cross section at Kotliči springs, B — shematic longitudinal section of the depression, 1 — rocky bottom, 2 — alluvions, 3 — faults and structure zone, 4 — flood height on January 4, 1982, 5 — karst spring, 6 — water flow directions, 7 — terraces, 8 — boulder rocks, 9 — altitudes

Fig.3.: Rakov Škocjan depression.

CAVES AT KRAŠKI ROB

Wednesday, July 2, 1997

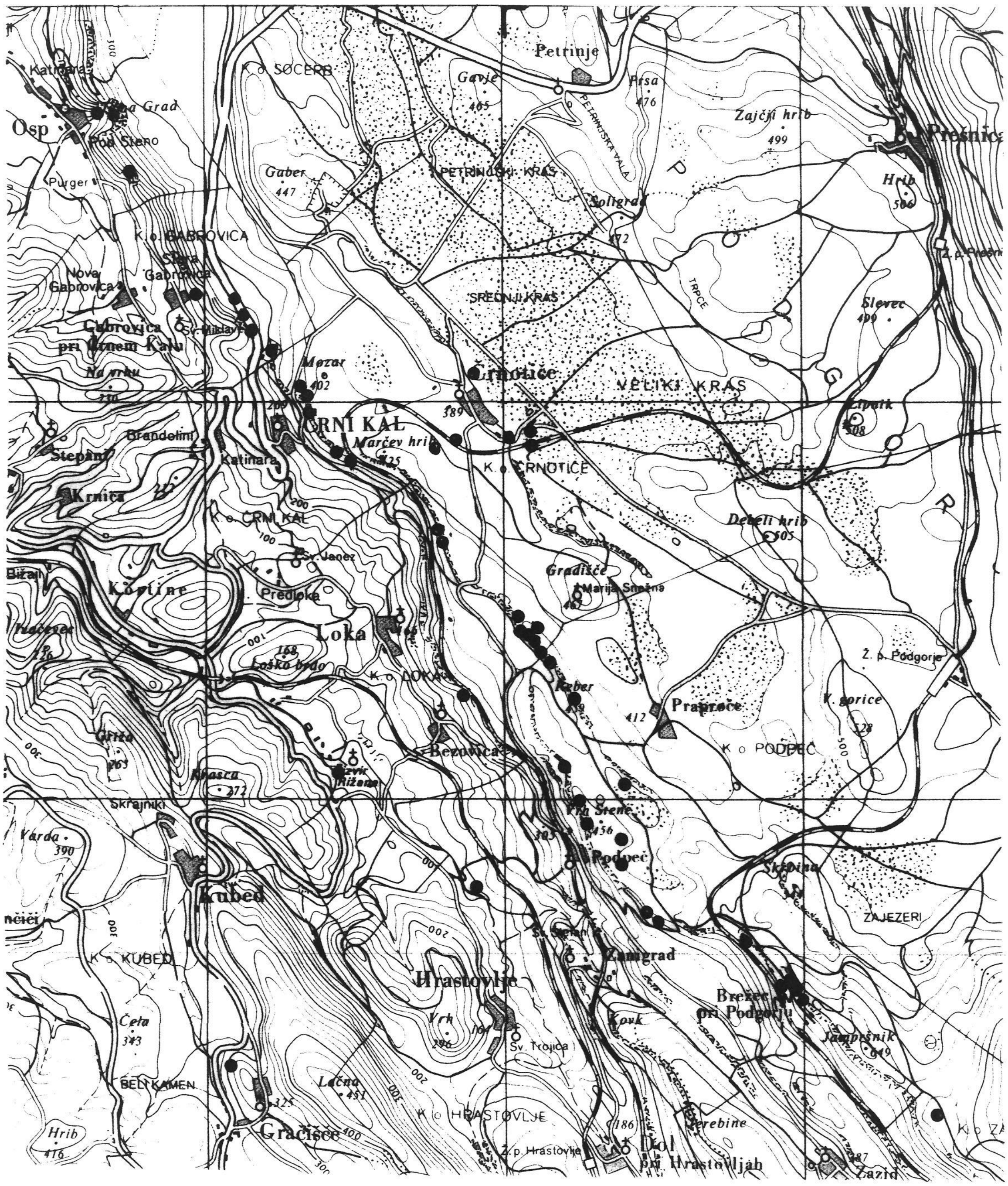
Tadej Slabe

Kraški Rob is an unique geomorphological and climatic part of the Slovene karst. The karst plateau of Podgorje and Socerb at 420 and 500 m a.s.l. ends at the western border by a karst edge, elevated above the littoral flysch by 300 m. Between Črnotiči and Podpeč the interjacent slices of Paleogene limestone alternate with impermeable flysch layers. At first the rocks were folded, then broken and partly slid one over another. In the walls that shape this edge and below them there is a series of smaller, mostly old horizontal caves. At the contact with flysch water rises below the edge near Rižana and above the Osp village as the Osapska Reka. At foothills and on slopes between the flysch layers there are several smaller springs.

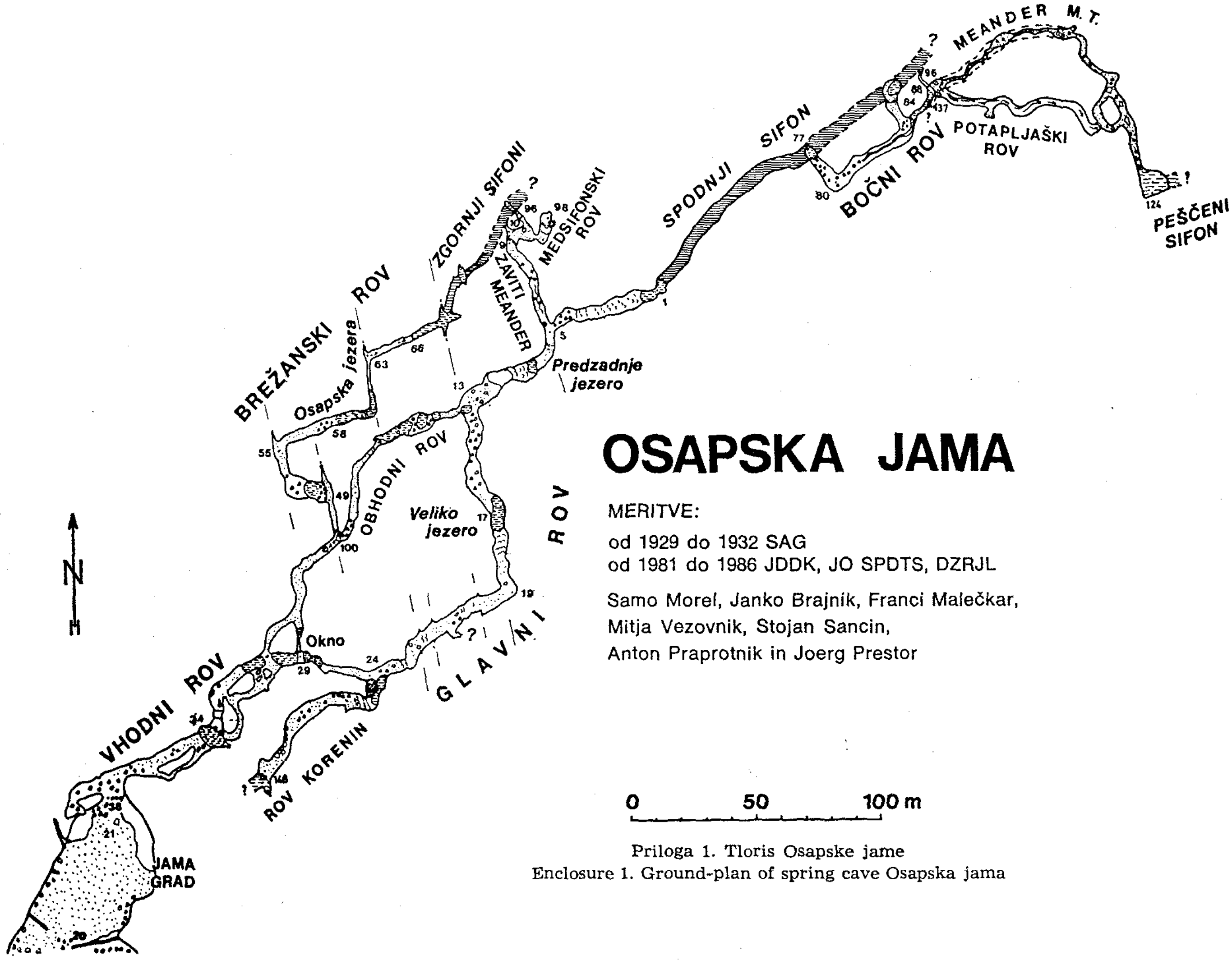
The caves at the karst edge are mostly old; these are accessible parts of the cave systems in single flakes of limestone. They preserve the traces of slow flows that shaped the passages. I did not find any trace of a faster flow such as are those in the actual spring cave Osapska Jama. In some caves there are also less distinctive above-sediment rocky features showing that a cave was for a short time filled by fine-grained sediments. In caves there is a lot of old flowstone. The walls of old caves are usually rough, dissolved by moisture due to air condensation. Such walls are also in Golobja Jama, where there are flutes on the ceiling. In the second, highest level of Kraški Rob is located the longest old cave called Jama Pod Krogom. The walls in this caves are covered by flowstone and traces of a slow flow in phreatic zone are preserved. These are large scallops and ceiling pockets; in its entrance part there are remains of ceiling channels. After relatively fast lowering of the underground water level the cave was reached by flood waters only.

Were these spring caves? Development traces in caves indicate relatively fast opening of a flysch dam that bounded the karst aquifer; the same is shown by preserved traces of a slow water flow through the caves. The caves remained hanging above the underground water level.

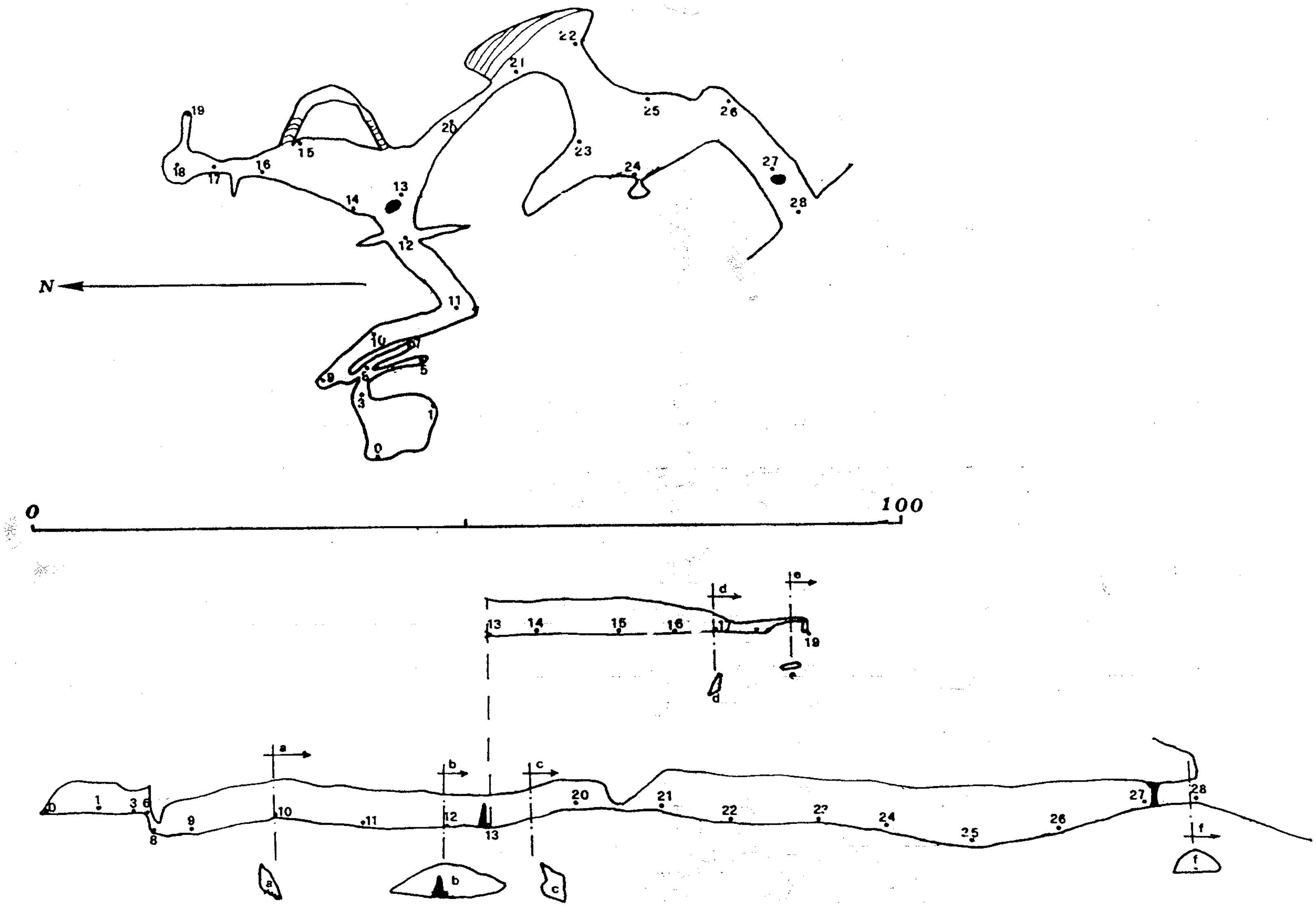
After a heavy rain or when snow melts the river rises out of Osapska Jama. Two directions of water flow may be traced in this cave. High waters flow upwards towards the entrance; during low water level the water from higher lying lakes flows downwards into the cave interior. The cave serves as a flood overflow from a wider karst background. The walls are shaped by the present time waters. On the walls there are smaller scallops, on the ceiling solution cups, on well jointed rocks are rocky knives and on floor frequently below-sediment solution niches; the cave displays a rocky relief typical of epiphreatic passages.



KRAŠKI ROB (1 : 50 000)



Priloga 1. Tloris Osapske jame
Enclosure 1. Ground-plan of spring cave Osapska jama



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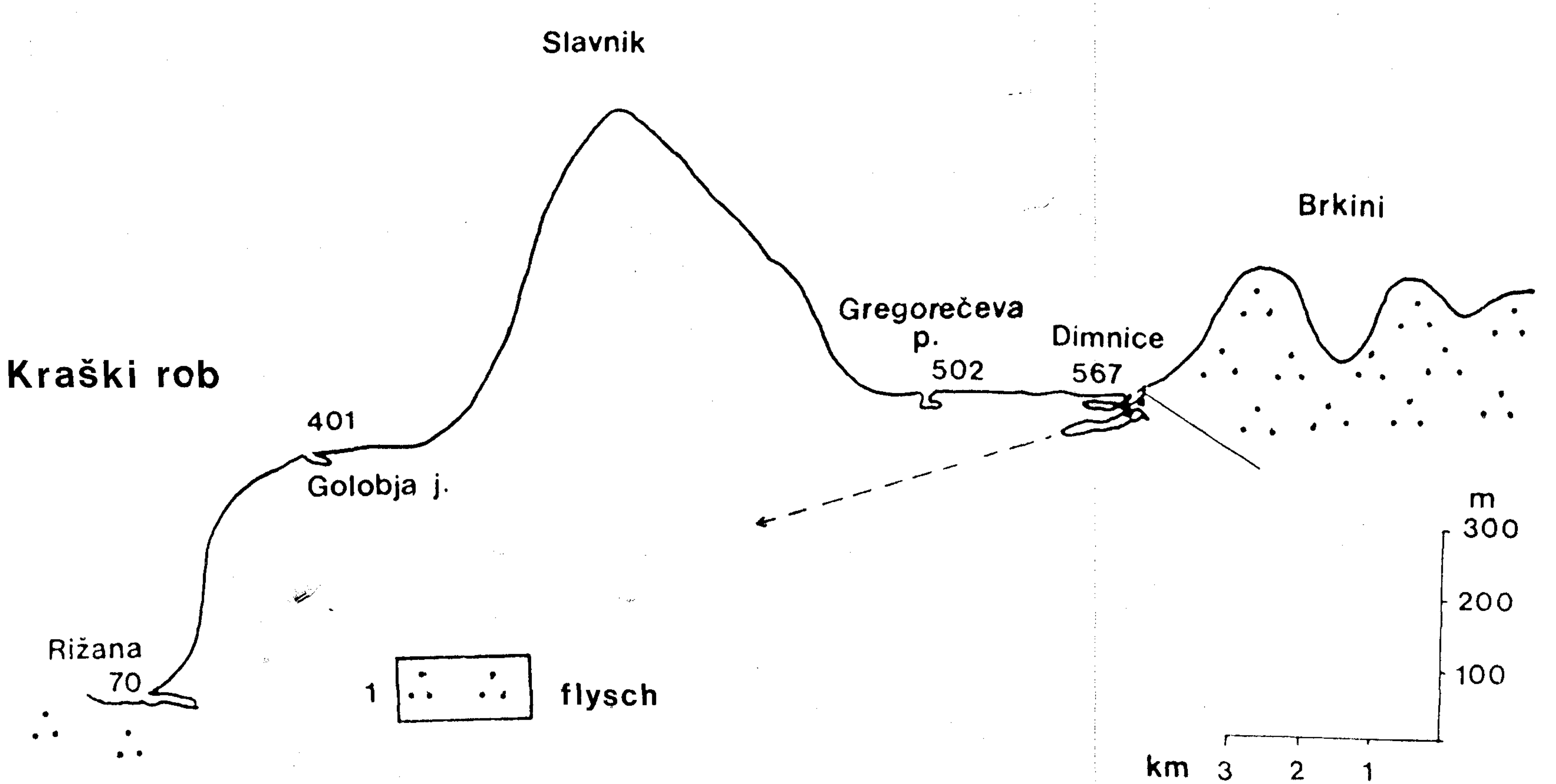
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WHOLE-DAY EXCURSION TO POSTOJNSKA JAMA
Thursday, 3.7.1997

View of the Postojna Caves entrance (Gruber, 1781)

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WHOLE-DAY EXCURSION TO POSTONJSKA JAMA

Thursday, July 3, 1997

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1. POSTOJNA CAVE - Mihevc Andrej, Zupan Hajna Nadja

Cave lies on the northern side of the Pivka basin in where Pivka river flows into it at 511 m above sea level. In Postojna cave system six caves are connected by underground river Pivka. The caves are Underground Pivka, Otoška jama, Postojnska jama, Magdalena jama, Črna jama and Pivka jama. Together these cave system comprises 19.500 km of channels. From the last sump at the end of Pivka jama there is still more than 2500 m of unexplored underground course to the sump in Planinska jama at the edge of Planinsko polje (Fig. 1/1).

The cave lies in the upper Cretaceous limestone (Fig. 1/2). All cave galleries are developed in the Postojna anticline ridge of Dinaric direction (NW - SE). Most of the galleries are in the steeper south-western wing. At first the Pivka was running through Glavni rov and Pisani rov northwards. Gradually cave course displaced itself lower and more westwards. The difference of altitude between higher and lower levels is about 18.5 m and the ceiling above the cave is up to 120 m. Several large collapses above the old galleries formed large collapse dolinas like Vodni dol, Jeršanave doline and Stara apnenica.

2. BIOSPELEOLOGY STATION - Polak Slavko

The responses given by the subterranean animals are very different although the environmental conditions are uniform in every specific micro habitat. A certain trend of features can be found, like depigmentation, loss of eyes, metabolic economy, increase in tactile sensitiveness, predominance of K strategy and others.

The first more or less objective indication about the occurrence of cave animal came from Janez Vajkard Valvazor, who commented on the existence of a sort of Dragon inhabiting the subterranean lakes near Ljubljana, Slovenia. In 1768, Laurenti formally described the animal under name Proteus anguinus and noticed, that the animal has nothing to do with a Dragon, and that it is an amphibian, indeed. Proteus anguinus (Fig.2/1) is the only cave vertebrate in Europe, its whole body is sensitive to light, it has atrophied eyes, it can survive several years without food and its reproduction in the wild is unknown.

Disclosure of Proteus anguinus, which is the largest cave animal in Europe was followed in nineteen century with discoveries and descriptions of many cave invertebrate taksons, new for science. Most of them are endemits, that means very locally dispersed.

In 1823 the discovery of first cave insect Leptodirus hochenwarti (Fig.2/2) was followed - bizarre beetle, blind and unpigmented by Luka Čeč in the Postojna cave during one of his explorations.

3. TOURISM - Mihevc Andrej

Postojna cave is one of the oldest and one of the largest tourist caves of the world. Important tourist development of the cave started in 1818, although cave was known for visitors in 13. century already (Fig. 3/1). Between the years 1818 and 1992 it was visited by 26.000.000 people, in 1990 only by 989.084 visitors. Later because of the wars in vicinity number decreased dramatically .

4. KRISTALNI ROV - Kogovšek Janja

a. Polluted percolated water

In all the cases where we registered pollution in the karst underground we found its origin on the surface. In the case of Kristalni rov it was the military object (missiles base) which is now abandoned.

In Postojnska jama there was on the area of about 20 m in diameter the polluted percolated water registered in an abundant trickle I at the entrance to Kristalni rov, in three smaller droppings that pass over to trickles after abundant rain only (trickles J,G,H and L) and in a seasonal trickling K (Fig.4/1). At these points and for the comparison with a "pure" point out of the pollution area we monitored the composition of the percolated water by regular analyses (temperature, SEC, pH, hardness, chlorides, nitrates, sulphates, phosphates, COD and BOD) under various conditions. At both polluted trickles I and J the following increased values were measured: specific electric conductivity SEC (up to 1150 µS/cm), total hardness (up to 10,3 meq/l), calcium (up to 184 mg Ca^{2+}/l), chloride (up to 70 mg/l), nitrate (up to 180 mg/l) (Fig.4/2), sulphate (up to 70 mg/l) and phosphate (up to 2,8 mg/l). Seasonal measurements of chemical oxygen demand (COD) reached the values up to 15 mgO_2/l.

Unpolluted trickle reached SEC 440 µS/cm, total hardness 4,5 meq/l only, chloride, nitrate and sulphate some mg/l only, phosphate were below 0,05 mg/l. The measurements and analyses were undertaken during various discharges. The pollution is intensively washed away during the discharge increase, while during high water level the effect of dilution prevails.

b. Tracing test

In 1993 we achieved two tracing tests through 100 m thick roof built of limestone above Postojnska jama in order to find out the size of dispersion, the velocity of the percolation at given directions, the intensity and duration of washing off the induced soluble stuff and the dynamics of rinsing in terms of quantity and distribution of the rainfall. At the first point we injected Uranine and washed it by 6 m3 of water. At the second point we injected Rhodamine. At infiltration through 100 m thick limestones relatively narrow water dispersion occurred having its centre in the trickle which discharge reacted the most and contained at the same time the highest Uranin concentration. On other points where Uranin presence was equally detected it appeared only after the rain which pressed the dye through obviously badly pervious conduits with big resistance and slow water exchange (Fig.4/3). The complexity of the runoff through well permeable conduits where the watered drain achieve the velocity of 2.2 cm s^{-1} (through 100 m thick limestones the water drained in 75 minutes) and badly permeable conduits where the tracer was detected 3 months later giving the apparent velocity of 0.0015 cm s^{-1} was shown. It was also evidenced that the substances accumulate for longer time in less permeable backgrounds of the trickles and this is why they are outwashed for long time. It partly explains why at bigger spills on our roads the immediate "catastrophically" consequences do not appear. We must be aware of the accumulation possibility and slow washing and cleaning of the karst background. Rhodamin was detected in the water of smaller channel of difficult access only near Glavni rov. We assess that the connection between the doline and lower lying passage, which is vertically uplifted in the direction of the doline for some 10 m, is very direct and pervious.

In November 1997 we made one tracing experiment in natural wet conditions when we injected only dissolved Uranine without added water. In these days the sampling comes to the end and we expect interesting new copgnitions.

5.,7.,9.,10. GEOLOGY OF POSTOJNSKA JAMA CAVE - Šebela Stanka

Tectonical conditions between Postojna, Planina and Cerknica are shown by epirogenetical movements in Cretaceous, orogentical thrusting and folding deformations after Eocene and faulting deformations from Neogene and Quaternary as is described in tectonic development of SW Slovenia (Placer, 1981). At the end of Eocene or in Oligocene Alpine-Dinaric region was submitted to thrusting. Bedding planes were first folded and than broken. In Micene and Pliocene with thrusting there were folding (Placer, 1982). Direction of thrusting is from NE to SW perpendicular to fold axis (Placer, 1996, 552). Postojna anticline is result of thrusting (Gospodarič, 1965, 1976). General direction of Postojna anticline is NW-SE. The axis is curved in horizontal and vertical directions (Šebela, 1994). Postojnska jama cave is built from upper Cretaceous limestone (Cenomanian, Turonian and Senonian).

5. Stara jama

Part of Postojnska jama cave NE from Male jame called Stara jama meanders between very good expressed stratification. Thick bedded limestone 0,5-1 m dips towards SW for 220-240/30-60^0. Between bedding planes we determined interbedded movements. Part of cave passage crosses direction of bedding planes. Gospodarič (1965, 124) described oval ceiling which is narrower in the ceiling than at the bottom. Also the direction of ceiling and bottom are not the same. In the hights of recent ceiling flow smaller waters and at the bottom bigger. Waters brought many clastic sediments and gravels what eroded ceiling and flanks of passage (Gospodarič, 1965).

7. Pisani rov

In Pisani rov tectonically broken zones are in different directions (Fig.5/1) of which those of N-W are the most frequent. Dinaric (NW-SE) and cross dinaric (NE-SW) directions are a bit less common (Šebela, 1992).

9. Velika gora

The largest rooms in the Postojnska jama cave are collapse chambers, of which Velika gora (Fig.5/2) is the largest: 70 m high, 160 m long, 100 m wide. It's very difficult to determine the time of the collapse in the Velika gora, it's only certain that the collapse chamber is much older than the stalagmites accumulated on the collapse blocks (Šebela, 1995).

10. Lepe jame

Lepe jame are made of Turonian limestone with cherts. We have chert lens and calcited chert lens. In the late diagenesis in some lens quartz was replaced by calcite (Šebela, 1989).

6.,13.,14. ROCKY RELIEF - Slabe Tadej

The main passages of Postojnska Jama should date to the end of Lower Pleistocene. I tried to complete the cited knowledge by studying the cave rocky relief, although it offers only partial insight into the cave development. The former perimeter of a presently dry passage is significantly transformed due to weathering, and is encrusted by flowstone and deposits. Frequent changes within the development of a dense network of passages caused younger rocky features to cover older ones. Short-term development phases are not reflected in rocky relief. The rocky relief in the caves may be divided into four development units (Fig.6/1). On the ceiling and upper part of the walls of the passage Rov Brez Imena large scallops and ceiling pockets occurred at 540 m to 545 m above sea-level. Probably the ceiling pockets between Velika Gora and Koncertna Dvorana (530 m a.s.l.) belong to the same time, as well as large scallops and ceiling pockets in Dvorana s Palmo in Pivka Jama at 500 m above sea-level. Similar traces left by slow water flow in the phreatic zone are found in a small passage which joins Male Jame at 520 m a.s.l. and in small passages below the ceiling (530 m a.s.l.) in Spodnji Tartar. These traces indicate the early period of cavitation. The passages were formed before the medium Quaternary inflling by sand and coloured chert gravel according to which Gospodarič (1976) inferred the older development of Otoška Jama and Zgornji Tartar. The phreatic conditions of passage formation differ from the conditions when the gravel was deposited. The eroded flowstone in Pisani Rov (Zupan 1991) at 530 m a.s.l. has been dated to the beginning of Mindel.

The relief typical of epiphreatic channels draining the water flow of medium velocity is found at the lower part of the perimeter of Rov Brez Imena, in Pisani Rov and in Stare Jame. Medium sized scallops and ceiling pockets indicate a water velocity of 0,25 to 0,35 m/s. These features lie at 520 to 530 m a.s.l. Even younger are the traces of more rapid epiphreatic water flow at 510 to 520 m above sea-level. The water flowed from the underground Pivka direction through both Tartars and through the initial loop in Male Jame towards Lepe Jame. Small scallops remain on the walls.

Anastomoses are found at the border of Koncertna Dvorana, in Rov Koalicije and in Matjažev Rov covering older traces of water streams. Hence the cave was filled up by fine-grained sediments. The relief of the underground Pivka river bed is formed by present-day waters of medium velocity in water-filled sections and free surface high velocity flows in the larger parts of the cave.

To summarise: the oldest water flows drained in the phreatic zone from the SE towards N and NW and through the cave of Pivka Jama. At that time or a little later, the water drained from Otoška Jama towards E and NE. Probably there were more swallow-holes. Younger, epiphreatic water streams that drained from the south to the north, have formed Stara Jama. Zgornji Tartar was reactivated when the water from the SW, from the ancient passages of the underground Pivka, drained towards the N.

8. SPELEOTHEM DATATIONS - Zupan Hajna Nadja, Mihevc Andrej

Different samples were dated by ^{14}C, U/Th and ESR method (Fig.8/1). The values of samples dated by ^{14}C method range from 7.500 to 39.500 years, Gospodarič (1972, 1977). By ESR method the ages of samples are from 125.000 to 530.000 years, Ikeya et al. (1983). Samples analysed by U/Th method are dated from 20.000 to more than 350.000 years.

The oldest dated flowstone in Slovenia is the red nucleus of the stalactite from Pisani rov, being about 530.000 years old. 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 Intraglacial 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 from the same channel have 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.

11. FLOWSTONE - Zupan Hajna Nadja

Same part of the cave are full of different speleothems. Intensive growth of sinter 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 pulls, 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 same speleothems are black coloured it was not proved yet 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.

12. ALLOCHTHONOUS SEDIMENTS -

Zupan Hajna Nadja

The Pivka river transports into the cave the sediments from the flysch recharge area. The river flows through lower levels of Postojna cave system and disappears in a siphon in Pivka Jama. The Cave contains two kinds of allochthonous sediments. Yellow and grey, prevailingly flysh loam, sands and gravel, which had at first filled the rooms up to the ceiling, after the erosion phase remained mostly in blind galleries and buried under collapsed rocks. Gospodarič (1976) analyses the sediments and the flowstone in the cave and their speleogenetical importance. He classifies the gravel of coloured chert as medium Quaternary, the gravel of white chert as Riss, red loam as Riss Würm interglacial and flood loam as early and late Würm.

Red loam is at the entrances mixed by debris but it is also found between separate layers of speleothems and in fissures on the walls, they are in the cave due to percolation through open fissures. Red loam consists of quartz 47 %, calcite 30 %, illite 10 %, kaolinite more than 5 %, plagioclase 4 %, chlorite 2 % and traces of goethite (Fig.12/1). Mineral composition is very similar to the red clastic sediments which were found on the surface above the cave.

Mineral composition of cave sand and loam is presented by two samples:

a. the sample of yellow sand and loam was taken from filled up passage from Umetni Rov. By x-ray were recorded 86% of quartz, 5% of calcite, 4% of muscovite, 1% of microcline, chlorite, kaolinite, plagioclase and goethite (Fig.12/2).

b. the sample is bedded loam from oxbow passage in Spodnji Tartar. Recorded were 71% of quartz, 7% of microcline and calcite, 4 % of muscovite, 3% of chlorite, illite and plagioclase and 2% of kaolinite (Fig 12/3).

Near Razdrto, 10 km east from Postojna, a sample of marl was taken from the Eocene flysch. In this sample is recorded 52% of quartz, 37% of calcite, 3% of microcline, kaolinite and muscovite, 2% of chlorite, plagioclase is present in traces.

Mineral associations of all three studied samples are the same, they only differ by quantity of single minerals. The mineral composition of studied cave sands and loams indicate that their origin lies in flysch rocks of Pivka basin.

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POSTOJNSKI JAMSKI SISTEM
POSTOJNA CAVE SYSTEM

POINTS

1. Ponor Pivke
- geographical and geological position of the cave

2. Biospeleology station
- cave animals

3. Plesna dvorana
- history of explorations
- tourisem

4. Kristalni rov
- chemistry of percolating water

5. Razpotje
- geology

6. Stara jama
- rocky relief

7. Pisani rov
- geology

8. Pisani rov
- speleothem datations

9. Lepe jame
- geology

10. Velika gora
- geology

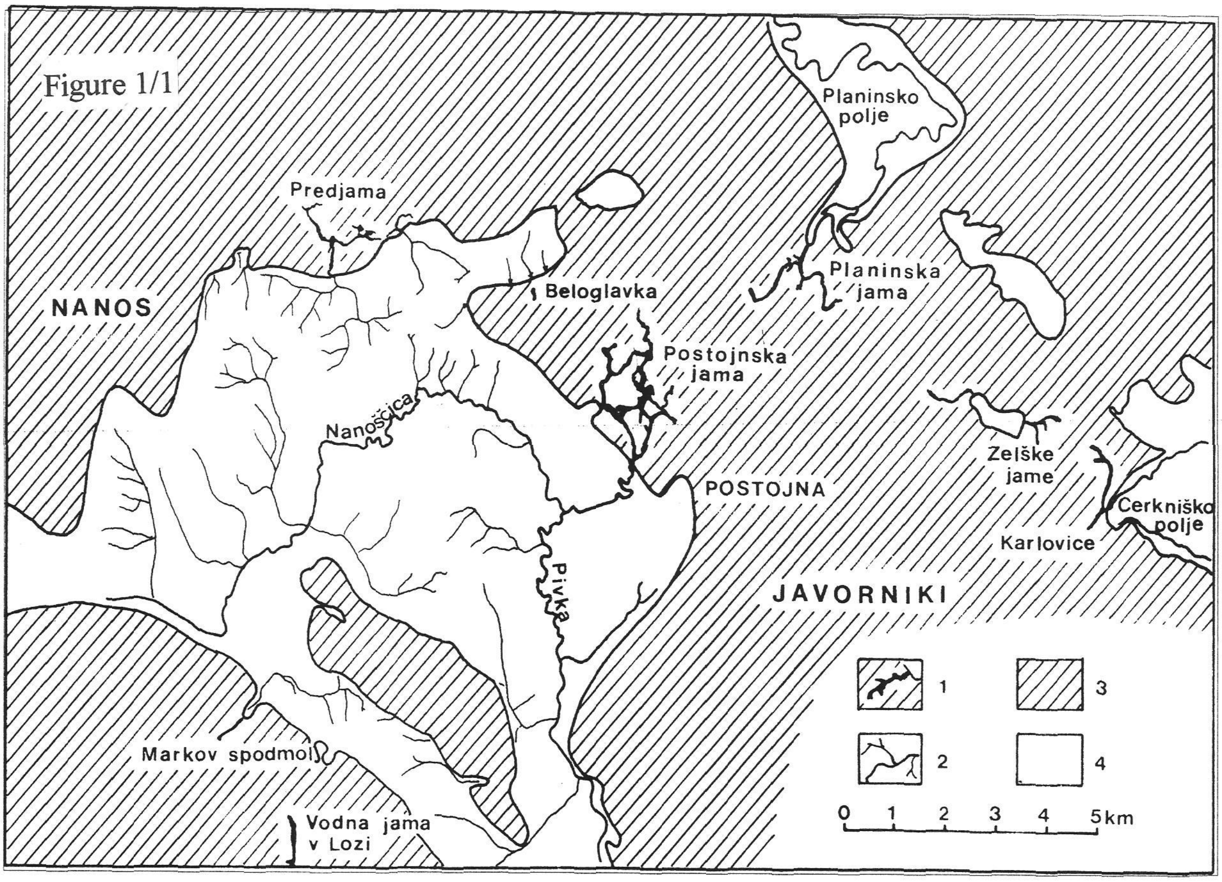
11. Zgornji Tartar
- flowstone

12. Spodnji Tartar
- alohtonous sediments

13.Podzemeljska Pivka
- rocky relief

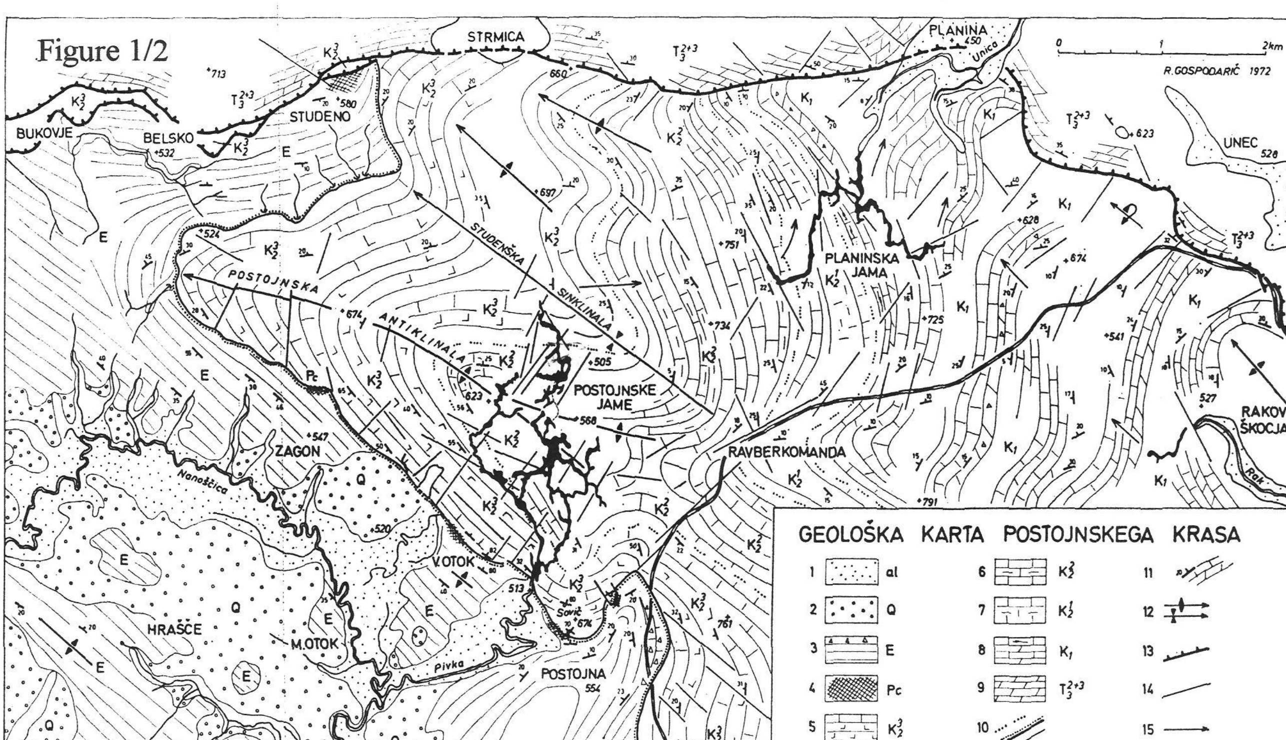
14. Male jame
- cave pearls

Figure 1/1



The Pivka basin and a part of Notranjsko Podolje with selected caves
1. caves
2. superficial water flows
3. limestone
4. impermeable soil: flysch and alluvium

Figure 1/2



Geological map of the Postojna Karst with Postojna Cave System drawn in. 1. alluvial deposits, 2 quaternary sediments in Pivka Basin, 3 marl sandstone, conglomerate and breccia, flysch rocks — Eocene, 4 limestone, limestone breccia, red and grey marl - Paleocene, 5 thick bedded limestone with Cheramospherinae, Sabiniae and Hippurites - Senonian and Maastrichtian, 6 bedded and nonbedded limestone with chert and radiolitids fauna - Turonian, 7 nonbedded limestone and zoogene breccia with Caprinidae and Chondrodontae-Cenomanian, 8 bedded and thickbedded limestone, limestone with chert and limestone breccia - Lower Cretaceous, 9 dolomite - Upper Triassic, 10 geological boundaries, 11 strike and dip of beds and isostrates, 12 folds, 13 over-thrust fault, 14 faults (wrenchfaults), 15 underground river direction

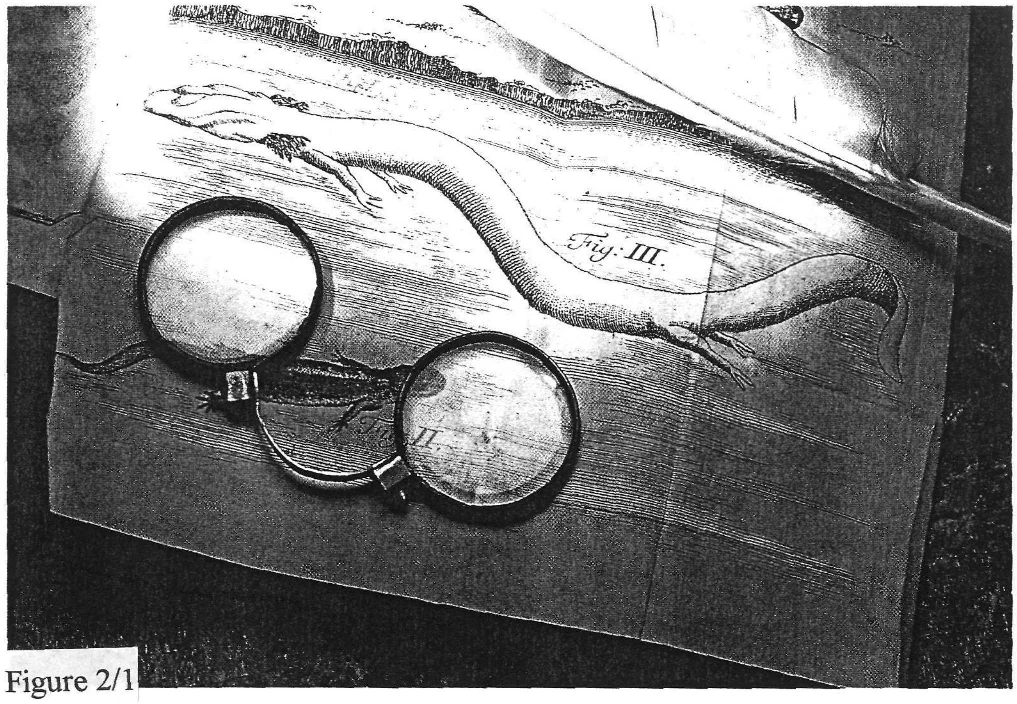
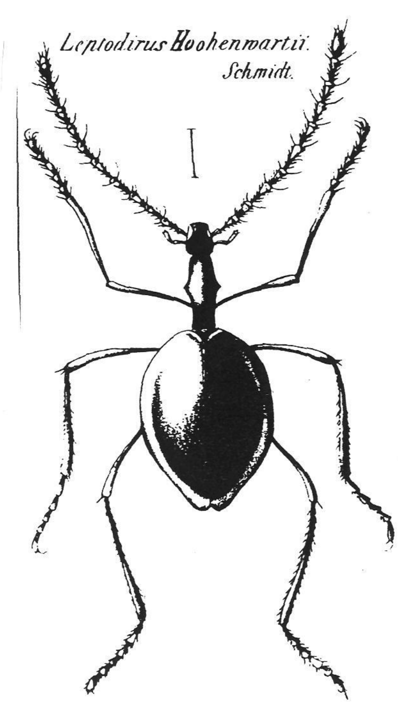


Figure 2/1

The first depiction of the proteus.
In 1768 Vienna doctor and zoologist J.N. Laurenti wrote himself into the history books as the discoverer of a new animal species. Visiting a friend in Klagenfurt he came across a jar containing a proteus, an animal unknown to him. It had been sent to Klagenfurt by the Idria physician and natural scientist G.A. Scopoli. Laurenti named the animal *Proteus anguinus* after the Greek god Proteus, servant to the god of the sea, Poseidon. He received the acclaim of the first discovery without even being certain whether it was an adult or a larva. He was also unaware of where his "discovery" originated. In any case he named the mysterious Lake Cerknica as the place of discovery, which at the time was famous for being something of an Austro-Hungarian Loch Ness.
In spite of his haste, the scientific name Laurenti chose for the local "Nessie" has remained with us ever since.

Figure 2/2



**The cave beetle
Leptodirus Hochenwarti
(Schiner, 1854)**

Figure 3/1

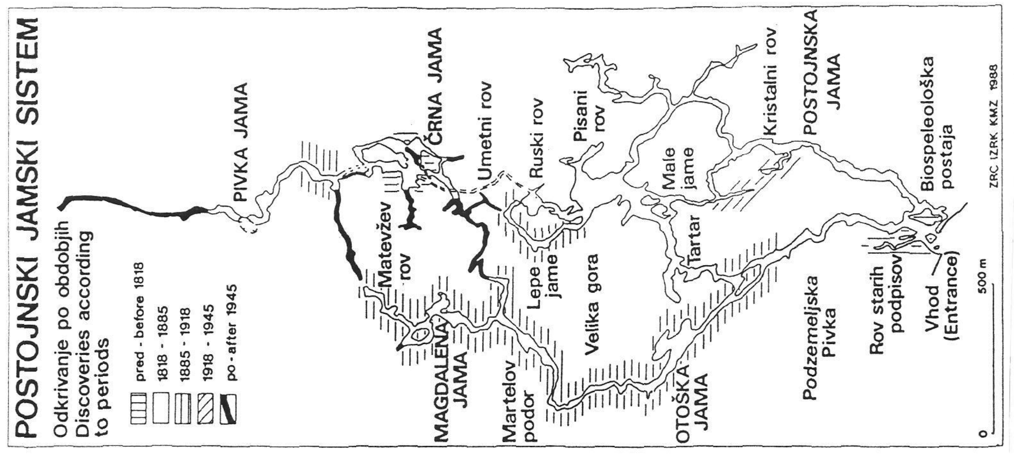
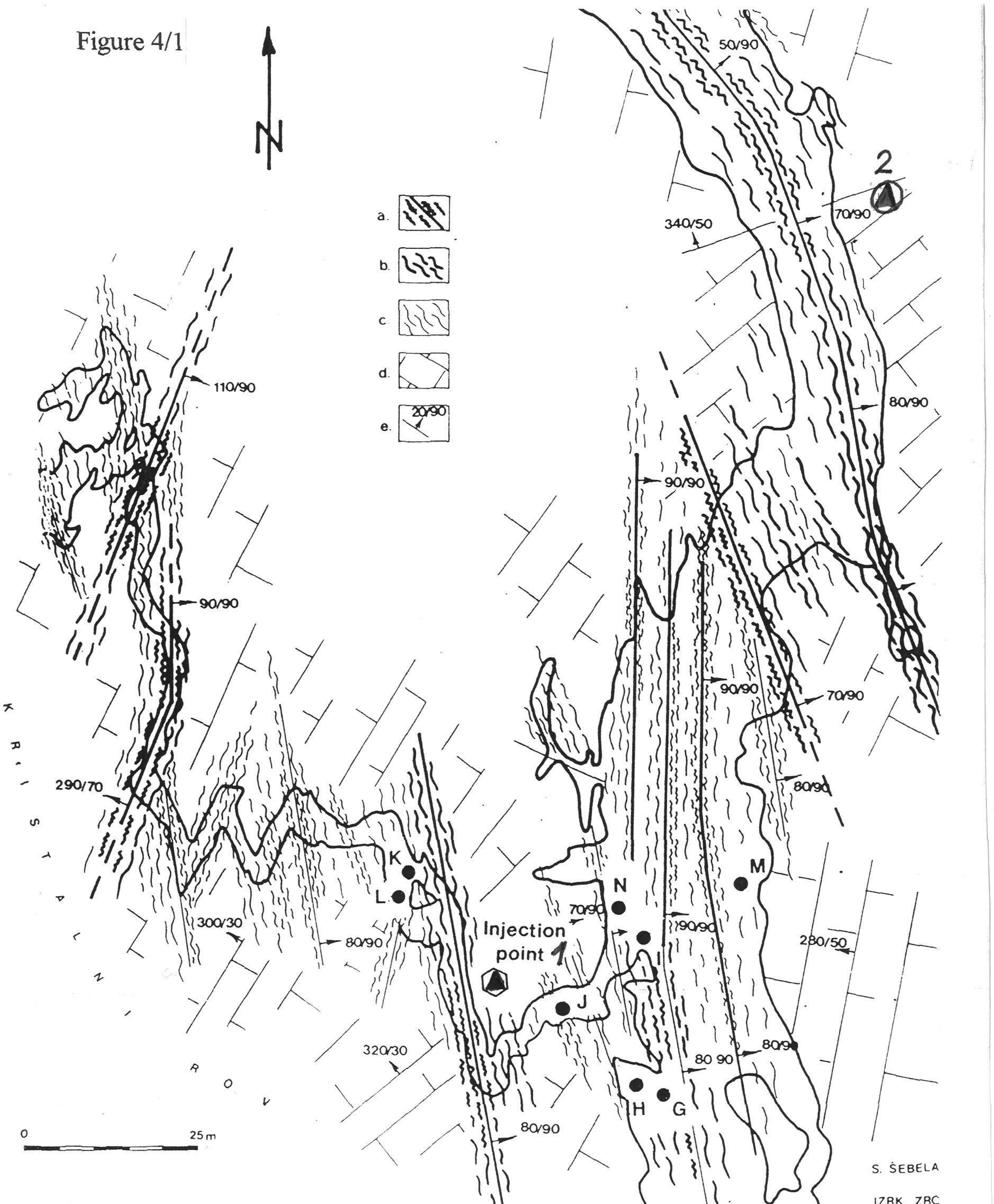
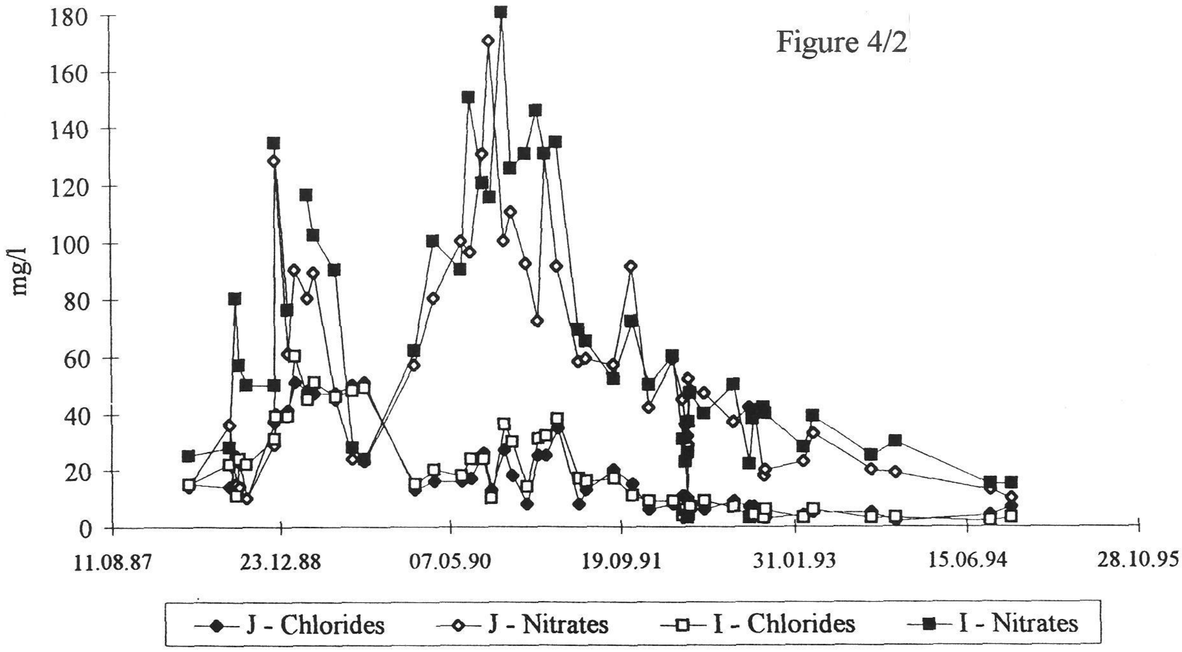


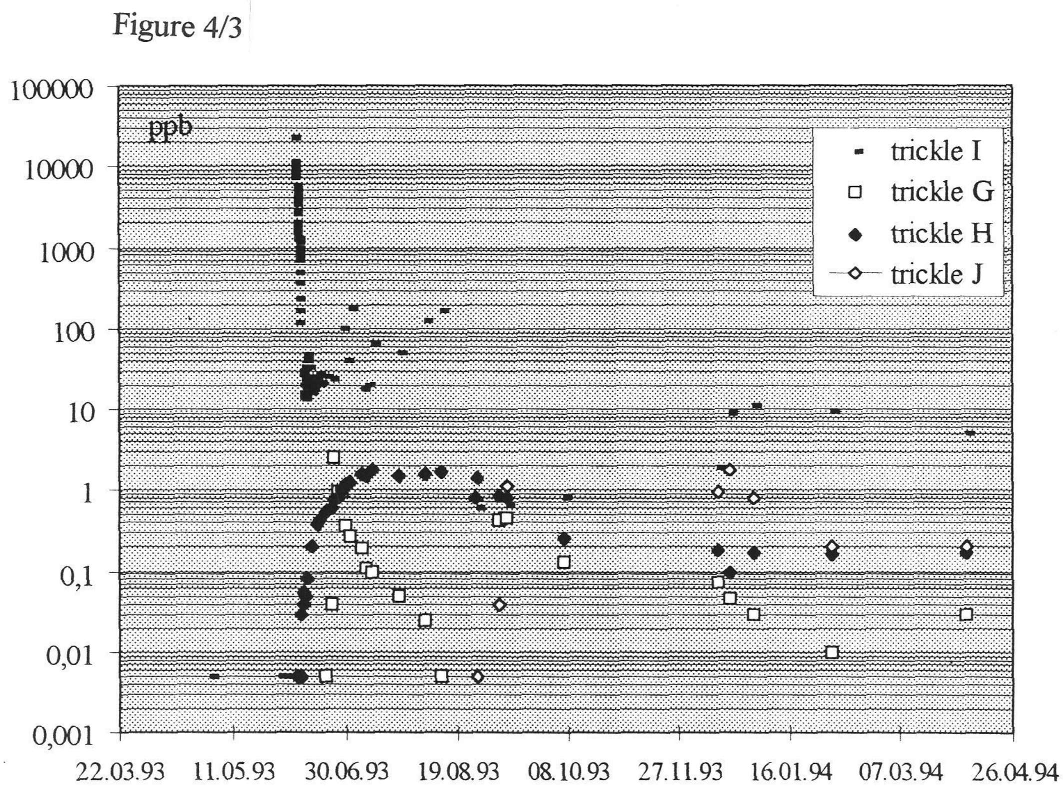
Figure 4/1



- Plan of Postojnka Jama from Glavni rov to Kristalni Rov. Trickles are indicated by letters: I, II, G, H, J, K and L.

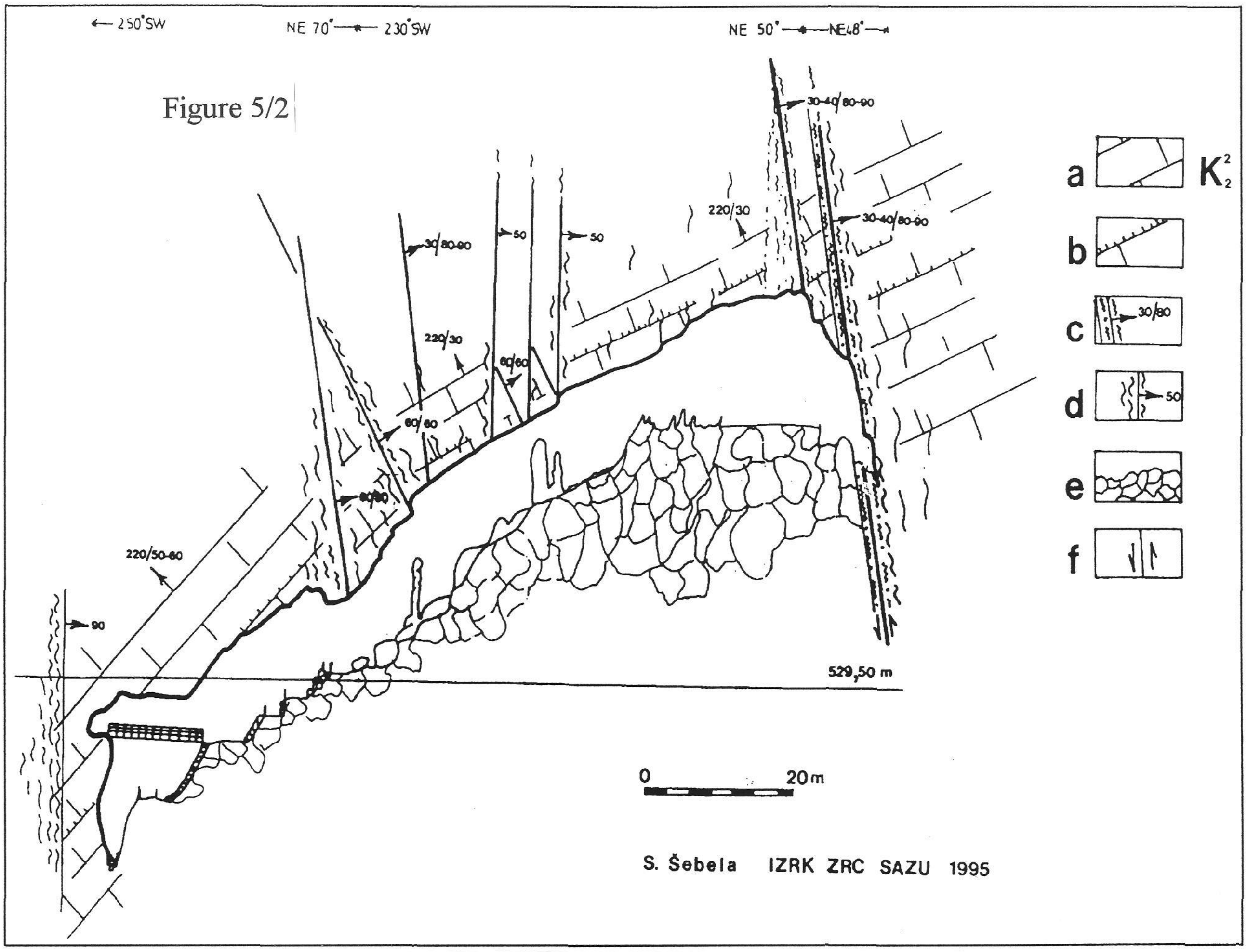


Chloride and nitrate levels in the trickle I and J in Kristalni rov



Kristalni Rov: tracer experiment in June 1993 - Uranine concentrations

Figure 5/2



Geological conditions in cross-section of collapse chamber Velika gora in Postojnska jama cave.
a - Turonian thick-bedded limestone, b -interbedded movements, c - crushed zone with geological elements, d - broken zone, e - block breakdown, f - vertical movement in fault zone.

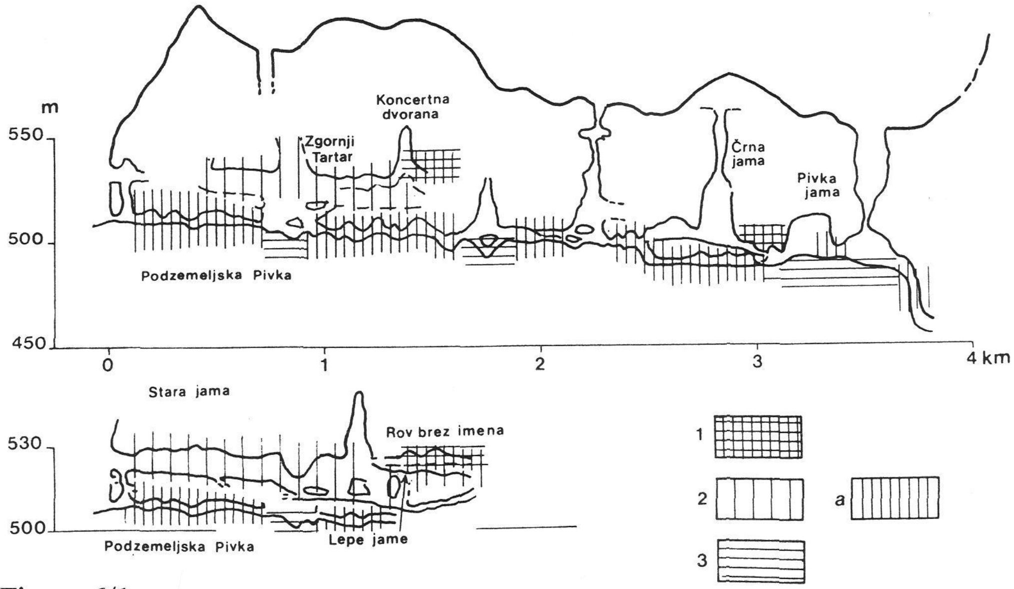


Figure 6/1

Hydrologicl zones shaping Postojnska jama, 1. phreatic zone, 2. epiphreatic zone with slow water flow, a. epiphreatic zone with more rapid water flow (present -day formation), 3. vadose zone.

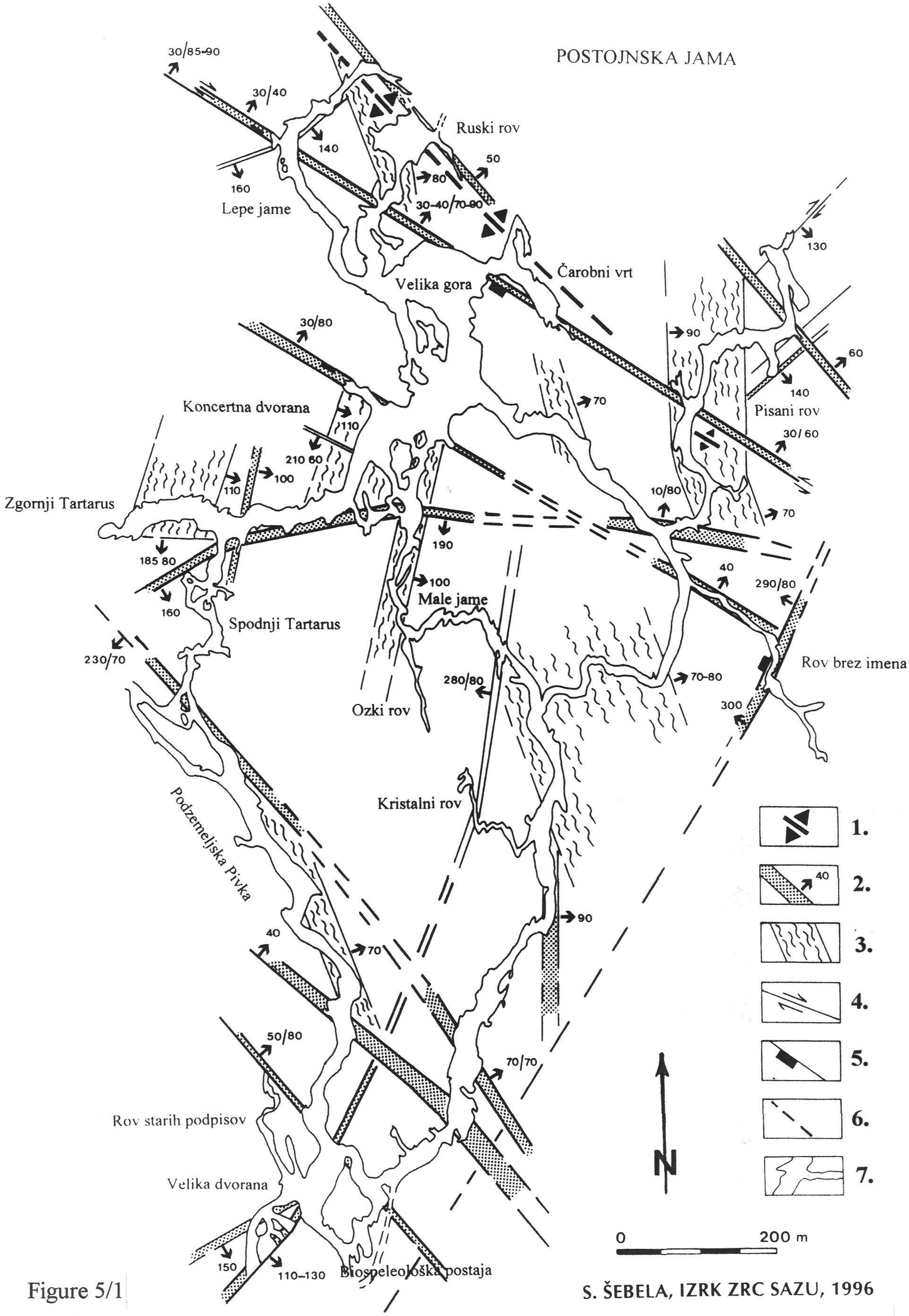


Figure 5/1

S. ŠEBELA, IZRK ZRC SAZU, 1996

Structural geology of Postojnska jama:
1- anticline, 2- crushed zone with geological structural elements, 3- broken and fissured zone, 4- horizontal movement, 5- vertical movement, 6- supposed fault zone, 7- ground plan of cave passage

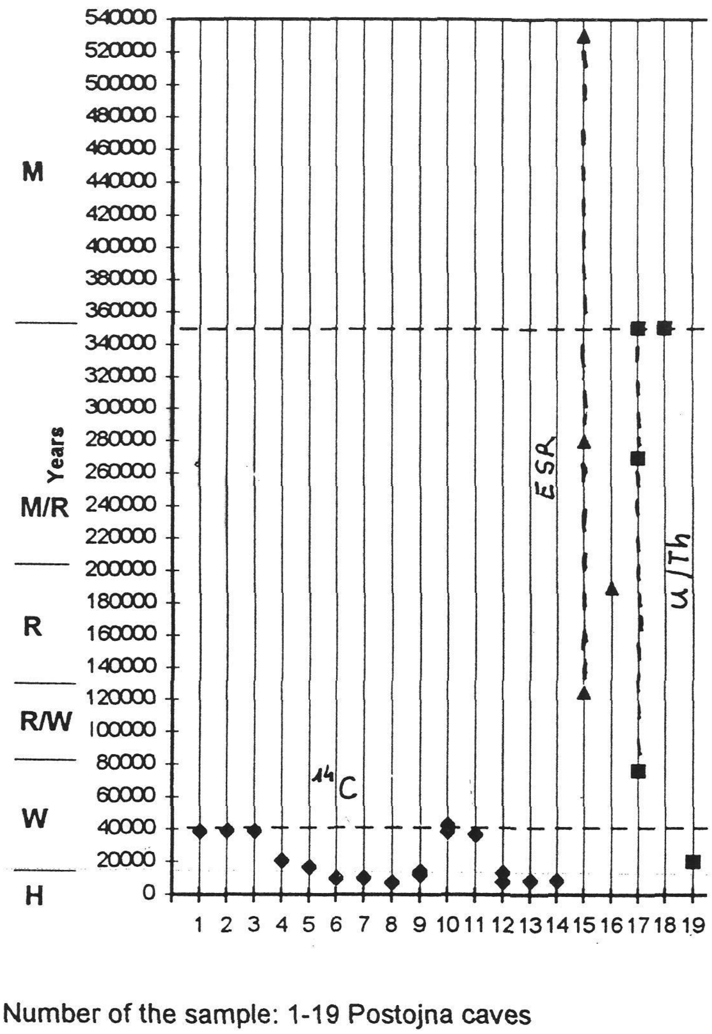


Figure 8/1

Figure 12/1

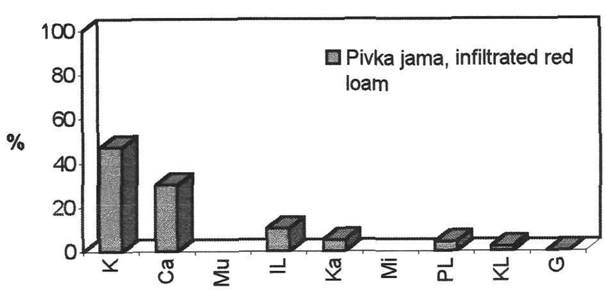


Figure 12/1, 12/2, 12/3: Mineral composition of allochthonous sediments
K - quartz, Ca - calcite, Mu - muscovite, IL - illite, Ka - kaolinite, Mi - microcline, PL - plagioclase, KL - chlorite, G - goethite

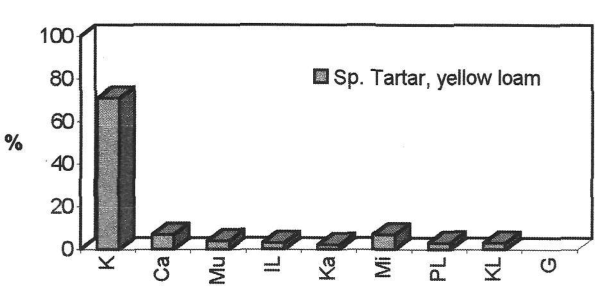


Figure 12/3

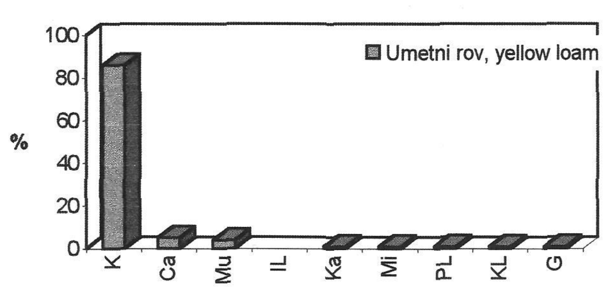


Figure 12/2

ABSTRACTS OF THE PAPERS TO BE PRESENTED

GENETIC TYPES OF CAVES IN SLOVAKIA

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The extent of karst regions in Slovakia is quite considerable and represents an area of over 2,700 sq.km. By orography, these regions belong to the Western Carpathians system.

From the morphological point of view, karst in these mountain regions is represented by plateau karst (Slovak Karst, Slovak Paradise, Muran Plateau), dissected karst of massive ridges, horsts and combined fold-fault structures (Strazov Hills, Lesser Carpathians, Ziar, Zvolen Basin), dissected karst of monoclinal crests and ridges (Low Tatras, Belianske Tatras, High Tatras, Greater Fatra, Choc Hills) and karst of klippen structure (Vrsatec Klippens in the White Carpathians, Manin Highland, Pieniny mountain). Karst of travertine domes and cascades occur both in mountain (Hincava in Slovak Paradise, Motycky at the boundary of the Greater Fatra and Stare Hory Hills) and basin position (Bojnice in Horna Nitra Basin, Drevenik in Hornad Basin, Sliac in Zvolen Basin). Karst in basin regions is represented also by karst of isolated blocs and monadnocks and karst of flood plains and terraces (Upper Hron Valley, Liptov Basin). All of these karst types are situated in the Central-European mild climatic zone.

Besides high-mountain karst on fold-fault and inclined structures (Red Hills in the Western Tatras, Belianske Tatras, High Tatras), kryptokarst related to lenses of crystalline limestones and magnesites, lying under an impermeable rock environment (Revuca Highland), is of special importance (J. Jakál 1993).

More than 3,800 caves and rock shelters meetting the criteria of underground space occur in Slovakia. Genetically these cave types are miscellaneous (P. Bella 1994, L. Gaál - P. Bella 1995).

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SPELEOGENESIS IN THE KONEPRUSY REGION (BOHEMIAN KARST, CZECH REPUBLIC): NEW DATA AND IDEAS

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Several phases of karstification have been distinguished in the Lower Devonian limestones which constitute closed synclinal structure in the southwestern part ofthe Barrandian basin. Karstification, which started during the deposition of limestone sequences predisposed all younger karstification processes, most probably. New developments in limestone quarrying brought new evidence on karstification by thermal waters. Important structures of thick parallel calcite veins (up to 10 m thick) trending in the NS direction were disclosed. They are accompanied by numerous features (karst depressions, shafts, caves) which can be connected with hydrothermal karstification directly and indirectly. Some hollows were filled completely by coarse crystalline hydrothermal calcite. Numerous caveshave walls covered by large calcite crystals. Some kinds of oldest speoelothems in the Konepruske Caves originated in waters with temperature below 60 degrees of centigrade and have typical appearance of speleothems formed from low temperature solutions. The hydrothermal activity is proved for Variscan times (Carboniferous) when a majority of calcite veins and calcite filled hollows originated. The second phase of hydrothermal activity is supposed for Eocene-Lower Miocene phase of intensive neovolcanic activity in surrounding tectonic rifts. In that time, larger portion of caves, including open-to-public Konepruske Caves originated, partly or completely inflenred by low temperature hydrothermal karstification.

SPELEOGEOMORPHOLOGY OF THE UPPER LEVEL PART (DRY PASSAGE) IN PROVALA CAVE (CROATIA)

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Pravala cave is located in fluviokarst area of Žumberak Mt., NW Croatia. Its entrance was discovered in 1995 and due to the complexity of passages, the exploration has been going on for over 2 years.

It is a two-level cave (active and dry) originated at the contact between Cretaceous beds of calcareous composition and Triassic dolomite. So far 1687 m of passages have been explored till the depth of 54 m, and the big part are narrow laterally passages. In the lower level there is a permanent water flow. The upper level, due to its hydrological characteristics, can be divided in three parts: 1. the southern part with permanent water flow, 2. the part with periodically water flow, and 3. the dry part. The last two parts called "Dry passage" were speleogeomorphological observed. The results of observations confirm the connection between extending and inclination of fractures af different nature and passage. Numerous erosional and corrosional features on the floor, walls and ceiling and different types of sediments in the passage were also recorded. The first ones are impartant as indicators, and the last ones are equally important as indicators, but also as factors in speleogenesis.

ORIGIN AND DEVELOPMENT OF CAVE SISTER IN THE ROSANDRA VALLEY (CLASSICAL KARST)

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In the carbonate massifs which form the Rosandra Valley sides there are many caves. They are part of a complex cave system and their evolution is conditioned more by lithologic-structural features than by base level variations. Tertiary rocks, both carbonate and siliciclastic, irregularly covered by Quaternary loose deposits outcrop in the area of Rosandra Valley. The carbonate rocks include limestone, filled by Foraminifera

(Paleocene-Eocene); the silicoclastic rocks pertain to the Flysch Fm., composed by marls and compact sandstone.

The geology of the area is quite different from that of the Karst plateau and it is, under a structural point of view, very similar to the one of north-eastern Istria (Cicarija). The valley is placed on a secondary syncline, cut off toward NE whose northerly side is complicated by several faults and overthrusts. A squat and smoothed anticline complicates the southern part of the area and lies the contact, by faults and/or stratigraphic limits, between the limestone and the Flysch. The structural sketch shows a general stress with dinaric directions (NE-SW with NW-SE structural axis).

On the right side of the Valley, at more than 200 meter high of the local base level there are long horizontal galleries belonging to the Gualtiero Savi cave system. The Savi cave system (more than 5 km of total development) can be morphologically subdivided in some stretches with similar morphological features.

We can recognise:

- paragenetic galleries with scallops sometimes. On the bottom speleothems cover poligenic conglomerate and very thick clay.

- large halls with impressive breakdowns, locally covered by flowstones.

- singenetic narrow trenches or meanders with scallops, conglomerates and clay.

Structural influences (faults or large fractures) are frequent and there are numerous evidences of recent movements on fault planes.

Morphogenetic and developing analysis can suggest at least five subsequent speleogenetic phases.

- 1. develop of a galleries network (today at 350 m a.s.l.) draining a lot of waters coming from Flysch basins.

- 2. develop of breakdown halls and tectonic imprinting by faults and\or tectonic bands which drain waters in deep. Base level lowers, rivers erodes limestone and Flysch. During floods the cave system is filled by clay and conglomerate.

- 3. deepening of the valley, opening of new lowers entrance as sinkholes and genesis of a lower cave system, with partial emptying of cave interior deposits.

- 4. further deepening of the valley, high galleries become fossil, new entrances (Fessura del Vento cave at 250 m a.s.l.) open lower, connection between of old and new cave systems. Landslides and breakdowns modify the sides.

- 5. quick erosion continue, all entrances become fossil, speleothems fill caves and increase the sides evolution.

It's very difficult to date these phases because we know only the chatian-langhian age of the original levelled surface (20 Ma BP) and the age of last speleothemes (120.000 years at least).

MOVED BEDDING PLANES, CONNECTIVE FISSURES AND HORIZONTAL CAVE PASSAGES (EXAMPLES FROM POSTOJNSKA JAMA CAVE)

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Postojnska jama cave system is the longest horizontal cave system in Slovenia (19 km). Horizontal cave passages are moostly prevailing. They are connected with shafts and siphones. In study about formation of horizontal cave passages Gospodarič (1965, 1976) stressed importance of interbedded movements. Results of newer investigations (Šebela & Čar, 1991; Šebela, 1994) prooved influence of cave passages formations on tectonic deformations. In example of Postojnska jama big part of primary development of cave passages was proved in places of interbedded movements (Šebela, 1994).

In Postojnska jama cave system there are some very good examples which proove development of inicial passages related to interbedded movements. In miocene and pliocene in SW Slovenia overthrusting was accompanied with folding (Placer, 1981). To that period belongs formation of Postojna anticline. Interbedded movements from that period are important factor because they made interbadded layers to comunicate for water and are important for formation of horizontal cave passges.

Part of Postojnska jama called Stara jama is built of upper Cretaceous limestone and lies in SW part of Postojna anticline. Parallael with bedding is about some meters wide fissured zone in general direction NW-SE. Folding caused interbadded movements for about some cm, also there can be no movements but just opening as fissure between limestone layers. Some opened fissures can be filled with secondary calcite veins. Horizontal cave passage in Stara jama of Postojnska jama meander between tectonic fissured zone and shows obvious development because of tectonic deformations in limestone layers.

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FACTORS OF STALAGMITE FORM

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The basic rule of the stalagmite width is a function of dripping (flowing) water discharge and the stalagmite height a function of its age has many modifications. The shape (formating) of the stalagmite top (and thus of dripstone diameter) is depending also on 1. the extent of dripping (flowing) water oscillation and on the height of the ceiling (splash of the drops), 2. the changeable position of dripping (flowing) water to the stalagmite head due to 2.1. shifting end of the stalactite where the water drops, 2.2. shifting place of water penetration through the flowstone crust on the ceiling, and changeable water conduit in the rocky ceiling, 3. dislocation of the base (consisting mostly of loose sediment) together with the stalagmite and its inclination. The height of stalagmite is depending also on the changeable amount of dissolved carbonates in the dripping water (growth on stalactite on the ceiling), in the windy part of the passage also on the water evaporation. The modificators are predominant factors of stalagmite shapes and thus of the speed of stalagmite growth, especially at older formations. The column is widened special water flow conditions.

DIAGENETIC CONCRETIONS FROM THE CAVE CLASTIC SEDIMENT

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Diagenetic concretions from Cave in Tounj quarry (central Croatia) are studied. Concretions are found in noncemented unsorted clastic cave deposit. They consist of particles of different size (clay to pebble) and from different provenance. Detrital particles: chert, quartz, muscovite, chlorite, ilmenite, magnetite and most of clay, are probable transported into the cave from different clastic sediments from the surface. Autohtone constituent of concretions are pizoids and calcite cement. One part of calcite and clay minerals are coming from speleothems and limestones from the cave walls. Composition of concretion is similar to the composition of surrounding noncemented sediment.

CAVES SYSTEMS IN SLOVENIA

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There is 9623 known caves in Slovenia. The deepest is 1370 m deep cave Čehi 3, longest is 19550 km long Postojnska jama. The mean length of the cave in Slovenia is 67 m and the mean depth is 23 m. There is 1.5 cave entrances per a km^2 of the limestone.

Caves are relatively short, they are all just a parts of the larger network of the underground cavities which are conducting water from the input to the output of the karst.

Each of the caves represents a system of interrelated cavities where special environment of chemical, physical and biological properties are found. But we use word system for the largest systems, so having in mind only hydrological or physical, dimensional aspect of the caves only.

ON THE RELATION BETWEEN SOLUTION DOLINES AND CAVES

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About 1.5 km^2 of the karst terrain east of Planinsko polje were geologically and geomorphologically mapped on the scale 1:5000. Though typically reworked by epikarstic and superficial processes, a number of segments of the phreatic system were indentified, appering on the surface. All of the tubes are presently unaccessible for man. Their spatial pattern reveals grouping in two corridors, while the tubes themselves are situated on the borders between limestone and dolomite strata. The large collapse doline, Rakovska kukava, situated in the studied area, was studied in detail so that it is possible to recostruct its geological conditioning, as much as its further development.

CAVES DISCOVERED DURING THE CONSTRUCTION OF A MOTORWAY BETWEEN DIVAČA AND KOZINA

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During the construction of new motorways (30 km) over Kras about 200 caves were discovered; in the area between Divača and Kozina (7,5 km) there were 37 old caves, most of them filled by sediments and some of them roofless, and 6 shafts. Old caves contain the oldest traces of initial stages of the karst aquifer development when it had still been surrounded and sometimes even covered by flysch. More important caves are preserved, either hidden below the roadway or accessible by artificial entrances.

THE ROLE OF TECTONIC CAPS OF CRYSTALLINE ROCKS IN THE GENESIS OF KARST MORPHOLOGYAND CAVE SYSTEMS IN THE WESTERN TATRA MTS. (POLAND)

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The paper outlines authors opinion on the role of contact zones between tectonic caps of crystalline rocks and carbonate series in the origin of alpine karst and cave systems in the Tatra Mts. In the existing literature relating to the problem the influence of tectonic discontinuities and glaciers are taken into consideration. Observations have made in the Malolaczniak and Ciemniak-Twardy Uplaz massives in the Czerwone Wierchy (Western Polish Tatra Mts.). In this area there are largest and deepest cave systems of the whole Tatra Mts. (e.g. Wielka Sniezna-Litworowa Cave System). Distinctive features of geology of the area are latitudinal direction and mostly southern slope of the tectonic structures lying over Cretaceous marls. These structures are built by complex of the Triassic, Jurassic and Cretaceous limestones of the Wierchowe nappes. In the investigated massives over carbonate rocks lie tectonic caps of crystalline rocks of the Giewont nappe. The contact zones between them are reach of dolines, shafts and cave entrances (e.g. Kotliny, Ratusz, Marmurowa Cave).

COMPARISON BETWEEN MINERAL COMPOSITION OF SOME CLASTIC SEDIMENTS FROM UNDERGROUND PIVKA RIVER SYSTEM

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The Pivka river flows through lower levels of Postojnska jama, Otoška jama, Magdalena jama, at higher water level also through Črna jama and disappears in a siphon in Pivka Jama. From there its route is unknown up to Planinska Jama, a resurgence cave in the eastern part of Planinsko Polje, and to spring of Malni. The Pivka river transports into the cave the sediments from the flysch recharge area. In the Postojna cave system and in Planina cave, Pivka and Rakov channel, the mineral associations are very similar, the quantity only varies a little. In some samples the quantity of carbonate minerals is unusually high, because it is known that the origin of the caves flood loams and sands is from non-carbonate rocks. Calcite can appear like cement but in analysed samples was presented in small grains, silt and clay size. These are small particles of limestone which were eroded from the cave walls.