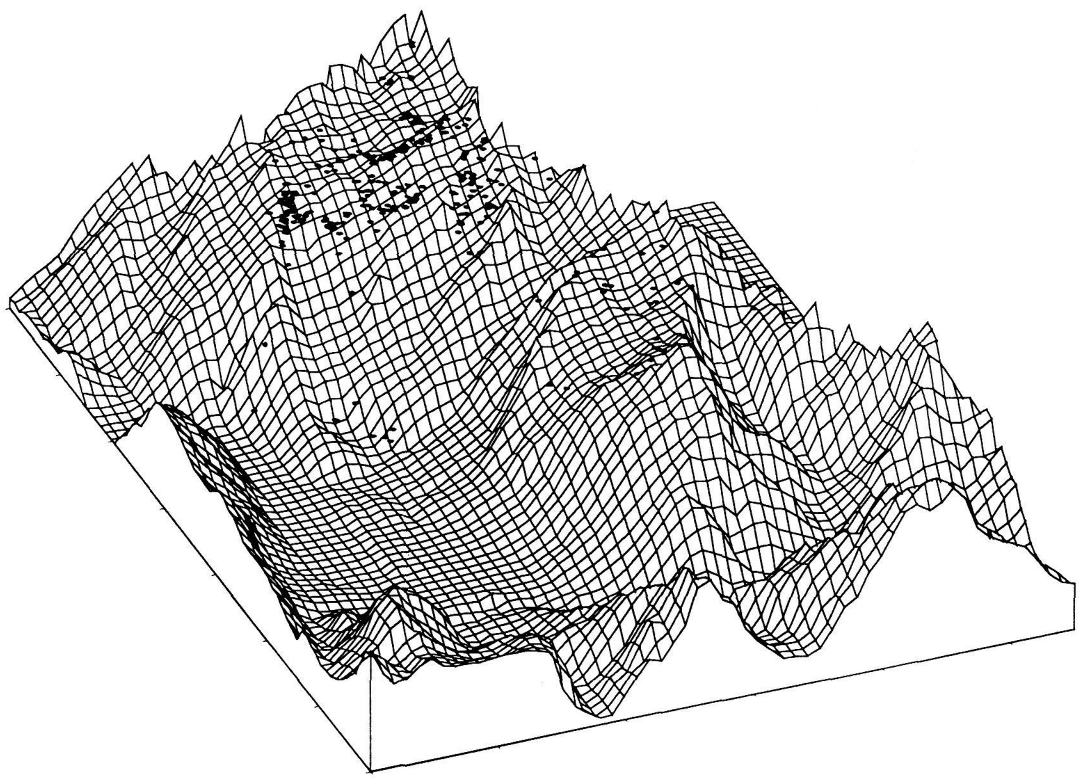
Speleological Association of Slovenia
and
Karst Research Institute ZRC SAZU

6th INTERNATIONAL KARSTOLOGICAL SCHOOL

Classical karst



ALPINE KARST

GUIDE-BOOKLET FOR THE EXCURSIONS
and
ABSTRACTS OF THE PAPERS

Trenta, June -July 1998

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

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PROGRAMME

Monday – June 29, 1998

8.00 - 8.30	**Opening**
8.30 - 10.00	**Opening Session (Chairman: K. Mais)**
	Jurij Kunaver: *Towards the regional geography of the high mountain karsts, the case of Julian Alps*
	Jože Janež: *Hydrogeological conditions in the upper Soča valley*
	Franci Gabrovšek: Caves and shafts of Kanin mountains area
10.00 - 10.30	**Break**
10.30 - 12.00	**Session 1 (Chairman: J. Kunaver)**
10.30 - 10.45	Seyyed Behzad Siadati: *Lithological characteristics and karst development in Alborz mountains (East Alpian Region) – n. e. Tehran, Iran*
10.45 - 11.00	Károly Barta & Tamas Tarnai: *Karstmorphological Research in the Mecsek Mountains, South Hungary*
11.00 - 11.15	Suzana Fiedler & Nenad Buzjak: *Speleological features in the mountainous karst of Risnjak mountain (Croatia)*
11.15 - 11.30	Milena Zlokolica-Mandić & Jelena Calić–Ljubojević: *Alpine(?) karst of Eastern Serbia*
11.30 - 11.45	Tomasz Klarenbach: *Caves of high mountains in Poland*
11.45 - 12.00	Alina Dana Tulucan & Tiberio Niculita Tulucan & Laszlo Beke: *The alpine karst in Romania*
12.15	**Official Opening Ceremony**
13.30	**Field work (Krajcarica, Mlinarica, Soča, Vršič, Zelenci, Planica)**

Tuesday – June 30, 1998

8.30	**A whole-day excursion (Karst of the Kanin mountain)**

Wednesday – July 1, 1998

8.00 - 9.45	**Session 2 (Chairman: P. Bosak)**
8.00 - 8.15	Nico Goldscheider: *Hydrogeological characteristics of folded Alpine karst systems exemplified by the Gottesacker Plateau (German-Austrian Alps)*
8.15 - 8.30	Andzej Tyc: *Hydrological and geomorphological effects of extremaly high water in karst regions in South Poland*
8.30 - 8.45	Anton Brancelj: *Limnology of mountain lakes in Slovenia*
8.45 - 9.00	Karl Mais: *Ice in caves - a climatic phenomenon and its morphological effect*
9.00 - 9.15	Bogdan Gadek & Leszek Litwin: *Glaciokarst of subalpine and alpine zone of the Mala Laka Valley, Tatra Mts., Poland*
9.15 - 9.30	Hubert Trimmel: *The last news concerning the protection of karst regions in the Austrian Alps*
9.30 - 9.45	Jurij Kunaver: *The measuring of the karst denudation with help of pearched blocks, the case of V. Vrata, Julian Alps*
9.45 - 10.15	**Break**
10.15 - 12.00	**Session 3 (Chairman: A. Tyc)**
10.15 - 10.30	Piotr Gajek: *Surface and underground karst phenomenas and their corelation with litology and tectonic (selected areas of West Tatra)*
10.30 - 10.45	Vladimir V. Tolmachev: *Karst and engeneering practice*
10.45 - 11.00	Boris Vrbek: *Heavy metals content in sediment of caves and pits in Croatia*
11.00 - 11.15	Edit Hoyk: *Investigations of the vegetation and soil in the dolinas of Mecsek Mountain, South Hungary*
11.15 - 11.30	Pavel Bosak & Petr Pruner & Nadja Zupan Hajna: *Palaeomagnetic research of cave sediments in SW Slovenia*
11.30 - 11.45	Katalin Takacsne Bolner: *Paleokarst Features and other Climatic relics in Hungarian caves*
11.45 - 12.00	Tadej Slabe & Martin Knez: *Origin and development of an old Alpine cave*
13.30	**Field work (Boka, Tolminka Gorges, Zadlaška jama cave, Kluže)**

GUIDE-BOOKLET FOR THE FIELD WORK AND EXCURSIONS

Prepared by: Bojan Otoničar, Metka Petrič, Franci Gabrovšek, Tadej Slabe, Martin Knez, Franjo Drole

Copied articles of: Jurij Kunaver, Jože Janež

INTRODUCTION TO THE KARST OF THE JULIAN ALPS

The Julian Alps are mountains in north-western Slovenia and north-eastern Italy; the highest peak is Triglav (2864 m). They are bounded by the valley of Kanal in the west and north-west, by the valley of the Zgornja Sava in the north and north-east; the high plateaux of Mežaklja, Jelovica and Pokljuka belong to them in the south-east and in the south they are bounded by Baška grapa and Kolovrat.

Due to fact that the Julian Alps consist mostly of carbonate rocks they are highly karstified. Typical high-mountainous superficial and underground karst phenomena are developed. The high-mountainous karst is the most distinctive on Kaninski, Kriški, Krnski and Triglavski Podi, on Goričica and on the Komna plateau but also elsewhere.

In the area of Julian Alps some deepest shafts and longest caves in Slovenia are located. The deepest is shaft called Čehi II, 1370 m deep, followed by Černelsko Brezno (1198 m) and Vandima (1182 m) – all three in Goričica below Rombon; in Kaninski podi the deepest shaft is Skalarjevo brezno (911 m), followed by Brezno pod Velbom (850 m) and Vrtiglavica (643 m), the latter being also the deepest vertical in the world; the longest cave is Pološka jama above the Tolminka springs (10.800 m) followed by Černelsko brezno (8.000 m).

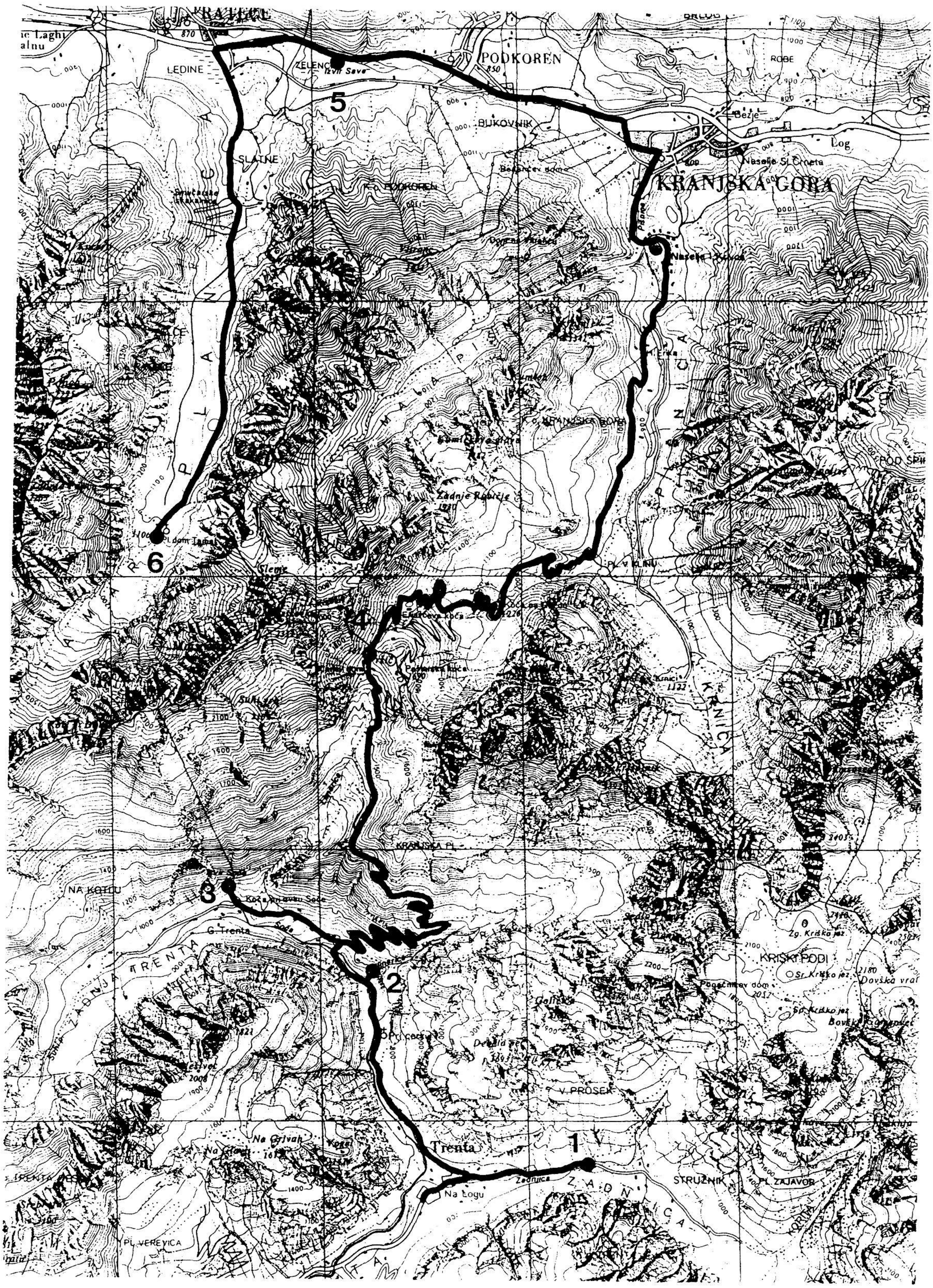
The water reappears at the foot of karst massifs, usually slightly above the bottom of the valleys in strong karst springs and active karst caves (the Savica and Govic in Bohinj, the Boka, the Glijun, the Soča spring, the Krajcarica, the Nadiža). In higher altitudes the superficial waters are relatively rare, seasonally, in particular in dolomite, torrents occur. The high-mountainous tarns appear only in the regions underlain with less permeable Jurassic and Cretaceous marls and sandstone (the valley of Triglavska jezera, Krnsko jezero) or consolidated morraine material (Kriški podi, Alpine meadow Jezero). In the north waters flowing out of Julian Alps gather rivers the Sava Dolinka and the Sava Bohinjka (Black Sea water basin) and the Soča in the south (Adriatic Sea water basin).

In the valley of Bohinj, glacially transformed, lies our biggest natural permanent lake – Bohinjsko jezero.

The last remnants of the ice sheet in the Slovene Julian Alps is so-called Zeleni sneg below Triglav Mt.

FIELD WORK - Monday, June 29, 1998

1 Krajcarica
2 Mlinarica
3 Soča
4 Vršič
5 Zelenci
6 Planica



INTRODUCTION

The area, we are going to visit, geographically belongs to Central Julian Alps. From a glacially shaped Alpine valley Trenta (the Trenta village lies 620 m a.s.l.) we shall ascend over high-mountainous pass Vršič (1611 m) in Zgornjesavska dolina (Kranjska gora, 809 m a.s.l.) to continue in glacier valleys Planica and Tamar (the hut in Tamar at 1108 m a.s.l.). The watershed between Adriatic (in the south) and Black Sea (in the north) is crossed at the Vršič pass.

GEOLOGICAL OVERVIEW

The geological setting of the area is lithostratigraphically and tectonically very heterogeneous. The whole area of Julian Alps belongs geotectonically to Dinarids, mostly to geotectonic unit of the Southern Alps to which in paleogeographic point of view the rocks of the former Julian carbonate platform belong. The Julian Alps consist of thrust nappes dissected by numerous faults, some of them still active. The rocks we shall meet during the excursion belong to vast Krn nappe. The area consists mostly of Triassic carbonate rocks, to a lesser extent there are magmatic rocks, klastites and vulcanoklastites. Between Kranjska gora and Planica there are in some places Upper Carboniferous and Lower and Middle Permian klastites and Permian limestones and dolomites.

The Lower Triassic rocks consist of mixed siliciklastic-carbonate rocks followed by Anisian and Ladinian bedded dolomite and limestone (the Vršič pass, the lower half of Prisojnik and a major part of mostly eastern slopes of the Velika Pišnica valley which we shall see fromVršič to Kranjska gora). In the Ladinian strong tectonic and volcanic activity occurred shown by magmatic rocks such as quartz porphyry and keratoporphyry appearing in the northern wall of Prisojnik and in southern slopes of Vršič. In this period the uniform carbonate platform disintegrated into Julian (southern Alps) and Adriatic-Dinaric carbonate platform (Outer Dinarids) separated by the Slovenski jarek (Inner Dinarids). Nearby to Kranjska gora there are also Ladinian klastites and vulcanoklastites and below Vršič limestones with chert nodules and beds of tuf.

Most rocks of the area consist of Upper Triassic carbonates. The Carnian stage is represented by massif ridge and bedded lagoon diploporous dolomites and limestones (the upper part of Prisojnik, slopes and some peaks above Planica and south-eastern slopes above Tamar and also western slopes above the Trenta village). Between Tamar and Vršič there are also Upper Carnian limestones and dolomites with cherts and marl and siltstone. The second unit is Carnian-Rhaetian master dolomite (in some places above Tamar) followed by the most extensive lithological unit of bedded Dachstein Norian-Rhaetian limestone and in some places dolomite (slopes above the Soča spring, peaks and slopes from Vršič past Mojstrovka to Jalovec and further on; and also the area on the south and south-east from the Trenta village). Some rocks are not classified in detail and they belong to Upper Triassic bedded and massive limestones (the area on the north and north-east from the village Trenta and above the Krajcarica spring). In some places of wider vicinity younger Jurassic and Cretaceous rocks outcrop. The valleys are usually covered by glacial and fluvioglacial sediments and other fluvial sediments. Collapse and slope debris are younger reaching the bottom of valleys frequently. There are also recent breakdowns which were particularly active during the last earthquake.

DEVELOPMENT AND THE TRACES OF THE LAST GLACIATION IN THE UPPER SOČA AREA - Jurij Kunaver (Kunaver 1980)

In the side valleys and in the main valley of the river Soča above the Bovec basin in the W Julian Alps there have been preserved numerous traces of local glaciations believed to have resulted from the last stronger post Würmian decline in temperature in the younger Dryas (Fig. 1). Due to this decline there have been formed, particularly in the side valleys, individual glaciers extending down for various lengths. It has been possible to establish that the longest glaciers were in those valleys which had comparatively the biggest Alpine hinterland, especially with high mountains. In our study the hinterland of an altitude above 1300 m has been taken into account. The longer the glaciers were, the more numerous terminal moraines have been preserved, but in no place more than five. The highest number of them is in the valley of Zadnja Trenta, while in the other valleys their number is two to three. The correlation between the length of the glaciers and the size of their hinterland revealed an interesting relation also regards the distance from the Bovec valley, or rather from western fringes of the Julian Alps. The glaciers situated more to the west are comparatively longer, and vice versa, which is due to the distribution of precipitation which was obviously also in the late Pleistocene similar to that existing today. This is confirmed also by the Kanin slope glaciers, which extended as far as the base of the mountain during the same climatic epoch.

The longest glacier was in the valley of the Lepena – 12 km; it reached already into Soča valley, which it closed off its front moraine at Čirča. In the next reliably established glacial stage or glacier push this glacier extended only as far as the end of the Lepena valley. But it therefore left there a system of at least two terminal moraines. Other signs of stages are in the Lepena valley unclear, but again therefore we find here a more clearly formed terrace system, related to the other glacier stage. At Vrsnik there were two glaciers, reaching together at their largest volume the village Soča. In the next younger withdrawal stage they had each by itself left terminal moraines just above the bottom of the valley.

The middle part of the Soča valley – between the village Soča and Trenta – is also not without traces of glacial stagnation. In the region of the lower part of the village Soča there was one morainic accumulation, and above Vrsnik another two. It appears, however, that these are traces of the stagnation of the main Soča glacier and they could be from a slightly older period.

At the same time a glacier was also in the Zadnjica valley and it reached as far as Trenta. At the end of the valley it had left another, reliably proved, moraine system. Then there is the valley of Zadnja or Zgornja (Upper) Trenta, which has clearly the most complete system of late glacial moraines preserved. The first of them is immediately above Log, the second between Juliana and the monument of Dr. Kugy, the next one is at the source of the Soča, the fourth one above Lower Zapoden, and finally the fifth one above the Upper Zapoden. Additionally, a side glacier in the valley of the Mlinarica has been established, and two nicely preserved moraine arches are to be found in the valley of Limarica below Vršič or rather below Velika Mojstrovka.

This contribution outlines the late glacial system of glaciers and in particular of their moraines, which together with proglacial and fluvioglacial terraces and elevations create a characteristic relief of the valley bottom in the Upper Soča valleys. It has also been attempted to establish a relation between the individual stagnation and the lower-lying terraces, which together form a genetic unit and a morphological complex. In this way we also sought to prove a relatedness between the glaciation and the terraces an the Bovec Basin.

In the continuation of our study we shall discuss the conditions in the drainage of the Koritnica, publish the cartographic material, and give a climatic-geomorfological survey of the developments and their effects in the transition from Pleistocene to Holocene, which had such a decisive influence in the formation of present-day physiognomy of the valleys in the Upper Soča area.

1. THE KRAJCARICA SPRING - Jože Janež

The Krajcarica river in the Zadnjica valley, Trenta is one of the major tributaries of the Soča. The catchment area consists of Dachstein limestones and the spring appears at the contact of limestones with a "master" dolomite. Quaternary sediments (moraines) are deposited in the valley itself and on the steep slopes above it.

The Krajcarica rises at 700 to 720 m a.s.l. in several springs flowing out of moraine on both sides of the valley and in the riverbed itself. The lowest discharge is 140 l/s, medium one 2 m^3/s and the highest 64,3 m^3/s. From January to March discharges are usually small due to retention effect of snow regime; snow starts to melt by the end of April. In May discharges increase to reach their maximum in June. From July to October discharges decrease to augment once again in November due to autumnal rains.

The headwaters of the Beli Potok, sinking into moraine only 300 m above the spring, and waters from Korita and Komar, sinking in the end of the Zadnjica valley, undoubtedly contribute to the Krajcarica spring. To its catchment area the massif of Veliki Vršovec and Zadnjiški Ozebnik may also be added. The wider area of the karst spring recharge is not yet delineated. The catchment area of the Krajcarica is bounded by the orographic watershed to over 20 km^2.

The water temperature of the Krajcarica varies from 4,7°C to 6,6°C. The total water hardness is from 4,3 to 6° NT and electro-conductivity from 146,5 to 210 μS/cm. The calcium level varies

24,8 to 30 mg/l, magnesium from 3,4 to 9,4 mg/l. rMg/rCa (meq) relation varies substantially, from 0,22 (rather small effect of dolomitic waters) to 0,63 (very important effect of dolomitic waters); its mean value is 0,43. Bacteriological tests show that this water is clean both in different time intervals and in all the seasons.

The Krajcarica catchment area is mostly high-mountainous, barren or modestly covered by vegetation. In Zadnjica valley there is one farmhouse and two summer houses. The growth of summer houses would, by all means, negatively affect underground water quality and maybe considered as a major danger to till now clean water of the spring. In a wider catchment area two mountain huts are located, Pogačnikov Dom on Kriški Podi with telpherline from Zadnjica and Tržaška Koča on Dolič, but maybe also Zasavska Koča on Prehodavci.

2. THE MLINARICA BROOK

The Mlinarica brook, a left tributary of the Soča river, flows into the Soča about 500 m south-eastern from the crossing of the main road Bovec - Vršič and the side road leading to the Soča spring. It flows permanently from a spring close to the roadhouse on the Vršič road. The Mlinarica has cut a narrow and winding gorge into the western slope of the Kukla. Several waterfalls were formed on its course (Fig. 2), the highest is the upper one, which has two steps and a height of 50 m. In the central part the gorges are so deep and narrow that no light can come through. In this part the walls are up to 80 m high. The valley with a total lenght of around 1.5 km was first scaled through with the use of caving technique not until 1989.

3. THE SOČA SPRING - Jože Janež (Janež 1995)

The Soča river is the biggest Slovene river that flows into the Adriatic Sea. The perennial springs of the Soča river are located at 870 m a.s.l. below the mountain hut Koča pod izvirom Soče in the moraines at the bottom of the Suhi Potok in the Zadnja Trenta valley. The stream flows over Upper Triassic dolomites from below the alpine meadows of Zapotok into Zadnja Trenta and disappears into well pervious glacier moraine; thus the torrential Suhi Potok, with about 2 km wide riverbed remains dry. After rain the water level rises in the moraine to the surface and forms a huge torrential river. The height of the spring in the valley depends on water level. The water takes its source on the left and right side of the riverbed in the valley, about 500 m a.s.l. During drought it is said that only about 200 l/s rise from gravel and rubble in a gulch (Habič & Čar 1989). In spite of their importance these springs are almost unknown. As the Soča spring a picturesque karst spring rising out of a limestone wall below Velika Dnina is considered (Rojšek 1991). This spring lies 960 m a.s.l. and rises out of siphon karst passage developed along a tectonic fissure. This spring runs dry during drought and only a siphon lake remains in the bottom of a shaft, more than 30 m deep. In July 1994 during a medium water level the karst passage yielded 150 l/s of water.

The waters yielded by the high-water recharge above the valley's bottom undoubtedly flow from high-mountainous karst aquifer of Velika Dnina; this is a ridge between Mala and Velika Mojstrovka and Jalovec continuing as far as Veliki Pelc. The eastern boundary of the aquifer consists of the fault of Mojstrovka passing over the Limarica indentation and Vršič. The origin of waters appearing in the surface riverbed at the beginning of Zadnja Trenta is not yet ascertained. It is supposed that a major part of these waters have the same catchment area as the highest spring. Karst base-flow must overcome the impermeable barrier of the Mojstrovka fault. The second underground flow towards the springs is underlain with moraine in the Zadnja Trenta valley.

In figure the geologic cross-section displays the geologic setting of the spring area (Fig. 3). The northern and north-western valley sides consist of Dachstein limestone of the Norian-Rhaetian age. Below limestone there are Upper Triassic dolomite and Tamar formation of Carnian age (limestone, marl, dolomite) that represent the impermeable basement of the karst aquifer. The southern and south-eastern sides and the lower part of the Trentarski Pelc and Plešivec slopes consist of Carnian and Norian dolomite, passing at the top of the ridge into Dachstein limestone. In the Zadnja Trenta valley young Pleistocene glacier moraine is deposited and on the slopes above the valley the parent rock basement is covered by slope debris and torrential alluvial fans. The Zadnja Trenta valley developed along the fault of Mojstrovka which continues north-eastwards over Vršič into the Pišnica valley.

Since 1952 a discharge gauging station operates on the Soča river below the village Kal-Koritnica before the confluence with Koritnica. In this period the following two extreme values were registered: $Q_{min} = 1.7\ m^3/s$ and $Q_{max} = 256\ m^3/s$.

4. ON GEOMORPHOLOGY OF DOLOMITIC VRŠIČ PASS IN JULIAN ALPS - Jurij Kunaver (Kunaver 1990)

The Vršič Pass in Julian Alps has a specific geologic structure because of the neighbourhood of the Anisian dolomite of Middle Triassic and the Dachstein limestone of Upper Triassic (Fig. 4). Once the Triassic limestone cover was weathered away, erosion advanced rapidly in the highly raised Middle and Lower Triassic bedrock and created this characteristic, deep incision in our Alps. The process was further abetted by the Mojstrovka dislocation, which traverses the region, contributing to the strong tectonic fragmentation of dolomite. For this reason, the dolomite does not act as a firm bedrock, but has been transformed into a crumbly, sandy material. Localised erosion has for this reason played an important role in the formation of the mountain pass, perhaps more important than that of the Pliocene river which is believed to have flowed from west over Vršič in the direction of the Karavanke and the Drava valley.

The region was also the region of late Pleistocene hanging glaciers, which left their frontal moraines on the pass itself and lower down. Also fossil perglacial screes are to be found.

Many badlands in the northern and southern side of Vršič, in the area of the headwaters of Suha Pišnica, the Močilnica and the Limarica attest to the intensity of the geomorphological processes. The rate of erosion of torrents is quite high, which can be shown by comparing photographs taken at different periods. Consequently, one may conclude that these badlands are of younger origin and that man has significantly influenced this process owing to his various interventions in the landscape. The magnification of the badlands is directly proportional to their size, which means that the natural process of erosion would develop even faster had there been no man-made obstacles in the form of torrent barriers.

Erosion troughs run down the slope from these badlands. They are quite deep at the beginning and become smaller further down the slope and not the other way around as would be expected. This phenomena is accounted for by the weak erosive force and relatively low water rate of the streams which do not have large headwaters. Some badlands are for the time being localised, but may eventually endanger a greater area. Due to the steep gradient, surface water can carry away quite a large volume of material, which is further facilitated by the crushing of dolomite into small sand particles.

The dolomitic regolith and the turf covering the slopes are being affected and damaged by the denudation and gravitation processes which have been, for the large part, trigged by man. Natural turf is being fragmented and removed to a point of exposing bare rock. Vršič is criss-crossed by numerous mountain and other trails as well as old military and new roads, which are cut into the slope and are therefore all potential sources of erosion.

Finally, on the basis of the fact that relatively intense denudation and erosion processes are the result of man's excessive interventions in the sensitive, high-altitude mountains, Vršič should be pronounced an ecologically endangered area of the Julian Alps.

5. THE ZELENCI SPRING

The emerald green small lake Zelenci is recognised as a spring of the Sava Dolinka, although the Nadiža spring in Tamar is the first spring of this river. Namely, waters of the Nadiža spring sink immediately into the gravel and emerge again in the Zelenci. Several smaller springs are situated close by the main spring at the altitude 842 m. Bright coloured silt from the bottom of the 2 m deep lake is constantly lifted by the water flow from these springs. From the spring the Sava Dolinka flows approximately 1200 m through the swampland and then further in the valley towards west. Near the lake there are several circular springs called by the locals "tumfi". In the swamp around the springs the peat moss can be found.

The Zelenci are at least partly recharged by the Nadiža, which flows under the so called Planica alluvial fan and at the impermeable barrier of the front moraine of the former glacier emerges again. Nearly constant temperatures all the year round were defined by the measurements of the water temperature in Zelenci in the years 1981 and 1982. The oscillation was only 1° C between 5.1° C and 6.1° C.

The gauging station on the Sava Dolinka is installed in Kranjska gora. In 1995 the minimum discharge was 0.24 m^3/s, the mean discharge 0.80 m^3/s and the maximum discharge 2.36 m^3/s.

6. THE PLANICA VALLEY

The Planica valley, which is known throughout the world for its ski-jumps, was formed by the smaller Planica glacier. A half-a-kilometer long longitudinal moraine of this glacier proves the inability of the side glacier for removing till out of the valley in the last Würmian and late glacial epoch. The moraine dam is partly overgrown by wood and extends in a gentle curve opened towards south. Large screes are on both sides of the valley. The material of these screes was transported by waters and then deposited in a wide alluvial fan extending to the front moraine of the former glacier.

Tamar is the last part of the Planica valley, so-called because of the enclosed space in which they penned livestock (tamar = pen).

Below the Rateške Ponce on the eastern rocky slopes of Tamar is the karst spring Nadiža. Spring water from the fissure falls over the dolomite step of the source in a small chute, then tumbles in a series of falls to the valley floor, where it disappears into the gravel glacial alluvium. Part of the Nadiža water emerges again in the Zelenci, while part pours into the Ziljica.

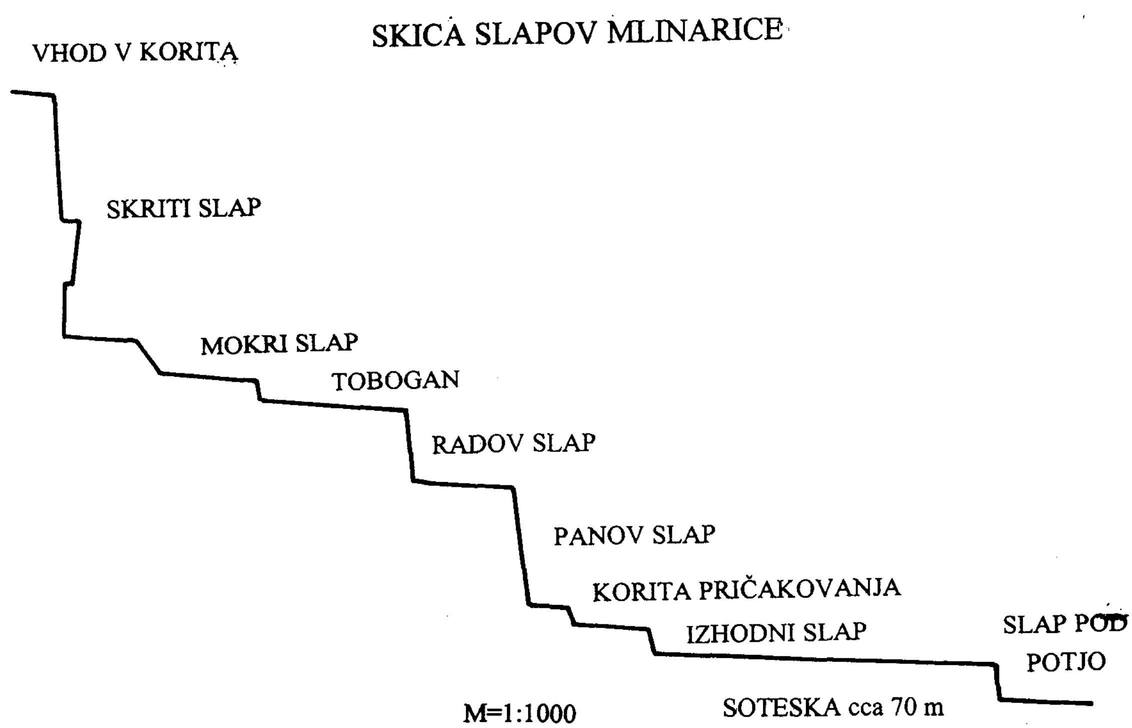


Figure 2. The Mlinarica waterfalls (Kladnik 1989)

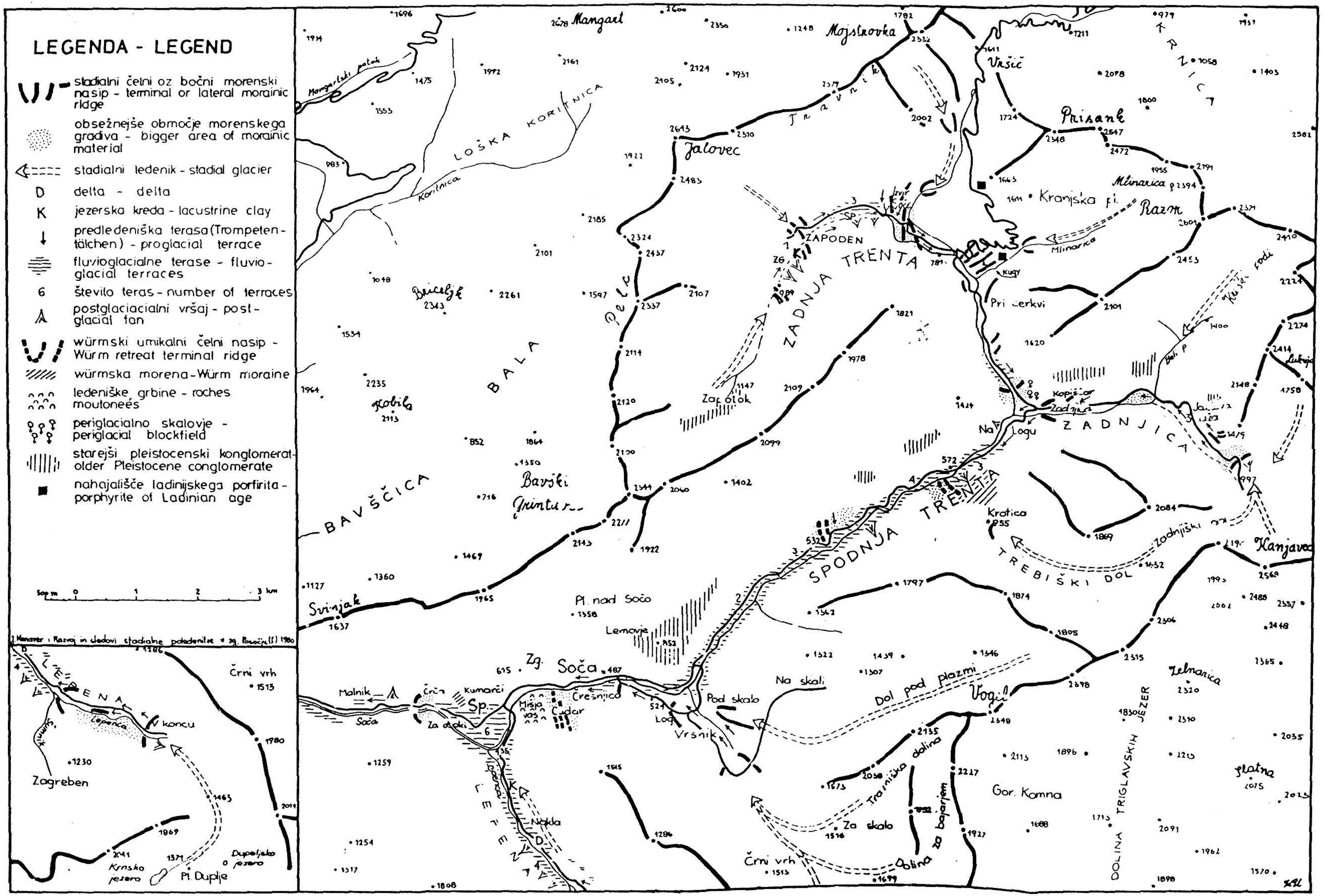
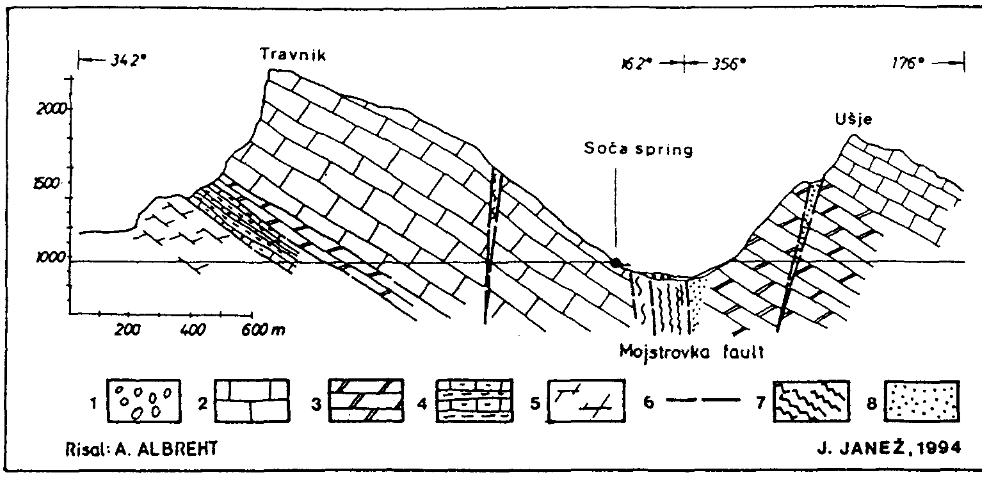


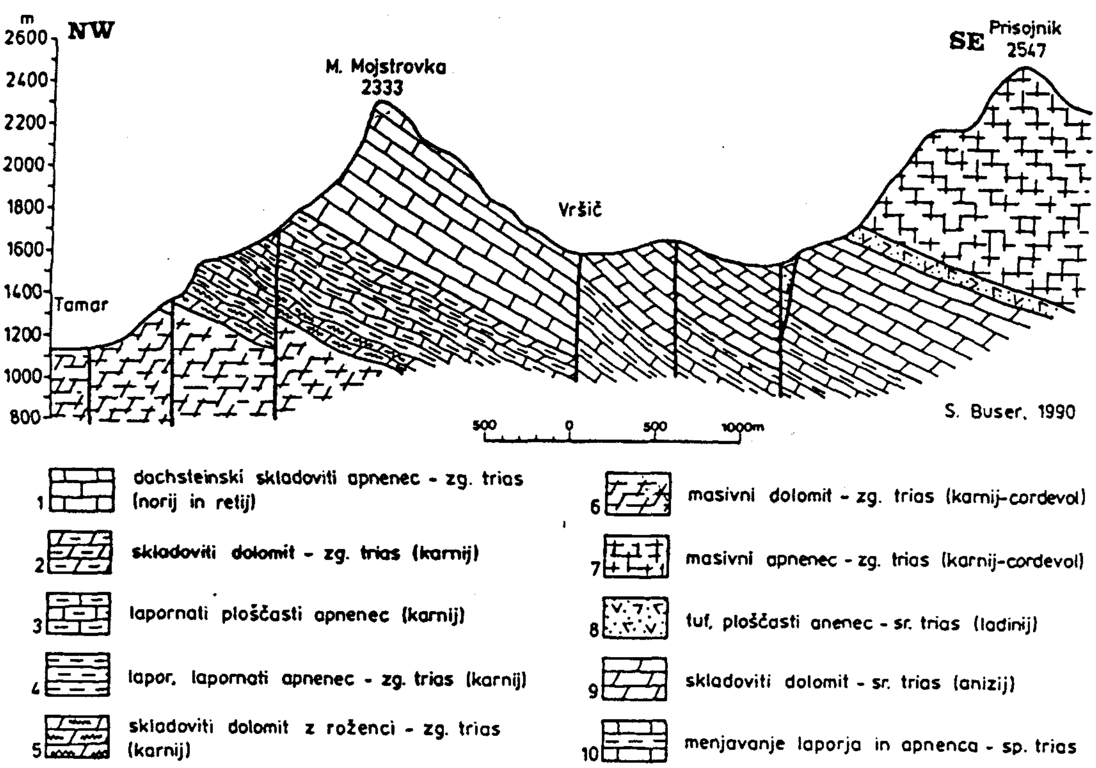
Figure 1. Traces of glaciation (Kunaver 1980)



Slika 1 Geološki prerez (1 - ledeniška morena, kvartar; 2 - dachsteinski apnenec, norij-retij; 3 - "glavni" dolomit, karnij-norij; 4 - tamarska formacija, zg. karnij; 5 - masiven in skladnat dolomit, karnij - cordevol; 6 - prelom; 7 - porušena cona v apnencu; 8 - milonit)

Fig. 1 Geologic cross-section (1 - morraine, Quaternary; 2 - Norian-Rhaetian Dachstein limestone; 3 - Carnian-Norian dolomite; 4 - Tamar formation, Upper Carnian; 5 - non-bedded and thick-bedded dolomite; Carnian-Cordevolian substage; 6 - fault; 7 - broken zone in limestone; 8 - mylonite

Figure 3 (Janež 1995)



Sl. 1. Geološki profil v Julijskih Alpah med Tamarjem, Vršičem in Prisojnikom (S. Buser)

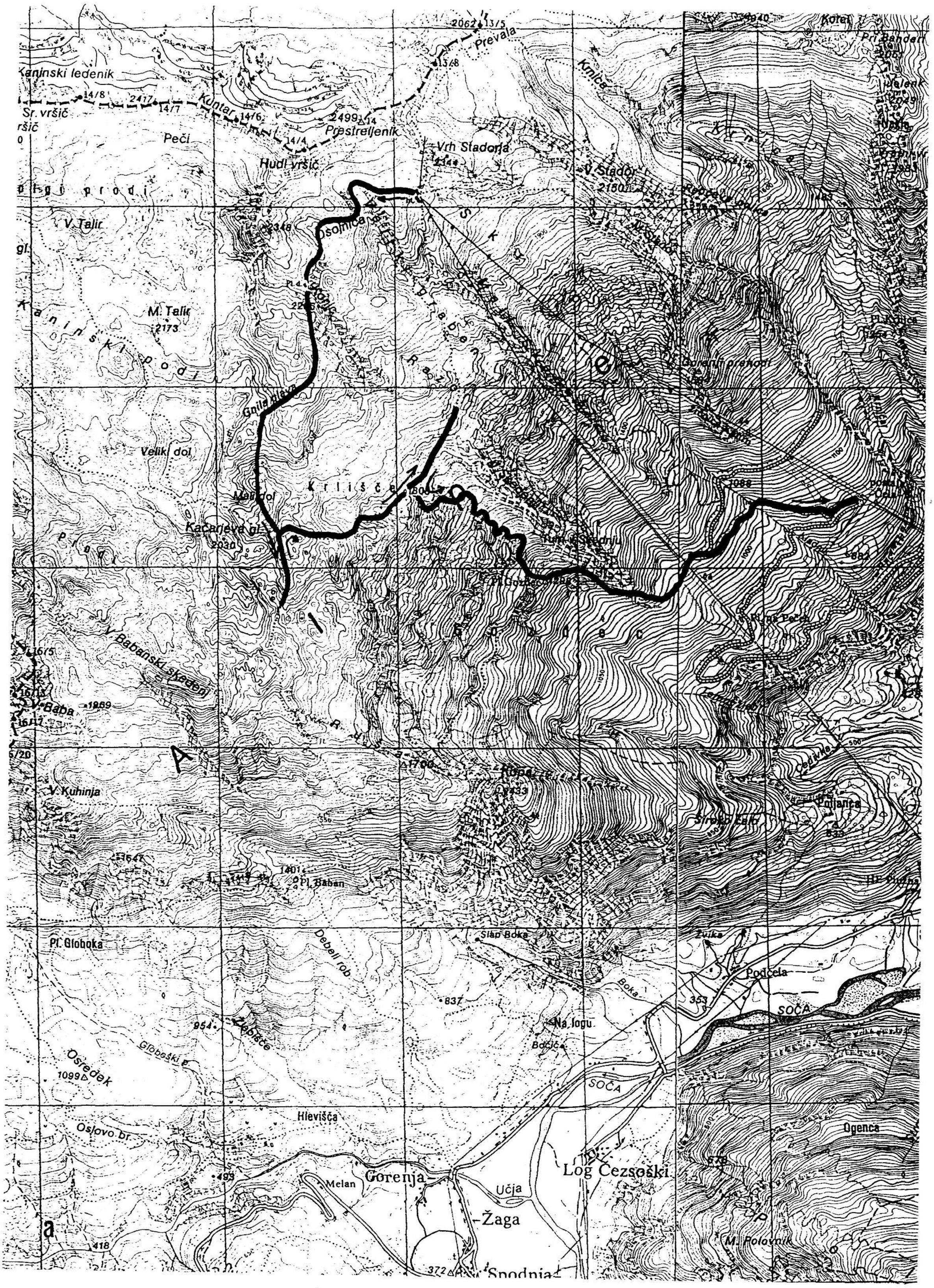
Fig. 1. Geological section between valley of Tamar, Vršič Pass and Mt. Prisojnik in Julian Alps (S. Buser)

1. Dachstein thickly bedded limestone-Upper Triassic (Norian and Rhaetian)
2. Bedded dolomite-Upper Triassic (Carnian)
3. Marly platy limestone-Upper Triassic (Carnian)
4. Marl, marly limestone-Upper Triassic (Carnian)
5. Bedded dolomite with chert-Upper Triassic (Carnian)
6. Massive dolomite-Upper Triassic (Carnian-Cordevolian)
7. Massive limestone-Upper Triassic (Carnian-Cordevolian)
8. Tuff, platy limestone-Midle Triassic (Ladinian)
9. Bedded dolomite-Midle Triassic (Anisian)
10. Marl and limestone-Lower Triassic

Figure 4 (Kunaver 1990)

A WHOLE-DAY EXCURSION - Tuesday, June 30, 1998

KARST OF THE KANIN MOUNTAIN



INTRODUCTION

Kanin is the most widely extended mountain massif in the Western Julian Alps bounded with Rezijska dolina in the west, Reklanska and Rabeljska dolina in the north and by Predel pass, the Predelnica stream and the Koritnica river in the east; to the south there is the basin of Bovec and Rezijska dolina. The excursion will take place in the central part of the Kanin mountains, to Kaninski podi. The main ridge that semicircularly encompass in the west and north the Kaninski podi is directed from ESE to WNW and it turns at the highest peak of the Visoki Kanin (2587 m a.s.l.) into W-E direction. Several narrow lateral ridges fork from the main ridge towards SE and E and between them limestone pavements and slopes are lying. Limestone pavement is karstified high-mountainous plateau, 3 km wide and 2 km long. From the upper lying, less inclined pavements (from about 2300 m a.s.l.) the surface descends gradually to the lower boundary of limestone pavement at 1800 m a.s.l. in the west and 1500 m a.s.l. in the east. Further down the surface passes into more steep slopes. The central part of the pavement is a larger gently sloping doline called Veliki Dol from which through valleys and dry valleys ramify towards higher parts with low ridges and elevations among them. In particular the southern part of the pavement is well dissected with several deep depressions and dry valleys.

GEOLOGY

Kanin Mt. consists of Upper Triassic Dachstein limestone overthrusted to Jurassic limestones of the Bovec basin. In the valleys of the Možnica and Krnica dolomite lies in the base and this may be seen also in some deeper parts of deep caves. In some places at the contact between dolomite and limestone the character of the caves passes from more vertical to more horizontal. The Dachstein limestone is typically bedded, the thickness of layers being from 0,5 to 5 m. Often the beds are displayed in more or less perfect cycles of the Lofer type composed of three units: the B unit is represented by sub-tidal, mostly micritic limestones with numerous Megalodontida shells followed by intertidal laminated, even stromatolithic limestone of the C unit; the top of the cycle is supratidal breccia with reddish cement, paleosoil horizon or black pebble breccia of the A unit. The A unit is frequently represented by a karstified surface, while paleokarstic features, in particular "solution cups" may affect the lower units as well. The C unit may be slightly dolomitized. An interesting feature are also neptunean dykes, cross-cutting Dachstein limestone to several hundred metres deep and infilled with reddish Jurassic, and slightly deeper with marine sediments.

Above Bovec the Triassic limestone of Kanin, making part of the Krn nappe, is thrusted to Lower Jurassic micritic and oolithic shallow-water limestone facies containing in some places Lias dominant shells lithiotidae. In some places there are over-laid smaller erosional patches of Jurassic reddish limestone with manganese nodules and single ammonites (similar to the limestone type called ammonitico rosso). The base of the Bovec basin consists of light-grey biomicritic limestone and reddish marl limestone followed by Upper Cretaceous flysch. In the Kanin slope, limestone and flysch contain interbedded limestone breccia. The bottom of the Bovec basin itself is filled by fluvial conglomerates, gravel and morraine material.

Kanin mountains are designated as the Kanin syncline area. In the western part the beds are trending south-westwards and in the eastern part eastwards. The Bovec basin is a syncline having flysch in its centre. Kanin is dissected by several faults, the most distinctive and numerous are those trending northwest-southeast. Some of the most distinctive morphological features developed along these faults, such as Krnica valley, Veliki and Mali Skedenj etc.

The shafts and caves development, in particular the direction of their passages, were strongly controlled by the Kanin geological setting. Shafts and oxbow passages are controlled by faults mostly, some older passages by bedding-planes also; genetically is extremely important the contact of limestone and dolomite in deeper parts where a general vertical direction is changed into more horizontal one. This is very well seen in Čemelsko brezno.

GEOMORPHOLOGY OF THE KANIN MOUNTAINS WITH SPECIAL REGARD TO THE GLACIOKARST (Northwestern Slovenia) - Jurij Kunaver (Kunaver 1983)

The Kanin Mountains are an extensive massive in Western Julian Alps. Its elongated character is related to the geological structure, for in its entirely this is the northern limb of the vessel-shaped Bovec syncline. In Kossmat's opinion, it has the characteristics of a monoclinal fold; according to Buser, it contains in the upper parts also smaller anticlines and synclines. Therefore the limestone strata are generally coinciding with the hillside slope in the direction of the Bovec basin. A different dip of the strata is occasionally to be found on the "podi". The more recent geological research has confirmed Kossmat's belief that the Bovec basin had formed itself on the area of a big syncline, filled normally with early Triassic, Jurassic and Cretaceous strata. The same kinds of strata are to be found on the slopes (Buser 1976, 1978).

The author has established that in addition to pure limestone there are frequent various degrees of dolomitized limestone; so, beside the typical dolomite, four degrees of dolomitization have been identified. The dolomitization hinders the corrosional shaping which is no longer found in weakly dolomitized limestone (6 % $MgCO_3$) or even earlier. On the other hand, the dolomitization makes limestone more exposed to mechanical disintegration. Thus we get in the massive regions with increased course gravel also below the lower level of mechanical disintegration. In the Krnica valley, is an extensive region of the Upper Triassic dolomite that is in contact with Dachstein limestone bedded, but in depth increasingly massive. The dolomite belt extends also in the upper parts of Goričica, Črnela and via Prevala on to the Italian side of the mountains. Prevala had formed itself through the discontinuation of the limestone cover over the dolomite. The same dolomite continues under Goričica into the Možnica valley; also, as may be assumed that dolomite forms the basis for the entire central part of the Kanin Mountains. It seems that in some places it indirectly affects the surface, in the region of collapse dolines at Škripi. Narrow belts and patches of chemically similar dolomite are occasionally found in the lower part of Kanin "podi", but this is possibly due to a subsequent diagenetic dolomitization.

The Kanin Mountains have two large plateaus, Kaninski podi and Goričica, and a number of smaller erosional plains. The statistical analysis has shown that the two plateaus are not a continued erosional (karst) plain, but that it is divided into several levels. The differences among them are hard to identify, since there is the interaction of geological structure, effects of the karstification with big depressions, possible remains of the old pre-quaternary fluvial relief and glacial transformation. Kaninski podi are thus a big, tilted erosional plain, which in three to four different levels come down from 2300 m to ca. 1950 m. In their clearly lower part they appear already as gentle slopes, down to the altitude of 1800 m. Then follow slopes, discontinued by terraces of partly erosional and partly structural origin. A more distinct, narrow erosional terrace, extending over considerable distance is Na Pečeh, on the lower slopes of Gozdec, Razor and Škripi, altitude between 870 and 1000 m. Possibly this is what has remained from the pre-quaternary bottom of the Bovec basin. This fold is more emphasised also because of the steep Peči, over the pocket valley Glijun, and other recent or older karst springs west to the village Plužna. Beside this strong karst spring there are here also periodic springs and older, dry outlet cave Srnica. The difference between the western and the eastern parts of the mountains, or between the two erosional plains, Kaninski podi and Goričica, shows an interesting difference in the altitude – 150 m – that may be a consequence of the differences in the neotectonic dynamics.

The neighbouring mountain ridges of Polovnik and Kobariški Stol show with the remains of erosional terraces and plains that the original consequent flow-off from the Kanin Mountains was more and more adapting itself to the geological structure. The Soča at Žaga is on a tectonically broken-up, recently lowered area, which must in the past favourably affect a possible river capture by eroding one stream into the drainage basin of another one.

The author has studied the origin of characteristic narrow ridges, "skednji", which go from the highest parts of the mountains parallel with slope-belts down to the altitude of ca. 1150 m. A comparison between the erosional deepening of the individual sections of slopes and the bigness of the mountainous background shows a harmonic proportion. Therefore these ridges are narrow remains of a formerly broader old Tertiary surface, as many of them start at the altitude of the lower edge of the "podi". The formation was made all the more easy because of the monoclinal and dip slope geological structure. Similar divides are to be found in other limestone mountains, where the strata are horizontal, and this is related to the characteristic vertical jointing of limestone strata. The fault lines on the slopes were more important for the formation of grooves and less for narrow ridges.

In the Kanin Mountains there are preserved numerous traces of the glacial erosion and accumulation (Fig. 5). Especially the glacial erosion has left marked traces on the live-rock basis. Despite the strong exaration there have in places been preserved fossil "kotliči" – Kettles (German: Schachtooline) and from one of the interglacial period eroded "škraplje", karren. The effect of the same processes and of the characteristic dip of the limestone strata is the high presence of pavements on the surface. The different relation between the dip of the strata and the steepness of the relief permits us differentiate as many as eleven types of the pavement surfaces. Most of the moraine material was deposited at Na Pečah, at the lower edge of the "podi", at the bottom of big karst depresions and on the upper part of the "podi" – which permits conclusions concerning the retreat stages. At the Krnica valley frontal moraines are clearly preserved. The morainic material is for the most part strongly karstified, especially at the bottom of depressions and bogazes.

The glacial transformation had caused that after the glacial period the high-mountainous karst surface gradually started to the karstify – both because of the polished surface and primarily because of the varying moraine coverings. The area is therefore karstified in varying degrees and exhibits in dimension and permanence a great variety of karst forms. One reason for this is also the different amounts of water flow-off, a consequence of the different snow covers in convex and concave parts.

The karst process is reflected not only in the great number of karst forms but also in the tiny dissection which is particularly noticeable on the bare, glacialy polished rock basis. Among the smallest corrosion forms are biocorrosional grooves, a consequence of the lithophile algea and lichen. Here the grooves reach a depth of up to 6 mm. Characteristically their colour goes from a patinated greyish one to the light yellow fresh colour of limestone. The effects of various forms of the action of snow-water onto the rock-basis under snow-covered ground was also noticed. The high number of pavements and other glacier-polished bare rocky surfaces have led in the Kanin Mountains to a great many different small or smaller forms of corrosion in the Holocene. On the "podi" the micro-grooves, Rillenkarren are rather more rare; that is possibly due to the higher amounts of snow in comparison with the rain-water. Very rare also the corrosional steps, explainable perhaps trough the petrographic properties of the Dachstein limestone and also the climate. Very often the live-rock surface is evened out, with numerous extraordinary big and elsewhere unknown corrosional levels, 20 to 25 cm thick. There are also five genetically different variants of kamenitza: closed, with flow-off, open, broken up, and eroded. The bare rocky surfaces must have been fine ground for numerous kamenitzas, developing over a long period in Holocene, until they started to be affected by vertical corrosional processes. In the strongly humid climate here an intensive development was in process also with Rinnenkarren and Kluftkarren all sorts especially on the lower sections of pavements. Their high frequency, size and depth, are a proof of a powerful erosional process. The meander groowes reach before the sink form place to place a depth of up to several metres.

Characteristic is the sequence of karst landforms on many pavements in the lower part of the "podi". Under the moraine deposit, which is gradually receding, are first Rinnenkarren, next karren, and these turning then into Kotliči and potholes. Such a sequence is directly related to the duration of the corrosional dissection of the rock surface because of the gradual receding of the moraine and also because of the different amounts of the aggressive water. Most commonly are to be found hole-like, eliptical and parallel karren, also such forms known as Rundkarren, and others. While in many places karren have straight ribs and as such may be a remnant of erosion of older karren, there has been found also a grouping of karren of possibly pre-Würmian period.

The sample of 39 Kotliči-kettles has given their following average dimensions: diameter – 7,1 m; depth – 5,9 m. The depth is normally bigger than width. These "Schachtdolines" are here among the predominant karstic form. They are to be found over 1600 m high up and as high up as the belt of the more intensive mechanical disintegration, where transitional forms, including doline are also to be found. Although their size would as a rule reflect the duration of the development, there must be assumed for also the possibility of an intensified development. Local conditions strongly influence the cross-section and the plan. About half of the Kotliči have a longish plan, either because of the joints or because the surfaces have a slope. In the latter case the "Schachtdolines" are longish because of the strong corrosion on the lower side. These forms are particularly numerous in places with high accumulation of snow.

Of post-glacial age are certainly the dolines in the moraine material; mostly they reach a diameter of 30 m and maximum depth of 15 m.

Because of the dense network of joints and fault lines their influence on the formation of karst forms is very strong. Therefore karstgassen are also very frequent.

In the Mountains we have come across 31 bigger karst depressions, with diameter of 80 to 680 m, and depth up to 45 m. Only a few of them might have been formed through collapse, most of them are of polygenetic origin. Depressions formed themselves mostly in bottoms of old valley-basins and at the meeting point of fault lines. The glacial transformation has on the one side deepened the depressions, while on the other the moraine material in places protected the bottom form the corrosional lowering. Nevertheless the depressions are doubtlessly areas of a relatively more intensive lowering of the surface, resulting from the thicker snow-cover, than convex areas.

The more recent, non-karstic transformation of the surface is most noticeable in the belt of stronger mechanical disintegration, i. e. over 2100 m high up. To this category belong also the rock falls and the interesting dry erosional trenches on the slopes, formed at time when the glaciers started to recede before at the beginning of Holocene.

CAVES ON KANIN

Kaninski and Rombonski podi plateaus are probably two of the most significant high karstic plateaus in Slovenian Alps. They exhibit all the typical surface and subsurface features of Alpine karst .

The area of Kaninski podi is one of the areas with the highest cave density in Slovenia (Fig. 6). First caves registered in the area date back to 1950. Since then the exploration activity become more and more insensitive. In sixties and seventies many new caves were discovered and registered. In eighties and nineties the modern technique enabled cavers to reach greater depths. Three of the deepest caves in Slovenia are in the area of Kanin mountains. Last years were marked with the discoveries of two deep shafts, Vrtiglavica (-643) and Brezno pod velbom (-501) , which rank among the three of the world's deepest verticals.

The list of deepest caves in the area (Fig. 7 - 11):

Kat. No.	Name	Lenght	Depth
6200	Čehi 2		**1370**
6040	Črnelsko brezno	4667	**1198**
6452	Vandima	2500	**1182**
6000	Skalarjevo brezno/Kanin	3216	**911**
6049	Brezno pod velbom		**841**
6926	Vrtiglavica	643	**643**
6050	Brezno Hudi Vršič	737	**620**

Typical for most of the caves is the meander-shaft pattern. They are the result of karstification under a specific condition of a relatively high hydraulic gradients, cold climate and low CO_2 content water. Some caves intercept the old phreatic galleries, which were formed in the previous phases of speleogenesis. In some of those, the cave-sinter was found also.

One of the recent challenges is to connect cave Mala Boka, which has an entrance at the foot of the mountains, to some of the caves on the plateau.

Figure 5 (Kunaver 1983)

DVA PRIMERA KARTIRANJA MEZO IN MIKRORELIEFNIH KRAŠKIH OBLIK V VELIKEM MERILU (KANINSKI PODI)
Two examples of big scale mapping of small and medium – sized high mountainous karst forms (massive of Kanin)

KRAŠKE OBLIKE NA MALO NAGNJENEM LAŠTASTEM POVRŠJU NA VRATCIH (1915 m)
Karst forms on slightly tilted pavement Vratca – 1915 m

KRAŠKE OBLIKE NA DELU HUDEGA LAŠTA POD MALIM BABANSKIM SKEDNJEM (1865 m)
Karst forms on the pavement Hudi lašt below Mali Babanski Skedenj – 1865 m

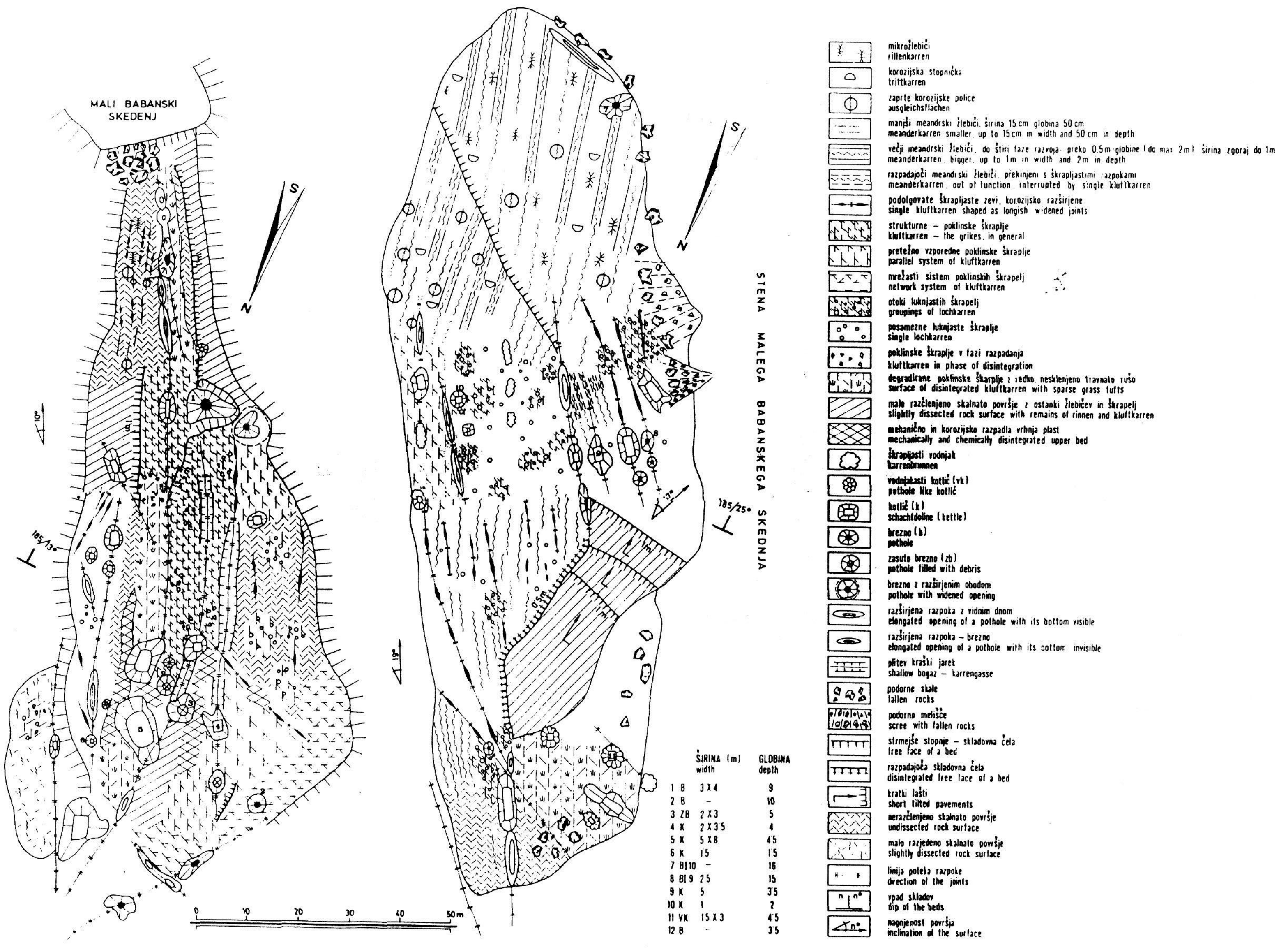
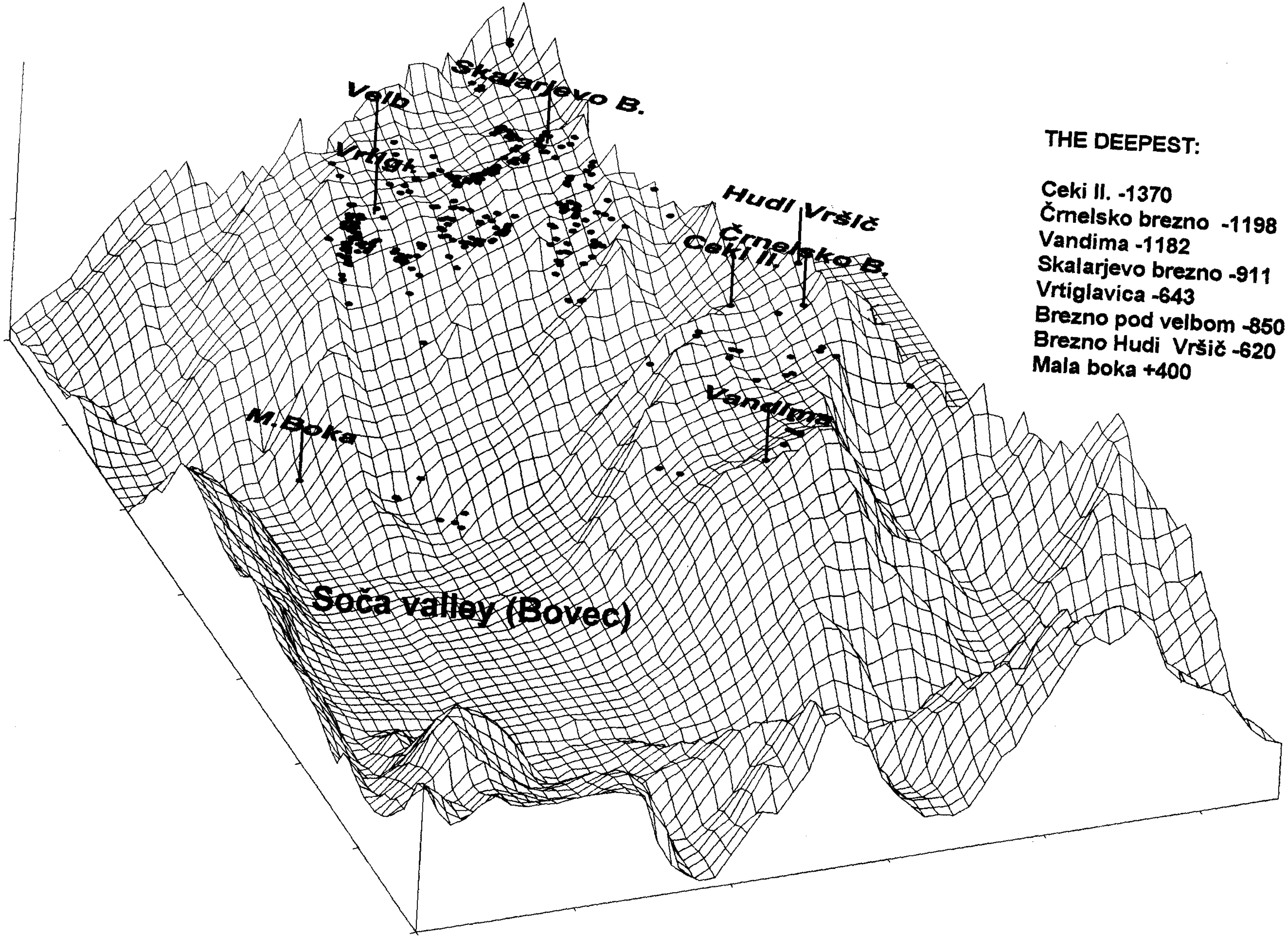


Figure 6

Caves of Kanin mountains



THE DEEPEST:

Ceki II. -1370
Črnelsko brezno -1198
Vandima -1182
Skalarjevo brezno -911
Vrtiglavica -643
Brezno pod velbom -850
Brezno Hudi Vršič -620
Mala boka +400

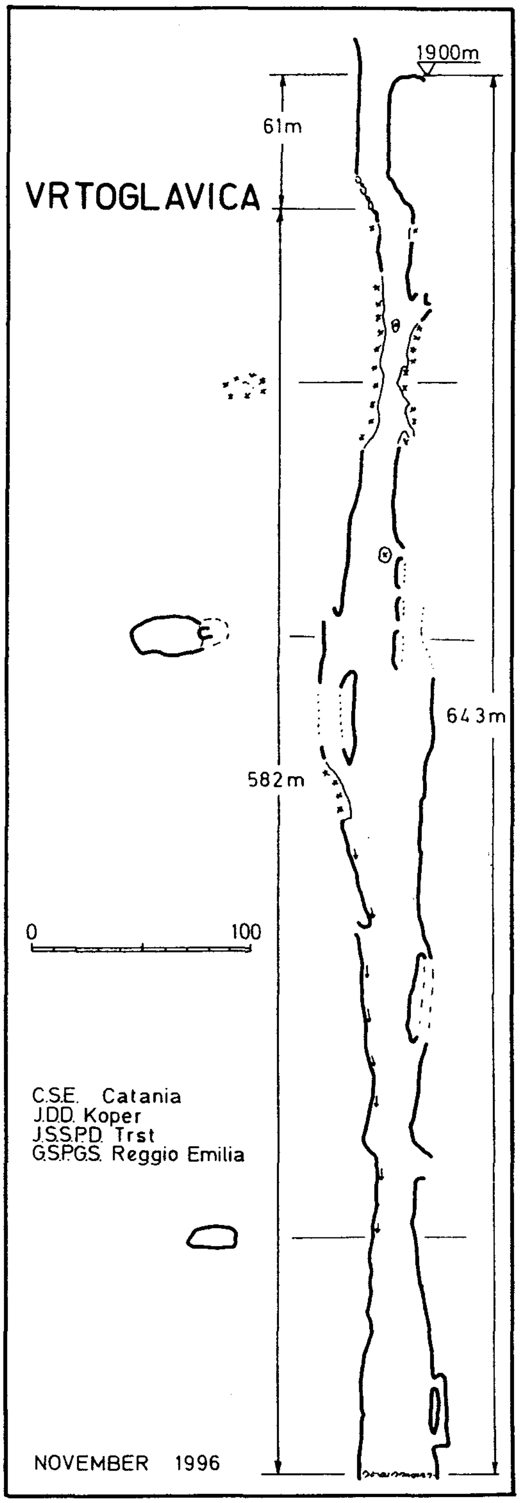


Figure 10 (Stopar & Pintar 1996)

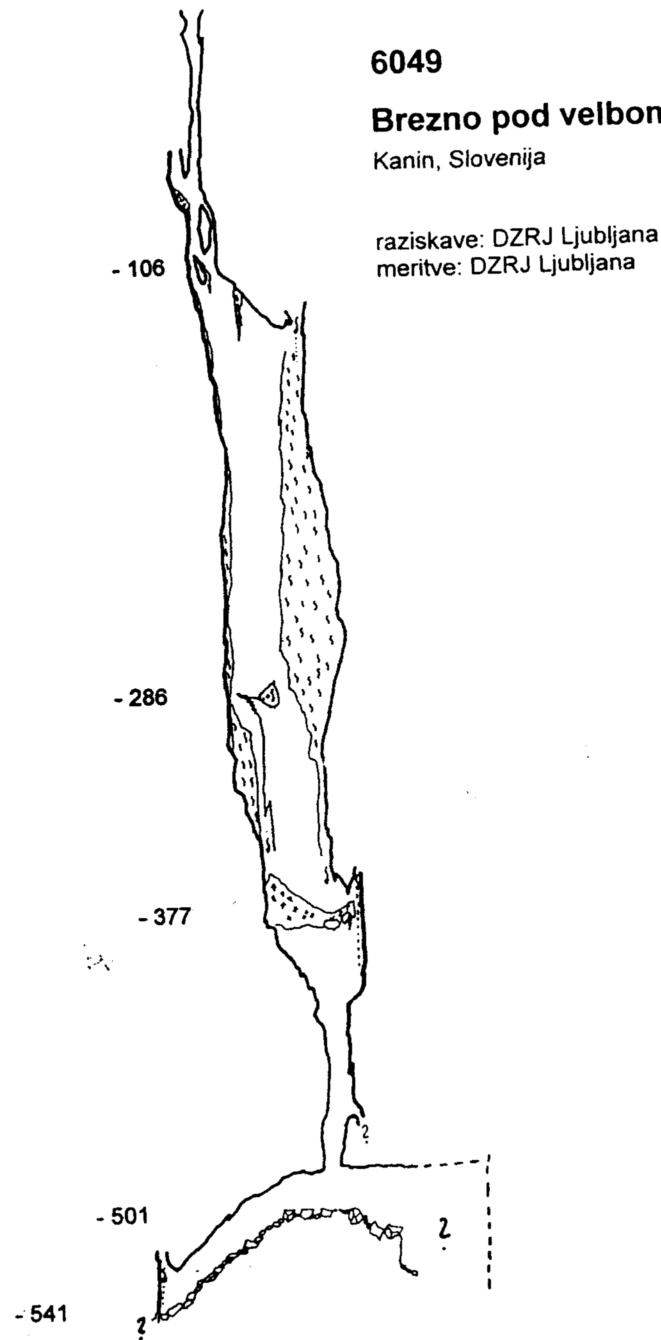
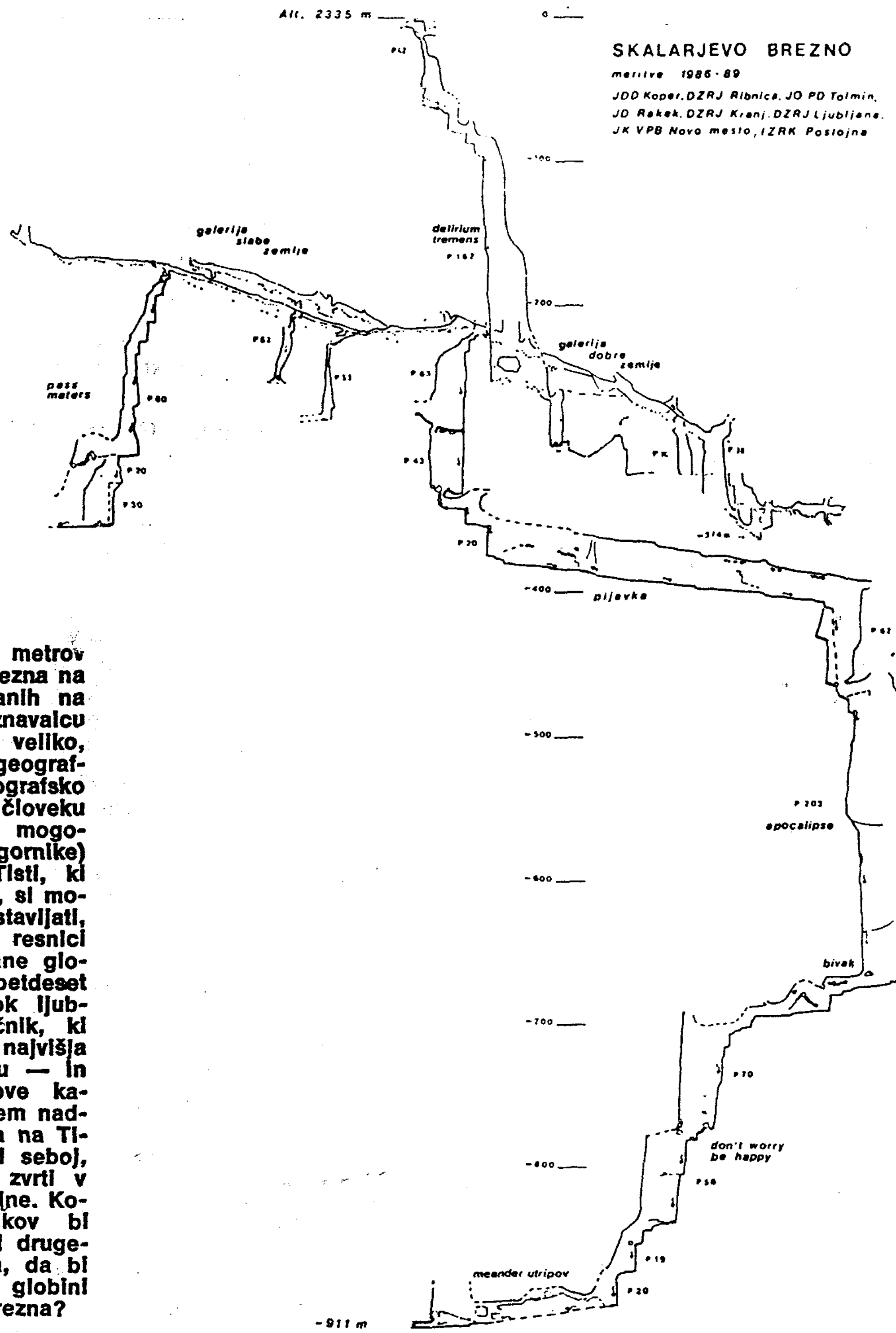
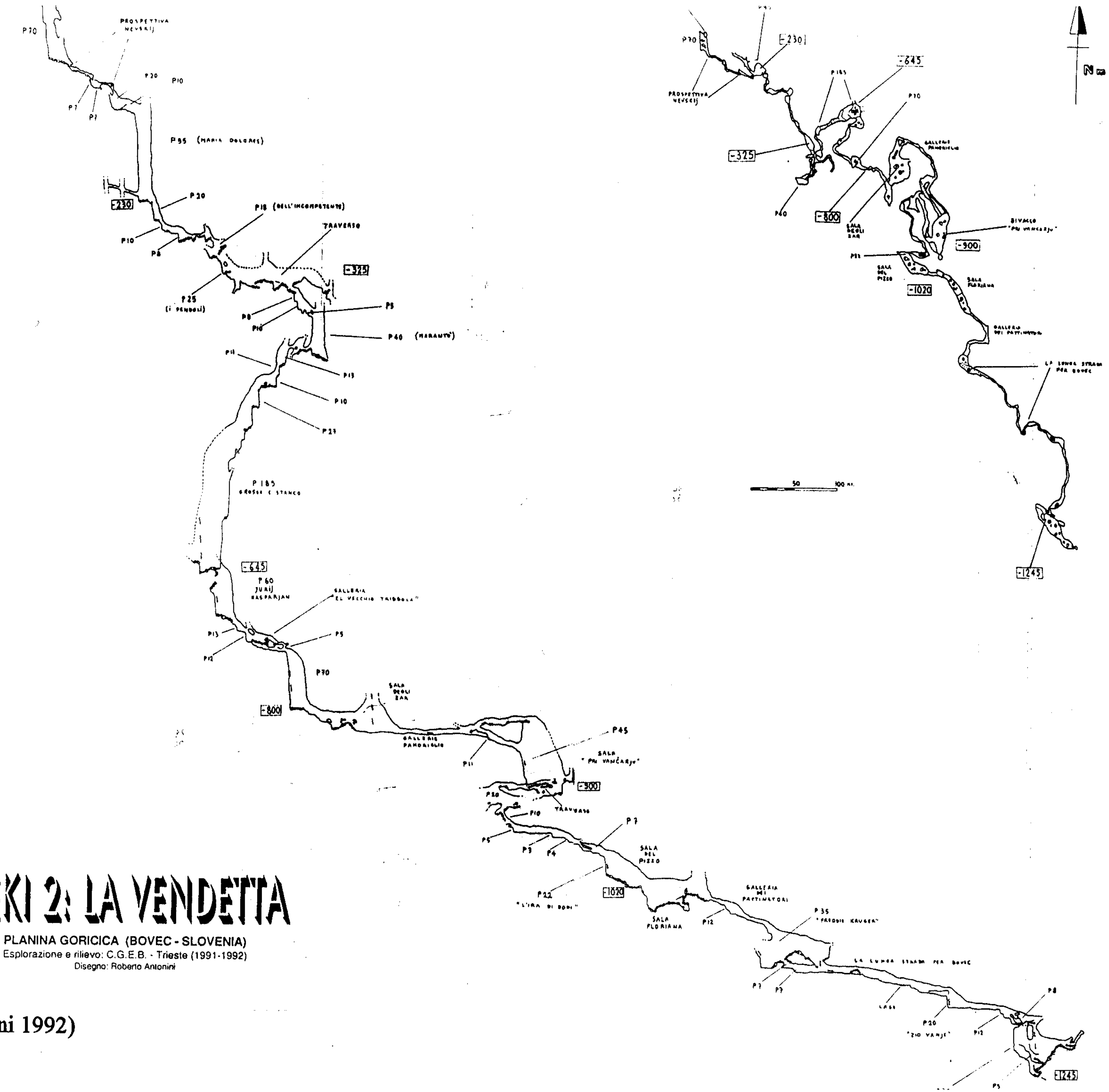


Figure 9 (Pintar 1995)



Skoraj tisoč metrov Skalarjevega brezna na Kaninu, prikazanih na načrtu, nepoznavalcu ne pove prav veliko, vsaj običajno geografsko in topografsko razgledanemu človeku (med katere je mogoče šteti tudi gornike) pa marsikaj. Tisti, ki gleda tak načrt, si mora seveda predstavljati, kaj pomenijo v resnici na njem narisane globine: dobrih petdeset metrov je visok ljubljanski Nebotičnik, ki je bil dolgo najvišja stavba v mestu — in kdor iz njegove kavarne v najvišjem nadstropju pogleda na Titovo cesto pod seboj, se mu skoraj zvrti v glavi zaradi višine. Koliko nebotičnikov bi morali postaviti drugega na drugega, da bi bilo to enako globini Skalarjevega brezna?

Figure 8 (Morel 1989)

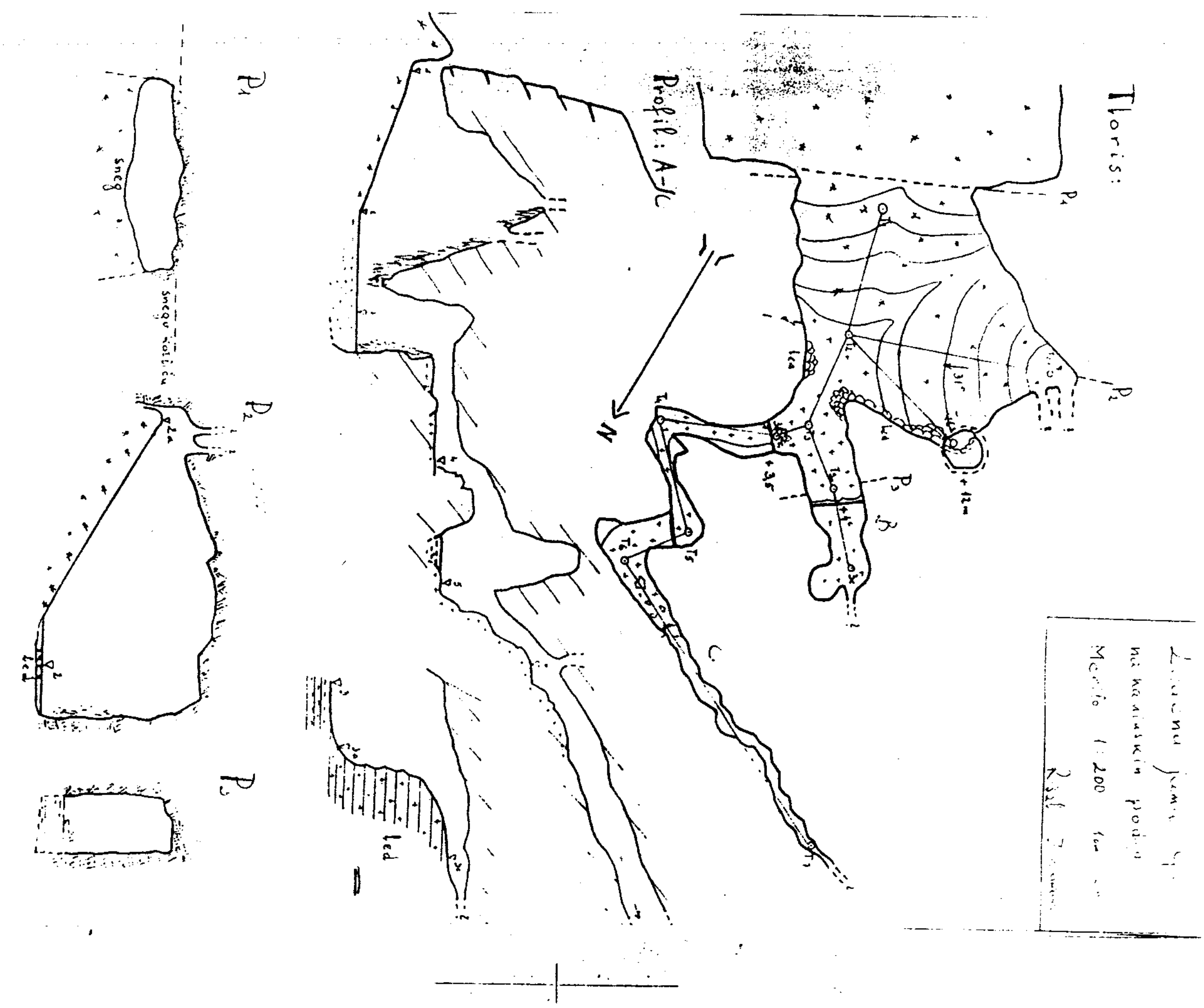


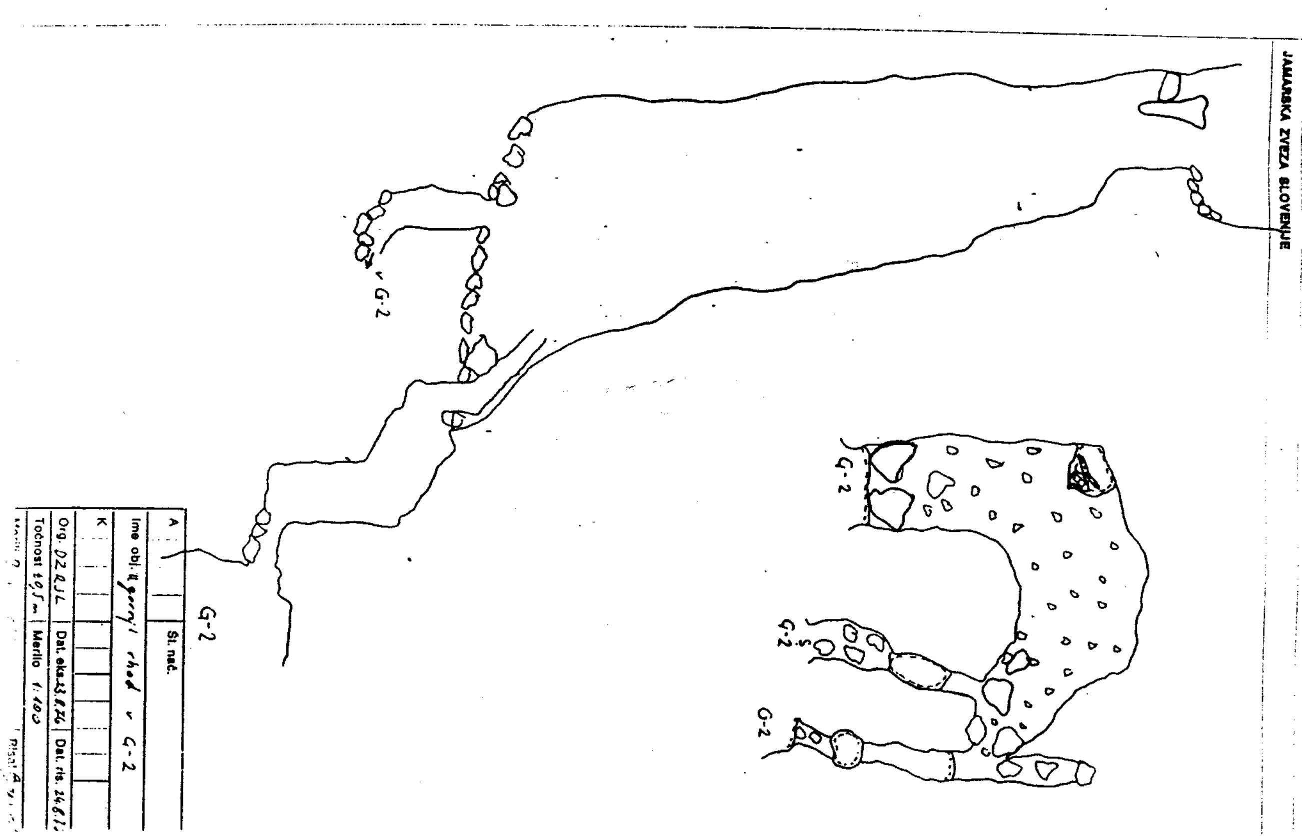
CEKI 2: LA VENDETTA

PLANINA GORICICA (BOVEC - SLOVENIA)
Esplorazione e rilievo: C.G.E.B. - Trieste (1991-1992)
Disegno: Roberto Antonini

Figure 7 (Antonini 1992)

Figure 11





Ledenica G-2

FIELD WORK - Wednesday, July 1, 1998

1	Boka	3	Zadlaška jama cave
2	Tolminka Gorges	4	Kluže

1. THE BOKA SPRING

A special position at the southern foothills of the Kanin mountain has the Boka spring, which is situated at the altitude 730 m in the middle of the steep wall 385 m above the Soča valley (Fig. 12). From the siphon outflow water falls 139 m deep in two steps (33 and 106 m) into the gable valley and forms a picturesque waterfall Boka. The Boka spring differs from the other springs at the Kanin foothills on its geological position. The spring is not formed at the contact between limestone and flysch, but because of the compact dolomite block, which dams karst waters and forces them to a siphon outflow to the surface. The recharge area of the Boka spring is not precisely defined, but on the basis of known geological and hydrogeolocical conditions the main part of the Kanin mountains can be included in it. The discharge of the spring is estimated to 100 m^3/s at high waters and some ten litres per second at low waters. At high waters Boka forms a short superficial flow - a right tributary of the Soča river.

The Boka cave

The Boka cave represents a large inflow channel of the Boka spring (Fig. 13). It is explored in the lenght of 750 m. The main part of the cave is a sequence of 7 siphons of different lenght (from 20 to 160 m) and depth (from -8 to -32 m), which are till now not completely explored. The total lenght of the siphons is 615 m, the other parts are channels partly filled with water. The explorations are the common work of Slovene and Italian divers.

The Mala Boka cave

The entrance in the cave is in the south-eastern slope of Kapa at the foothills of Kaninski podi 150 m northern from the riverbed of the Boka stream. From the bridge on the main road Žaga - Bovec one has to walk approximately 500 m to reach the entrance. The Mala Boka cave is a temporary spring with a permanent flow inside the cave. Till now it is explored in the lenght of 3545 m (Fig. 14). The cave was explored from the lowest part at the entrance upwards and the difference in the height between the entrance and the final part of the cave (explored till now) is +353 m. The general direction of the Mala Boka cave system is towards north. According to the documents the first visit to the cave was on November 1, 1968, and up to now more than 100 exploratory missions were organised.

Other springs

At the contact between Upper Triassic limestone and Cretaceous flysch at the southern foothills of the Kanin mountains several karst springs are situated (Fig. 12). The contact is mostly covered by rubble and rock debris, which partly covers older gravel and morainic sediments. The most important springs are Glijun, Bočič, Žvika and Suhi potok. They are recharged from the extensive karst area of the Kanin mountains. On the basis of the so far made researches the narrow recharge areas of the individual springs can not be defined. The discharges of the springs are not regularly measured, but the strong influence of the intensive rainfall on Kanin and of the snow-melting in the spring was evidenced.

The Glijun spring is located 90 m above the Soča valley near the village Plužna western from Bovec. Water flows from the rock debris and rubble at the altitude 440 m. At extremely high waters also the temporary spring in the Smica cave 130 m above the permanent spring is active. At low waters the discharge is around 150 l/s. The energy of water is used by a small hydro-power station.

On the left bank of the valley floor approximately 1 km north-eastern from the village Žaga is a permanent spring Bočič. Water springs at several points from a small hole in a rocky slope and from the slope rubble. At low waters the discharge is 2 - 5 l/s. The spring is captured for the water supply of the Žaga village.

Several springs of Žvika are situated near Podčela by the road Bovec - Žaga. Springs at the border of the Quaternary sediments are permanent and at high waters also the temporary springs about 30 m above the valley are active. At low waters the common discharge of all springs is only 1 l/s, but at high waters it exceeds 100 l/s.

About 700 m further towards south-west is the periodical water stream Suhi potok, which is dry at low waters. At heavy rains and snow-melting several m^3 of water flows into the stream from the Mala Boka cave.

2. THE GORGES ON TOLMINKA AND ZADLAŠČICA

The geological structure of the Tolmin area is extremely complicated. Along the thrusts and faults are the contacts of three large geotectonic units: Southern Alps, Inner and Outer Dinarides. Several kilometers north-eastern from Tolmin interesting natural phenomena can be seen: gorges on the Tolminka and Zadlaščica rivers, and the Zadlaška jama cave.

The valley of the Tolminka river, a typical spring alpine valley, is formed along the strong Zadlaščica fault with the NW-SE direction. In the lower part the gorges are cut in the Upper Triassic limestone, upstream the riverbed is in platy micrite and calcarenit (limestone of Volče). This change expresses also the transition from Outer to Inner Dinarides.

Discharges of Tolminka have been regularly measured since 1952 at the gauging station Tolmin. Therefore the common discharge of the Tolminka and the Zadlaščica are measured. In the period 1952 - 1995 the lowest was 0.4 m^3/s, and the highest 130 m^3/s.

The Zadlaščica spring

Zadlaščica is the main left tributary of Tolminka. The lenght of the valley is approximately 5 km. The spring is situated between Tolminske Ravne and Razor at the altitude 780 m approximately 6 km north-eastern from Tolmin. Water flows from the partly cemented moraine covering the joint between the overlying permeable Upper Triassic carbonate rocks and the impermeable Lower Cretaceous flysch. The recharge area was estimated on 15 km^2 and is bordered by the Ravne fault on the south-western side, by the Rodica fault on the north-eastern side, and by the Zabiški Kuk ridge on the south-eastern and Vrh Škrli on the north-western side. Mean discharge of the Zadlaščica spring is 1.2 m^3/s, mean low discharge 0.24 m^3/s and mean high discharge 13.4 m^3/s. The mean temperature is 5.5°C. Water is bacteriologically and chemically non-polluted and the spring is captured for the water supply of the Tolmin area. On Zadlaščica is also a small hydro-power station.

The thermal spring and the Jama pod Hudičevim mostom cave

A special phenomenon of the Tolminka valley is a thermal spring in the fault zone in the narrowest and deepest part of the gorges (Fig. 15). The spring on the left bank of the river at the altitude 185 m can be seen only at extremely low waters, because at higher waters it is completely flooded by the Tolminka. In February 1992 the discharge was estimated to 1 . 2 l/s. The measured temperature of the Tolminka was 7.2°C and of the spring 18.8°C. In February 1993 the temperature of the Tolminka was 5.5°C and of the spring 20.8°C. The spring water is highly mineralised.

Near the spring is the entrance to the nearly horizontal cave with the lenght of 18.6 m. Also the cave is flooded most of the time. It is partly artificially made - some attempts were made to get warmer water. In the cave there are two small lakes of thermal water.

3. THE ZADLAŠKA JAMA CAVE

On the southern slope of the hill Kalec above the Zadlaščica near the confluence with the Tolminka, three entrances into the dry and old Zadlaška jama cave are situated at the altitude of 310 m. The cave is 1140 m long, and the elevation between the lowest and highest point in the cave is 41 m (Fig. 16). The cave has several vertical and horizontal segments.

The entrance into the Zadlaška jama cave lies in Maastrichtian limestone breccias at the extreme northern border of the Outer Dinarides tectonic unit; due to appearance of Megalodontid shells it is presumed that the northern parts of the cave developed in Upper Triassic limestones. Tectonically the Cretaceous but also Triassic carbonates are strongly broken.

Several systems of former water passages controlled by geological factors are found in the cave. Two of them are more distinctive: one developed along bedding-planes or at the contact of beds parallel to bedding and the other along fissures and faults which are transverse to local bedding.

The cave was an anastomose-maze like network of initial tubes that overgrew into passages. The first and the most important factor was water that slowly flowed through the passages. Later the cave was filled by fine-grained sediments. Water flowed above them leaving above-sediment rocky features. The parts of lower lying passages from which the sediments had been removed were shaped by fast water flow after the lowering of the underground water level. Relatively soon the cave remained hanging in the slope and was dry. Then the rocky perimeter was partly reshaped by a condensation water.

4. THE FORTRESS OF KLUŽE

The fortress Kluže is located at the contact between the Koritnica and the Bavšica valley. Picturesque gorges were formed there by the Koritnica river. They are up to 70 m deep. This area is built by Upper Triassic limestones, and partly dolomites. Limestone beds dip very steep.

The gorges were formed by deep river erosion in the Holocene age. The formation was influenced by the elevation difference between lateral and main glacial valley.

The narrows and bridge have always been of exceptional strategic importance, as shown by the ruined fortress of Kluže. From the 15th century on, they controlled from here the entrance to Bovec basin from Predel. The fortress, in its contemporary form, was built in 1882. It was connected to the upper fortress above the gorge by vertiginous ladders.

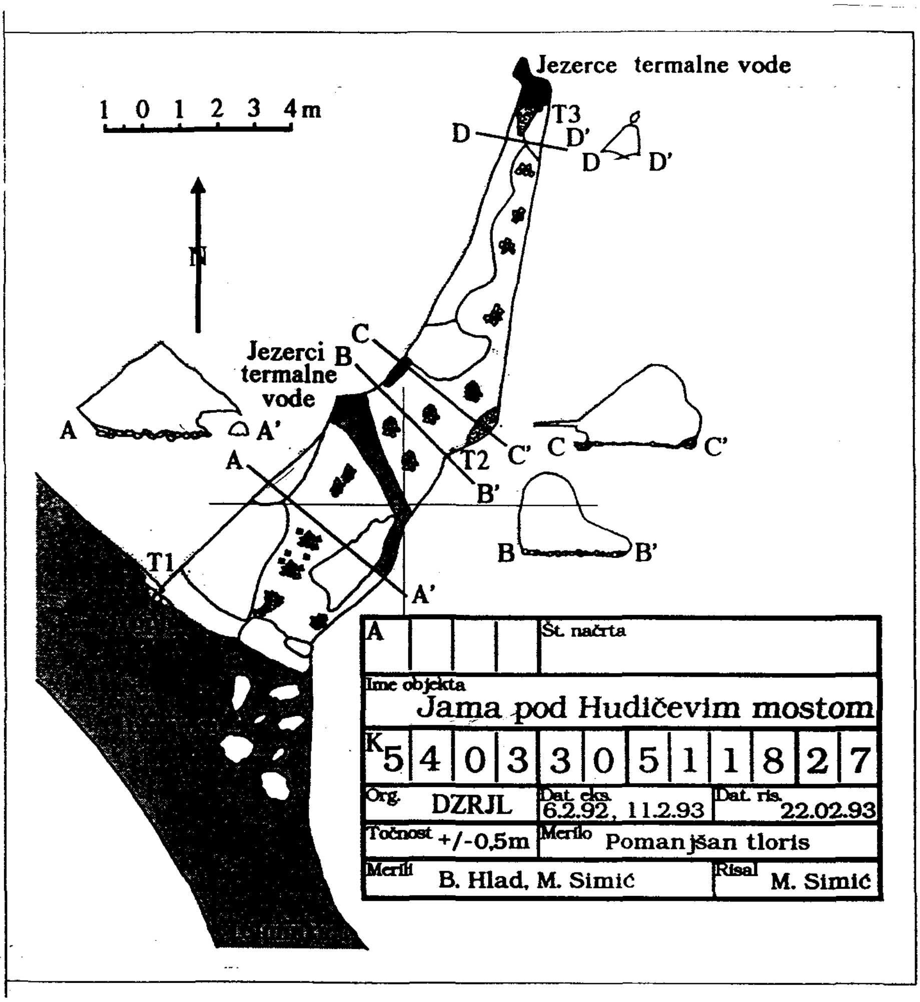


Figure 15 (Simič 1993)

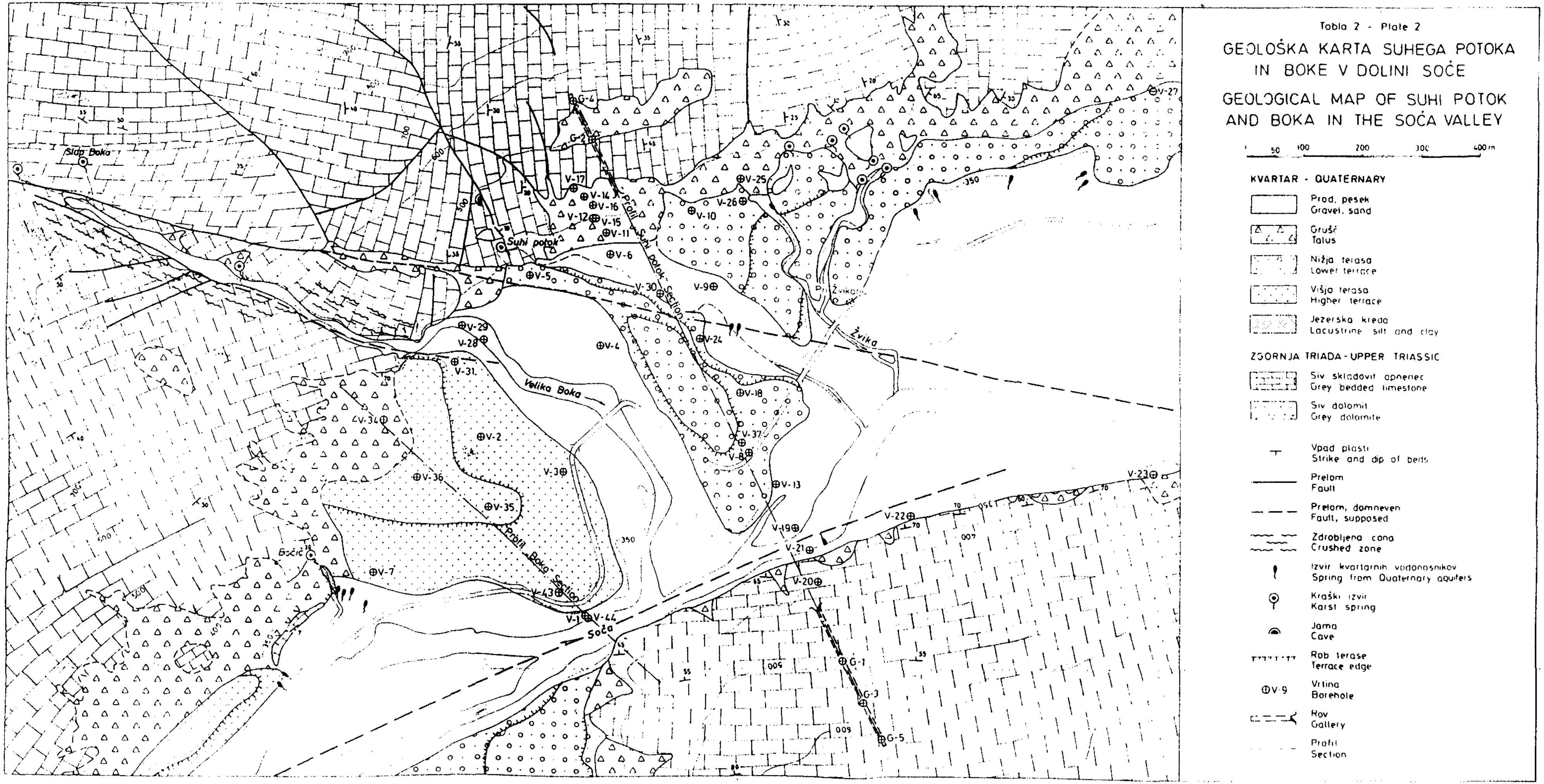


Figure 12 (Kuščer et al. 1974)

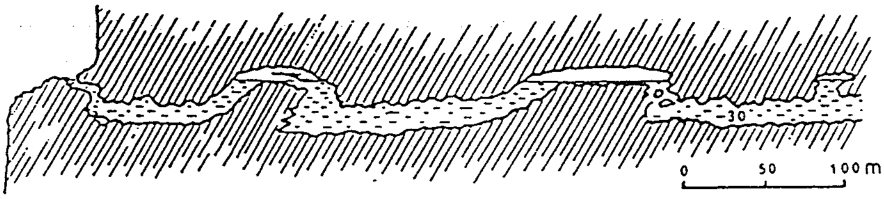


Figure 13: The Boka cave

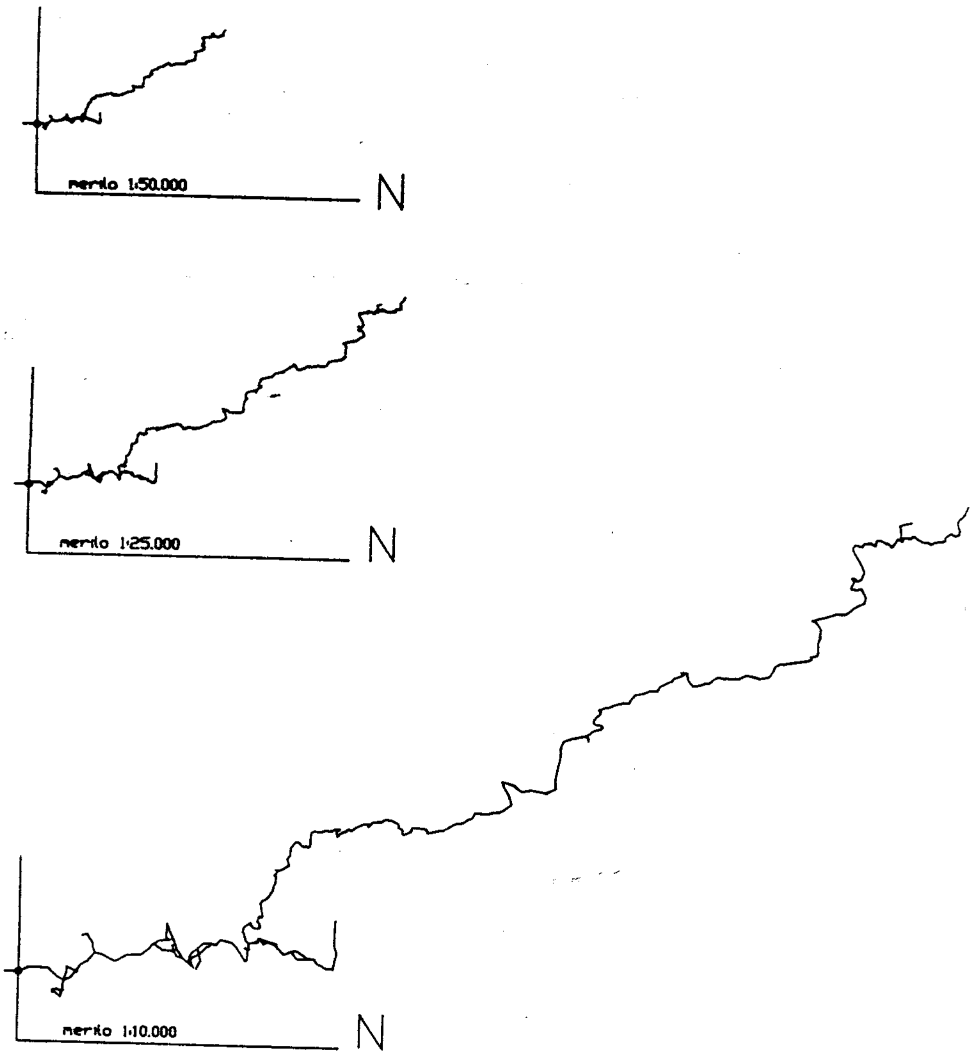
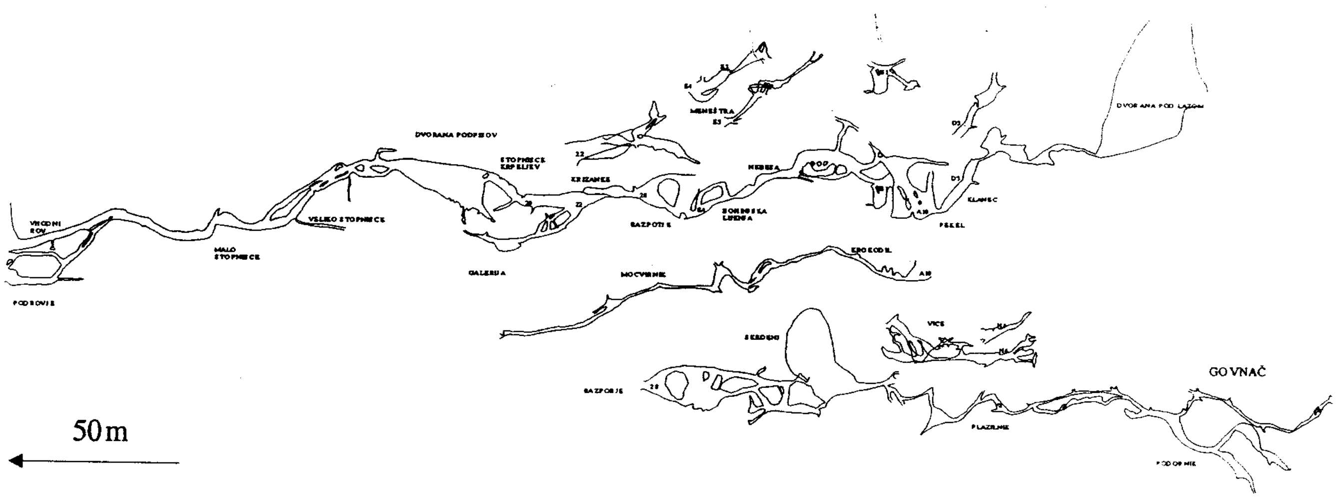


Figure 14: The Mala Bóka cave

ZADLAŠKA JAMA 804

TLORIS

VZDOLŹNI PR EREZ



JSPD Tolmin 1979

Andrej Rutạr

Figure 16

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ABSTRACTS OF THE PAPERS TO BE PRESENTED

ABOUT REGIONAL GEOGRAPHY OF THE HIGH MOUNTAINOUS KARST: THE CASE OF JULIAN ALPS

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The paper gives a review of different types of the mountainous karst in Slovenian Alps and their morphoclimatic differentiation in the system of Alpine karsts in general. The author compares the objectivity of some general descriptive, graphical and quantitative tools in presenting different karst areas. The litological, climatical, morphological and speleological criteria in understanding the individuality and the denomination of separate morphological types are also discussed. This offers the way of easier morphological and genetical comparison among the regions and also of regional geography of the world high mountain karst. Some specific features as are kotlič-snow kettle and limestone pavements were used for the differentiation between some types of the Alpine karst in Slovenia in the past. Is this still actual?

HYDROGEOLOGICAL CONDITIONS IN THE UPPER SOČA VALLEY

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A large Alpine karst area in the upper Soča river basin extends over the whole northern part of the river basin north of the line the Učja river - Drežnica - Tolminske and Kneške Ravne - Podbrdo. It includes the Kanin mountains, the Koritnica river basin as far as Mangrt and Jalovec, the Trenta area as far as Vršič and Triglav, Polovnik and the Krn mountains, the Bohinj ridge with Komna, Vogel and Črna prst. Big karst springs in the middle or at the border of this area are the basis of the water storage of the Soča river. These springs or the river basins of the tributaries of the Soča river are the Soča spring, Mlinarica, Krajcarica in Zadnjica, Vrsnik, Lepena, Kršovec, Koritnica, Možnica, Šumnik in Bavšica, Glijun, Boka, Učja, Podlaznica, Tolminka, Zadlaščica, Kneža, and the water sources of the Bača river.

The karst aquifers of the Bohinj ridge, Krn and Triglav mountains and Komna, the mountain ranges from Vršič to Jalovec, Bavški Grintovec and Mangrt, Rombon and Kanin mountains are among the biggest in Slovenia. They represent the recharge area not only for the Soča river, but also for the water sources in the river basins of the Sava - the Sava Bohinjka and the Sava Dolinka, and for the water sources between Rateče and Rezija in Italy.

CAVES AND SHAFTS OF KANIN MOUNTAINS AREA

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Caves in Julian Alps have been intensively explored during the last few decades. Among many high Alpine karstic plateaus, two of them, Kaninski and Rombonski podi (Goričica) above Soča valley near Bovec, are most perspective for cavers.

These plateaus are the main parts of the Kanin mountains. Upper Triassic (dachstein) micritic limestone and dolomite are the most occurent rocks there. Kaninski podi spreads between 1950 and 2300 m a.s.l., in an area of about 9 square kilometres. It was intensively explored during seventies and not much results in deep caves were achieved then, although most of the known caves were actually found and partially or completely explored at that time. The area of Kaninski podi ranks among the areas with the highest cave density in Slovenia, i.e. 25 caves per sq. km. But the big depths were waiting for the next generation... First success was Skalarjevo brezno, where the depth of 911 m was reached in late eighties. Last big caving successes were two shafts explored during the last few years. First one was Brezno pod Velbom (-840 m), where entrance shaft of 501m was bottomed in 1994. Second in 1996, Vrtiglavica is 643 m deep sinlge vertical and is regarded as the words deepest shaft.

Before 1988, not much attention was paid to lower Rombonski podi plateau, just a few kilometres NE from Kaninski podi. Than Italian cavers began exploration there and explored the first Slovenian -1000 m cave, Crnelsko brezno. Since 1990 three caves deeper than kilometre were explored there; Crnelsko brezno (-1198 m), Ceki II. (-1370 m), both explored by Italians and Vandima (-1182 m), explored by cavers from Ljubljana caving club (DZRJL).

But most think, the best is yet to come. Depth potentials are estimated up to 2000 meters. In the Mala Boka, with the entrance at the base of the mountains, cavers have penetrated deep into the massif and reached the point that is 450m higher than the lowest part. The cave is very promissing and still largely unexplored. Cavers hope to join the cave with Skalarjevo brezno, what would make the system almost 1900 m deep.

KARSTMORPHOLOGICAL RESEARCH IN THE MECSEK MOUNTAINS, SOUTH HUNGARY

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Hungary is relatively rich in karstic areas, from which the most known are the very well investigated Aggtelekien Karst which is part of the World Heritage, the Bükk Plateau and the thermal caves around Budapest. Besides these more famous karst areas there are some less investigated and less known ones, like the Mecsek Mountains in South Hungary. For 4 years research has been conducted to confirm the existence of a cave system of several kilometre length beyond the most abundant spring of the karst of the Western Mecsek, the Vízfő Spring. Attempts have been made to find the optimal site for opening an entrance to the cave. Our research has been focussed to the next problems:

1. Collect more evidence of the existence of this cave system and find answer some interesting

morphological and genetic problems we have met during this research.
2. Determine the optimal point for exploring.
3. Estimate the size and the length of the system.

This paper is meant to show the methods and achievements of preliminary geomorphological and hydrological field surveys, which were preceded by a thorough study of literature. Parallel to clearing the entrance to the cave, observations of karst processes and features were also made. The paper presents the findings concerning tile impacts of young tectonic movements on the extension and links of the catchment area, the connect between surface and underground water-courses and cave formation.

One of the speleologists' main problems is the determination of the cave's sizes that they want to explore. If we know the approximate size of passages then we can decide whether it is worth to start the exploration or not. In our research we have tried to apply morphometrical methods to determine the expectable cave's sizes. The method can be used in allogenic karst where you can compare the non-karstic catchment areas connecting to the different sinkholes. Our aim has been the estimation of the unknown passages' sizes based on measurable surface parameters. The obvious connection is that bigger caves belong to bigger non-karstic catchment areas but we wanted to show numerical relation between them.

Naturally we must be careful to apply the method because there are lots of other factors which we are unable to show but they play very important role in the cave forms, e. g. softer rock strata, tectonic faults, e. t. c. The work is to be continued with exploration of the Szuadó Cave, whose length is 150 m at present. It is found hard connection between the examined surface parameters and the passages' sizes.

In the future we would like to continue the exploration and to expand our comparative research to the spring caves and their catchment areas. We want to compare the absolute size of the catchment area, the rate of the karstic and non karstic catchment area with the caves' sizes.

THE ALPINE KARST IN ROMANIA

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The most typical Romanian alpine karst could be found in South Carphathians more exactly in Piatra Craiului M-tines and Retezaz M-tines, between 1900 - 2300 m. Developed especially in limestones medium and high fractured, karstic features are represented better by shafts and surfaces micro and macro forms as dolinas, karrenor blind valleys. Recent exploration shows about an interesting -600 m shaft (Avenul din Grind).

PALEOKARST FEATURES AND OTHER CLIMATIC RELICS IN HUNGARIAN CAVES

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Though the karsts of Hungary are bearing the characteristics of medium-height karsts in the temperate zone, in the past of the Earth history they experienced several phases of karstic development in geographical locations absolutely different from the modern ones and the climatic conditions during the modern karstification phase have also been significantly changing due to the climatic oscillations of the past two million years. These changes, ranging from cold, dry periglacial climate to the explicitly warm, humid climate of some interglacials, can well be traced in several caves in the form of passage cross section variations, gravel terraces and other sediments, as well as in changes of the volume, character and colour banding of speleothems.

Besides these relics, definite paleokarst features can also be studied in some Hungarian caves. The most excellent representative of them is the 2D maze of Cserszegtomaj Well Cave (Keszthely Mountains, Transdanubian Mountain Range) developed along the contact of Triassic dolomite and Pannonian sandstone, which exposes the sandstone-negative of a subtropical karst relief. The uppermost sphaerical chambers and convection cupolas of the hydrothermal Beremend Crystal Cave (Villány Mountains, South Transdanubia) exposes also from below the sediment fill of a Lower Pleistocene karst shaft, the character and age of which could be determined by the rich vertebrate fauna embedded into the red clay matrix of this sediment. The small paleokarst cavities within the upper Eocene bedrock of Mátyás-hegy and Pál-völgy Caves (Buda Hills) preserve the relics of an even more exotic paleogeographical situation: the morphology and the laminated Upper Eocene sediment fill of these allow to interpret them as the salt-fresh water mixing zone cavities formed during a short emersion of a tropical reef.

PALAEOMAGNETIC RESEARCH OF CAVE SEDIMENTS IN SW SLOVENIA

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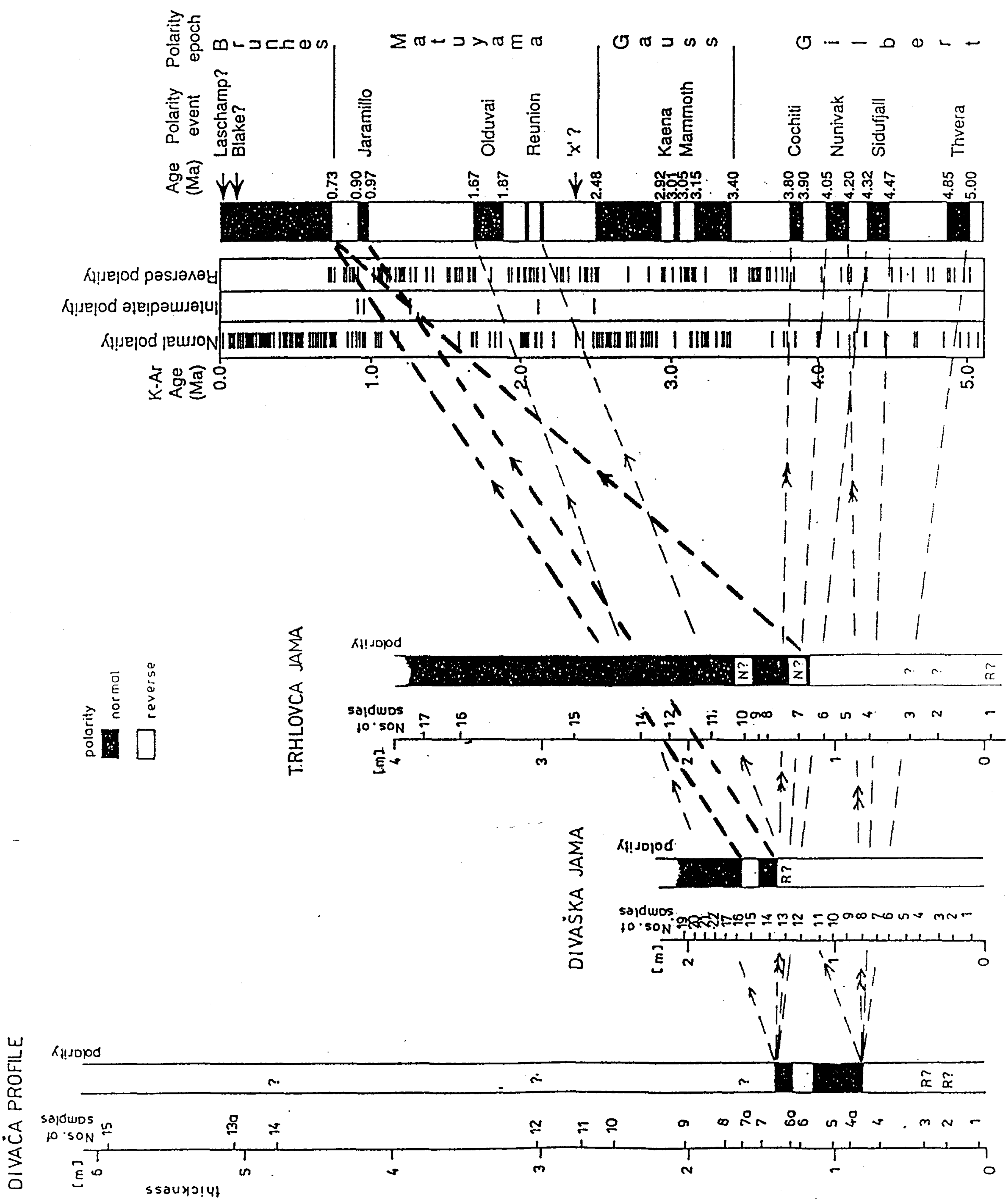
Three profiles of caves sediments (Divača fossil cave, Divaška Jama and Trhlovca Cave) were studied in the Kras near Divača village. Mineralogical study proved relatively uniform mineral composition of the light fraction indicating the main source from weathered sediments of Eocene flysh. Some minerals were derived from weathering profiles and crusts (e. g. gibbsite).

Detailed magnetostratigraphic investigations of three profiles defined normal and reverse polarity magnetozones and show the correlation between the profiles in the Divaška Jama and Trhlovca Cave. The narrow normal magnetozones probably correlate with the Jaramillo polarity event (0.90 to 0.97 Ma) of the Matuyama epoch. Those data indicate the substantial age of cave in which the last phase of filling started before 0.97 Ma and finished before the Brunhes/Matuyama boundary, i. e. around 0.73 Ma.

Magnetostratigraphic data of the Divača profile detected two narrow normal magnetozones within the long reverse polarity zone which probably correlate with Olduvai and Reunion polarity events (about 1.67 to 1.87 Ma) of reverse Matuyama epoch or with some of normal magnetozones (about 3.8 to 5.0 Ma) within reverse Gilbert epoch (Fig. 1). Data indicate the possibility that the cave can represent a part of the drainage karst system which originated during the expressive Messinian sea-level fall (Upper Miocene) connected with the evolution of deeply entrenched relief forms and deep karst in the Mediterranean Basin.

Figure 1.
Magnetostratigraphic data for three cross-sections and the correlation according to Pliocene-Pleistocene geomagnetic polarity time scale.



LIMNOLOGY OF MOUNTAIN LAKES IN SLOVENIA
- lakes as indicators of pollution and climate changes

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Comparing neighbouring Alpine countries, Slovenia has, as a consequence of the geology, very small number of mountain lakes. In total, fourteen lakes could be put into that category. As mountain lakes are here declared that lakes, which are above the elevation of 1300 m. Lakes are situated in the region of Julian Alps, in the area of Triglav National Park. Prevailing geology are limestone formations from Triassic period with well developed karstic phenomena. In the past glaciers on some locations formed small depressions with impermeable bottom in limestone strata which were later filled with water.

Slovenian mountain lakes are well known and relatively easy to access but very few complex studies has been done there. Till 1990 only occasional studies on biology and chemistry of some lakes existed. The only exception was work on lakes morphometry from the geographical point of view. After 1990 research on mountain lakes has intensified, mainly from the biological point of view. Biological investigations on fauna and flora of those lakes were accompanied by chemical analyses of water quality and physical parameters of water column. In the last few years investigations were focused also on local meteorology and sediment analyses, to reconstruct lake's history for last two or three centuries.

Mountain lakes, especially those above tree limit, are in general very simplified ecosystems. Due to this fact they are relatively sensitive to environmental changes. In the last few decades the most significant changes are those, originated from human activities. Two of them, namely pollution and climatic changes, are especially important. Because mountain lakes are far away from sources of pollution and their ecosystems are very simple, are ideal object for research of such topics. Both effects, i. e. that of pollution and environmental changes, are recorded in lake's sediments in form of physical (radionucleids, carbonaceous particles), chemical (nutrients, isotopes), or biological data (remains of biota). Combining all three sources of data allow us to reconstruct changes within the lake and it's surrounding for few centuries, and especially for the last century, when most of changes have intensified.

SPELEOLOGICAL FEATURES IN THE MOUNTAINOUS KARST OF RISNJAK MOUNTAIN (CROATIA)

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Risnjak mountain is located in western Croatia. Its central area is, together with nearby Snježnik mountain and upper part of the Kupa river valley, a part of National Park Risnjak. Since it is completely built of heavy broken Jurassic carbonate rocks (limestones mostly), there were all kinds of karst features well developed. Among exokarst forms, dolines (some of them are up to 200 m in diameter and depth) predominates. Among speleological features pits are most often forms. There are a few morphological types of them in altitude range between 680 and 1520 m. The pits are mostly up to 50 m deep, and the deepest pit researched by now is 180 m deep. In proportion with high altitude and severely climate in few pits thick beds of snow and ice were found.

Near by the south-eastern border of National Park area there are a few creeks which flow over the less permeable Triassic dolomite beds and impermeable Triassic and Permian clastic beds. They sinks at the contact with permeable carbonate beds. Among their ponors the largest is Ponor Vele Vode cave which is 1495 m long.

GLACIOKARST OF SUBALPINE AND ALPINE ZONE OF THE MAŁA ŁĄKA VALLEY, TATRA MTS., POLAND

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The paper presents karst and glacial landforms situated above the upper forest limit in the Mała Łąka Valley, West Tatra Mountains. The Valley is located in the norhern part of the mountains and covers an area of 6 km^2. It is built mostlyof Mesozoic limestone and dolomites and represents the main area of caves in the Polish part of the Tatra Mountains. This area however does not show typical karst relief. In the lower part of the Valley, such factors as alternating ocurrence of karstic and non-karstic rocs, their large inclination, cover of weathering material and forest do not favour karst development. In the upper part of the valley karst relief was transformed in Pleistocene by glacial and peryglacial processes.

The paper discusses the age of the karst and glacial landforms and the attempt is made to determine the influence of karst substratum on the dynamic of glacial processes at the end of last glaciation period.

SURFACE AND UNDERGROUND KARST PHENOMENAS AND THEIR CORELATION WITH LITOLOGY AND TECTONIC (SELECTED AREAS OF WEST TATRA)

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In areas where the alpine karst can be investigate, Tara Mnts. (most North part of Internal Carpathian belt) took a special place. On surface of less than 100 km^2 (thick Mezozoic formation), nearly 800 caves have been reported and most karst landforms of temperate climate were described. Carbonate rocks appear presently as nappe-strips with transversal elevations and depressions remaining hight compression, folding and subsequental uplift to Middle Eocene with more deformation and asimetric uplift since Middle Miocene.

On the base, study of correlation of wide range karst forms with well recognized tectonic openings, litological contact and litology itself were done. Method of multilevel analyses and data processing where used to separate: key geological complexes and groups of "types and kinds" of karst forms. Using graphic correlation all datas where investigate. The results give the light to distribution of karst phenomenas in certain geological structures, variation and type of dependance of tectonic factor for karst development. The work suggest perspectives for mezo-scale karst investigation especially for interbranch researches.

HYDROGEOLOGICAL INVESTIGATION OF THE ALPINE KARST SYSTEM HOCHIFEN AND GOTTESACKER PLATEAU (GERMANY/AUSTRIA)

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Mount Hoher Ifen (Hochifen) and the Gottesacker Plateau are situated in the Northern Alps at the German-Austrian border and are an impressive examples for the typus of bare, folded alpine karst systems. The site belongs to the Säntis nappe, the biggest thrust sheet in the Helvetic nappe system. The Säntis nappe is surrounded by penninic Flysch nappes in the north, south and east, forming a large tectonic half window. The Helvetic stratas are strongly folded with approximately east-west-trending fold axes that reach an axial culmination in the Plateau.

The Department of Applied Geology at the Karlsruhe University (AGK) has been studying the Hydrogeology of this karst system since 1996 in the frame of four master theses and one doctorate thesis still in progress (Goldscheider 1997, 1998). By carrying out hydrogeological mapping, hydrochemical investigations and three multi tracing experiments with 15 injection points and 5 different fluorescent tracers, it was possible to determine the hydraulica properties and the underground flowpaths of this alpine karst system, to delineate the catchment areas of the karst springs and to obtain information about a possible contaminant transport.

The karst aquifer is formed by the so-called Schrattenkalk, an extremely karstified cretacious limestone that builds nearly the whole surface of the Gottesacker Plateau. The underlying Drusberg Marls and slates form the base of karstification while the overlying Glauconitic Sandstones and the nearly impermeable Amdener Marls are mostly eroded. They are only preserved in the cores of some synclines where they seal the top of the karst aquifer. The tracing experiments proved that the plunging synclines form the main flow paths of the underground discharge in the western and south-eastern direction.

In the south-eastern direction, the helvetic stratas plunge under the penninic flysch nappes in the Schwarzwasser valley, which therefore marks a well defined tectonic boundary of the karst system. However, the hydrological boundary of the karst system is more complicated: In the whole valley, the Schrattenkalk forms a hydraulically connected karst aquifer in the underground, collecting all karst waters from the Gottesacker Plateau as well as the surface runoff of the Flysch mountains that reaches the karst aquifer by seepage of swallow holes. The aquifer is discharged by several karstic springs in the lower Schwarzwasser valley. Therefore all of the tracers that were injected in the eastern part of the site reached all the karstic springs in the Schwarzwasser valley; the hydrochemical properties of these springs are nearly similar as well.

In the western direction the Subersach valley cuts through the Helvetic anticlines, following an axial depression and a stike-slip fault. As there is no hydraulically connected karst aquifer in the valley the plunging synclines form rather isolated recharge areas. The synclines are discharged by several karstic springs in different altitudes which show significant differences in their hydrochemical properties.

INVESTIGATIONS OF THE VEGETATION AND SOIL IN THE DOLINAS OF MECSEK MOUNTANIN, SOUTH HUNGARY

Edit Hoyk

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This karstecological study done in a Hungarian karstic region, in Mecsek Mountain. The Mecsek Mountain can be found in Southern part of Hungary. The Mecsek area can be evaluated by comparing recent data with those of the earlier analysis in Bükk Mountain and Aggtelek. This territories can be found in Northern part of Hungary.

The western part of Mecsek Mountain is rich in karstic forms. There is a karstic plateau of approximately 14 km^2 extension to the South-East of Orfü, divided into 3 smaller plateaus by the Orfü-Pécs road, the Körtvélyes- and the
Szuadó-valley.

Summarising our analysis conclusions can be made on the stage of dolinas in Western Mecsek, in the development of karst regions in Hungary on basis of vegetation and soil.

The rock of the base of the sampling area is made of middle Triassic limestone, which is strongly fissured. This circumstance plays an important part in karst forming.

From a morphometric point of view these dolinas are significantly different from those in karst areas of Bükk and Aggtelek. The difference can be clearly seen in their smaller size, small area, big depth in relation to size and funnel-like form. The big relief ratio is reflected by the vegetation, since species characteristics of ravine forests appear also.

Among climatic factors the 700 mm precipitation per year can be underlined which plays an essential role in dolina forming.

The CO_2 production of root systems of arborescent phytocenoses covering the territory is also an important factor contributing to the ongoing intensive development of dolinas.

Soil research studies also support the juvenility of dolinas in Western Mecsek. According to the grain content curves there has not occured yet a remarkable differentiation between bottoms and sides of these dolinas that refers to the short time passed since their formation.

Dolinas in the Orfü karst plateau are characterised by a natural state, the territory can be considered as more or less free from antropogenic influences. This refers to the direct effects, since the indirect effect can be shown by the fact that the soil pH is turning sour.

This state close to its natural condition is a great value of the landscape. Nowadays it is an important task to conserve the natural conditions of the environment, especially those of karstic regions. The karst is a highly vulnerable natural system that reacts with great sensitivity to antropogenic influences, so it requires an increased protection. On the basis of all this it would be reasonable to involve the Orfü karstic region into conservation projects.

CAVES OF HIGH MOUNTAINS IN POLAND

Tomasz Klarenbach

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Mountains of alpine origin - Tatra Mts., cover only small part of Poland. Karstified rocks occure in Western Tatra Mts. and cover ca. 50 km^2. Within this small area 600 caves are known, longest and deepest in Poland among them. Three caves are over 10 km long and fiveteen over 1 km long. There are three caves with denivelation over 500 m and fourteen over 100 m. Last intensive exploration works result in discovery of many new cave galleries. Most important cave in Tatra Mts. - is Wielka Sniežna-Litworowa Cave System (814 m of denivelation and over 20 km long) - deepest and longest cave in Poland. After possible join with Sniežna Studnia Cave it could be 26 km long cave system. Caves are grouped mostly in upper part of the Polish Western Tatra Mts., and are of different genetical type and age. Part of them are of proglacial origin or are transformed by glacial water in Pleistocene.

ORIGIN AND DEVELOPMENT OF AN OLD ALPINE CAVE

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The entrance into Zadlaška jama lies in Maastrichtian limestone breccias at the extreme northern border of the Outer Dinarid tectonic unit; due to appearance of Megalodontid shells it is presumed that the northern parts of the cave developed in Upper Triassic limestones. Tectonically the Cretaceous but also Triassic carbonates are strongly broken.

Several systems of former water passages controlled by geological factors are found in the cave. Two of them are more distinctive: one developed along bedding-planes or at the contact of beds parallel to bedding and the other along fissures and faults which are transverse to local bedding.

The cave was an anastomose-maze like network of initial tubes that overgrew into passages. The first and the most important factor was water that slowly flowed through the passages. Later the cave was filled by fine-grained sediments. Water flowed above them leaving above-sediment rocky features. The parts of lower lying passages from which the sediments had been removed were shaped by fast water flow after the lowering of the underground water level. Relatively soon the cave remained hanging in the slope and was dry. Then the rocky perimeter was partly reshaped by a condensation water.

THE MEASURING OF THE KARST DENUDATION WITH HELP OF PERCHED BLOCKS, THE CASE OF V. VRATA, JULIAN ALPS

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In the region of V. Vrata, 1924 m, the karst dividing ridge between the Soča and Bohinj valley, above the plateau of Komna the perched blocks are one of the best examples of these phenomena of the whole Julian Alps. They are so well preserved due to specific geological setting, characterised by the thick subhorizontal Dachstein limestone strata and due to their location in the highest and the latest glaciated areas. The perched blocks have up to 15 cm high base only, which doesn't express the whole karst denudation in the Holocene. This paper discusses the question of the real amount of the surface karst denudation and its distribution in the same period related to present situation and possible changes in the past.

ICE IN CAVES
- A CLIMATIC PHENOMENON AND ITS MORPHOLOGICAL EFFECT

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Ice in caves is a peculiar climatic phenomenon. In our climatic stage ice appears from lowlands up to the alpine regions. It depends on percolating water freezing in caves. Deep temperatures during the whole year preserve the ice, but deep temperatures do not exist continuously in caves during the year and therefore do not preserve the ice. A high dynamic in persisting ice stocks follows oscillating climate. Sometimes the shape of the ice changes year by year or in longer periods. Nowadays ice is melting more rapidly than before in different caves, thus it will be important to study the morphology of ice, all kinds of inclusions, the effect of ice an the cave walls as well as freezing effects. These studies have to be finished, before the ice has probably disappeared.

Observations of ice temperatures and morphological effects in recent caves are given - if there are some. Phenomena, possibly resulting from ice pressure or freezing zones are shown from east alpine caves, such as inside sediments, brocken sinter layers, wall rocks and wall configurations. The effects are discussed, for caves in alpine and periglacial regions.

APPLICATION OF STEREOSCOPIC IMAGES IN KARST RESEARCH

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The paper presents results of application of 3D images in karst investigation. The stereoscopic images come from conventional aerial photographs and also unconventional low-level aerial photography and terrestrial photography. The advantages and disadvantages of each of these methods are discussed.

The paper attempts to justify the concept that unconventional survey can offer an inexpensive, rapid and accurate alternative to some parts of a conventional field programme in karst studies.

LITHOLOGICAL CHARACTERISTICS AND KARST DEVELOPMENT IN ALBORZ MOUNTAINS (EAST ALPIAN REGION) - n. e. TEHRAN - IRAN

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In the center Alborz Mountains of Iran, the upper Jurassic is represented by a sequence of marine carbonates, known as "Lar formation". This lithostratigraphic unit was measured and sampled in Garmabadar and polour northeast ot Tehran. Detailed petrographical studies indicate a sharp difference in depositional facies and diagnetic characteristics of the two above mentioned sections.

Lar formation in Garmabadar predominantly is composed of allochemical carbonates mainly bioclastic, which is transformed into very dense homogeneous and micritic limestone in Polour area.

Karstification is the most significant and widespreade diagenetic event in the Lar formation. However, it appears in two different models in the studied sections. In Garmabadar, karstification is related to subareal weathering that is responsible for creation of features such as karrens and rills. On the other hand in Polour there is dual nature and varying magnitude, surface karstification is lesser development, while the depper part (400 m) large and numerous caverns have been formed indicated the presence of more chemically aggressive water. Four sets of critera and evaluated.

(1) Geologically - pervasive faults and fractures in the area acts as a conduit network which facilitates surface water movement to the phreatic zone. The piezometric surface is measured at a depth of 210± 10 meters.

(2) δ^{13} C and δ^{18} O measurement shows average carbon and oxygen in matrix limestones are about (-1.3 %0 δ^{13} C and -6,5% δ^{18} O PDB) and similar Jurassic limestones, while fracture filling calcite cement have dual origin, in the above part cement from metoric sourse (-2.3%0 δ^{13} C and -6.9% δ^{18} PDB). Whereas in the lower part cement formed by warmer water (-2.0%0 δ^{13} C and -10.6%0 δ^{18} O PDB) it appears that meteoric heated water at depth were responsible for karstification and subsequent cementation in the Lar formation.

(3) The Hydrochemical character of hot-spring water shows, this spring which carries CO_2 and H_2S, reaches the surface in the vicinity of the Damavand volcano. The acidification mechanism to develop karst appears to be associated with volcanic fumaroles. The CO_2 and carbonic acid dissolution is balanlded by subsequent calcite cementation.

(4) Polish section studies of the subsurface cores shows indiomorphic pyrite formation during fracture - filling cementation is a strong indication of the presence of H_2S within this karstic system at depth below 400 m. Upon H_2S arrival at the oxygented zone. Sulfuric acid is formed which subsequently causes major dissolution and karstification.

In conclusion, Damavand volcanism with its several tectonic effects on the adjacent areas and hydrothermal conditions in the deeper part is currently intensifing the magnitude of karstification in the Lar valley and polour area.

KARST AND ENGINEERING PRACTICE

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Economic mastering of karst areas sets geologists, engineers, ecologists, economists and lawyers tasks of theoretical, methodological and administrative character. The most complicated problems arise on the junction of karst study and scientific disciplines of engineering and economic profile. The decision of these problem is the aim of engineering karst study. It should be noted that engineering karst study owing to the specific character had detached itself from traditional karst study. In engineering karst study its own approach to the karst researth is forming which connects with necessity to come to concrete projected or administrative decisions under condition of the stochastic character of the karst process, insufficient information, the limited time of investigations, insufficency of money for antikarst protection, special features of engineering construction, the character of practical tasks, ets.

The main aims of karst study are:

1. Discovery of the character of a karst danger and its long-term forecast in reference to some types of building objects and conditions of karst development.
2. A short-term and operational forecast of a karst danger for exploited objects.
3. Elaboration of strategy and technology of engineering-geological investigations with a consideration of special features of an object and probable methods of antikarst protection.
4. Elaboration of methodology of karst monitoring at various levels: regional (for example, on a city scale), local (for example, on an enterprise) and object levels (for example, on some site of a plant or a bridge, etc.).
5. Elaboration of anthropogene forces upon the intensity of the karst process.
6. Valuation of the industrial karst danger with a consideration of probable technological, ecological and social consequences after disasters.
7. A complex decision of problems concerning an arrangement and exploitation of waste disposals in karst terranes.
8. Definition of parameters of antikarst protection planning.
9. Improvement of methods of antikarst constructions' calculation.
10. Elaboration of methods of planning and economic grounds of antikarst protection.
11. Elaboration of principles of objects' and projected decisions' insurance in karst terranes.
12. Valuation of karst terrances' cost.
13. Improvement of parameters on investigations, planning, building and exploitation of different objects at federal, regional and object levels.

For the decision of above - mentioned aims efforts of various specialists are needed. These aims are not only perspective ones for researchers. They are formulated on the base of real investigations which is conducting in State Venture "Antikarst Protection".

THE LAST NEWS CONCERNING THE PROTECTION OF KARST REGIONS IN THE AUSTRAIN ALPS

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Protection and conservation of karst regions, caves and karst waters based on scientific researches by different laws have a long tradition in Austria. Recently, changements of laws and of the demands of use have created new conditions for a sustainable preservation of the typical character of such regions. In connection to the ecological sensibility of alpine karst regions is seems be necessary to realize all possibilities for a long-time protection of the natural resources of karst landscapes in the Alps and especially in Austria and his provinces, given by laws on the one side and by information of the public essentially by non-government organisations on the other side.

This possibilites recently used are the admission of general prevention measures in the laws of natural protection ("basic protection"), the creation of large protected regions and national parcs and the nomination of karst regions in the protection network "Natura 2000" of the European Union. Further impulses are attended by the realisation of the International Convention concerning the development of the Alps ("Alpenkonvention").

The most actual event was the official presentation of the document confirming the inscription of the region "Hallstatt-Dachstein-Salzkammergut" including the Dachstein caves and the vaste karst plateau in the World Heritage List of the UNESCO on June 13, 1998.

For a better information of the public concerning the Austrian karst regions and their problems a group of interested experts has elaborated under the auspices of CIPRA-Austria a booklet, published also in June 1998.

HYDROLOGICAL AND GEOMORPHOLOGICAL EFFECTS OF EXTREMALLY HIGH WATER IN KARST REGIONS IN SOUTH POLAND

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The period of years 1996-1997 should be recorded as an extremal for karst regions of South Poland and Czech Republic. Early spring of 1996 some areas of the Silesian-Cracow Upland were flooded due to intensive rain falls in the period of snow melting. All this year was wet, with storms during summer and early autumn. Exceptional high precipitations were recorded in July 1997, when monthly precipitations were over 600 mm in the Sudety Mts. and Western Carpathians and over 400 mm in the Silesian-Cracow Upland (mean yearly precipitations in Poland are 650-700 mm). Maximum rain fall occured on July 6th, 1997 and in some meteorological stations were recorded over 200 mm/day. In effect upper part of Vistula river basin and all Odra river basin flooded, most important karst regions in Poland among them. This hydrometeorologial situation results in specific extremal phenomena in karst systems. Some inactive caves or their part were flooded and in many places „fossil" overflow springs began active. Catasthrophic mud flows and subsidence dolines developed. Most active and giving long chain of processes due to exceptional high water were recorded in karst areas affected by intensive human activity.

HEAVY METALS CONTENT IN SEDIMENT OF CAVES AND PITS IN CROATIA

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Results of some heavy metals content (Pb, Cu, Zn and Cd) of silt within some speleological objects in Croatia have been reported. Investigations include also standard chemical and physical soil analyses.

Samples were compiled in different parts of caves and pits from long distance of entrance and in upper parts of channels. Round 1 kg of silt was put into plastic bag, marked and firmly closed till treatment. Average depth of sample taking was 1 – 15 cm. A total of 25 samples were compiled and analysed during 1981-1997. Chemical analyses and mechanical content have been carried out in soil-physiological laboratory of Forest Research Institute, Jastrebarsko. Humus content %, total nitrogen content %, pH in H_2O and n-KCl, $CaCO_3$ %, P_2O_5 and K_2O content, mechanical soil composition and some heavy metals content (Pb, Cu and Zn) were defined on that occasion. Heavy metals were determined by atomic absorption spectrophotometer "Perkin Elmer 300 S". Standard solutions are prepared according to working instructions PAWLUK (1967), (Analytical methods, 1973).

The samples found in Lukina jama-Trojama pit system on mount Velebit, (over the 1000 m deep pit system, samples number 10 and 11) and samples in caves from very long distance by the entrance (minimum 2000 m, samples no. 20 and 23) have the lowest contain of heavy metals between 25 samples collected and analyzed from other caves and pits through Croatia. Values presented in Tab. 1 (No. 10, 11, 20 and 23) have natural content of heavy metals for Karst area in unpolluted subterranean systems in Croatia.

Key words: Heavy metals, caves, pits, Karst, Croatia.

Tab. 1: CHEMICAL AND PHYSICAL ANALYSES OF SILT FROM CAVES AND PITS																				
No. of sam-ple	Deep in cm	Year of sampl.	Kind of Speleo. object	Locality in Croatia	Long. Deep in m	$CaCO_3$ %	pH H_2O	pH KCl	P_2O_5 mg/100 g AL-method	K_2O mg/100 g AL-method	Humus %	Total N %	Mechanical soil composition in Na-pyrophosphate [illegible]	[illegible]	[illegible]	[illegible]	Texture	Heavy metals content Pb micro g / 1 g [illegible]	Cu	Zn
1	1-15	1981	Cave	Hajdova Hiža, G. Kotar	1200*	48.39	7.5	7.2	1.5	9.6	0.43	0.05	2.7	11.4	43.3	42.6	Easy clay	26	10	20
2	1-15	1985	Cave	Rumin, Sinj	420*	20.25	7.5	7.3	3.4	9.2	0.91	0.07	2.6	64.1	2.4	30.9	Sandy clay	24	8	15
3	1-15	1985	Cave	Ševerova, Bunić, Lika	156*	17.15	7.5	7.3	5.6	6.5	0.42	0.04	0.8	42.2	37.8	19.2	Loamy clay	26	12	28
4	1-15	1986	Cave sys.	Đula-Medvedica, Ogulin	16 250*	20.17	7.7	7.4	3.3	6.1	0.87	0.08	1.7	65.7	28.7	3.9	Fine sandy loam	28	10	11
5	1-15	1986	Pit/Cave	Golubača, Zir, Lika	155*	7.78	7.5	7.4	8.9	9.9	0.33	0.05	5.4	39.9	33.6	21.1	Loamy clay	20	5	14
6	1-15	1990	Cave	Veternica, Zagreb	6 125*	6.77	8.2	7.5	9.9	9.1	0.21	0.03	0.2	24.3	46.7	28.8	Dusty Clay	23	4	8
7	1-15	1992	Cave	Miljacka, Kistanje,	1135*	37.81	8.1	7.5	1.8	7.9	0.71	0.04	1.1	77.2	15.1	6.6	Fine sandy loam	27	6	10
8	1-15	1994	Cave	Mihovilovići, Klis	280*	18.65	7.5	6.8	8.5	24.3	0.08	0.03	1.2	22.4	23.2	53.2	Heavy clay	26	6	22
9	1-15	1995	Pit/Cave	Sušica, G.Kotar	234*	63.14	8.1	8.4	4.1	3.5	0.59	0.04	23.1	57.3	7.5	12.1	Fine sandy loam	20	2	4
10	1-15	1995	Pit sys.	Lukina jama-Trojama, Velebit	1365	49.9	8.9	7.9	1.8	4.8	0.83	0.03	13.3	19.3	18.5	48.9	Heavy clay	15	5	2
11	1-15	1995	Pit sys.	Lukina jama-Trojama, Velebit	1365	23.1	9.1	7.9	3.3	3.4	0.59	0.05	0.8	54.2	36.3	8.7	Sandy loam	15	5	2
12	1-15	1995	Cave	Ograda, Feštini, Istra	134*	65.28	8.2	7.6	0.4	7.3	0.22	0.02	1.1	33.7	49.8	15.4	Dusty loamy clay	27	4	4
13	1-15	1995	Cave	Ograda, Feštini, Istra	134*	7.63	7.9	7.2	8.3	16.1	0.73	0.04	5.1	31.1	38.5	25.3	Easy clay	19	11	9
14	1-15	1995	Pit/Cave	Grobnjak, Istra	65*	7.66	7.8	7.1	7.2	3.7	0.16	0.07	4.7	29.3	42.5	23.5	Clayed loam	19	4	8
15	1-15	1995	Cave	Golubača, Mljet	85*	53.41	8.2	7.8	3.2	7.8	0.59	0.04	28.6	19.1	31.6	20.7	Loamy clay	32	9	24
16	1-15	1995	Cave	Gospodska, Cetina, Lika	1125*	8.92	8.6	7.5	2.6	6.8	0.52	0.03	1.8	11.7	42.9	37.6	Dusty loamy clay	21	7	12
17	1-15	1996	Cave	Rašpor, rašpor, Istra	365	41.51	8.1	7.2	4.1	12.3	0.96	0.07	20.9	13.7	35.5	29.9	Easy clay	24	8	24
18	1-15	1996	Pit	Baračeva, Čampari, O.Krk	156	22.58	8.4	7.7	6.6	12.4	0.88	0.08	13.2	24.8	29.4	32.6	Easy clay	23	10	17
19	1-15	1996	Pit	Ledenica, Velebit	655	62.73	8.1	7.5	0.4	5.2	0.73	0.04	30.7	25.4	24.1	19.8	Loamy clay	31	5	6
20	1-15	1997	Cave	Jopičeva, Budačka r., Kordun	7655	2.54	8.1	7.6	15.7	16.1	0.33	0.02	28.4	14.3	9.1	48.2	Heavy loam	12	3	11
21	1-15	1997	Cave	Kamenol. Tounj, Kordun	15245	25.3	8.2	7.7	2.9	7.5	0.81	0.09	6.1	40.4	31.9	21.6	Clayed loam	20	4	8
22	1-15	1997	Cave	Kamenol. Tounj, Kordun	15245	3.38	8.3	7.7	5.3	13.6	0.37	0.07	1.1	16.1	53.6	29.2	Dusty Clay	22	5	10
23	1-15	1997	Cave	Kamenol. Tounj, Kordun	15245	1.69	8.1	7.3	7.2	9.9	0.52	0.06	0.1	18.1	63.7	18.1	Dusty loamy clay	10	3	4
24	1-15	1997	Cave	Cerovačka, Gračac, Lika	3785	9.24	8.2	7.6	5.8	14.7	0.43	0.04	5.1	33.2	34.5	27.2	Easy clay	33	5	9
25	1-15	1997	Cave	Cerovačka, Gračac, Lika	3785	8.46	8.1	7.6	6.3	15.1	0.44	0.04	4.4	29.8	39.2	26.6	Easy clay	32	4	9
					* Aproximative value															

ALPINE (?) KARST OF EASTERN SERBIA

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Eastern Serbia abounds in various karst features which could be classified into different traditionally determined types (tropical, alpine...), although it does not have neither climatic nor elevation parameters characteristic for those types. After introducing the basic postulates of the pure karst model, as well as the theories of inception and development, the fact which becomes evident is that, for example, Alpine and Dinaric karst differ only in dimensions and frequency of features, but not in the basic morphological characteristics. Eastern Serbia is an area which was explored more than a hundred of years ago (area of classical explorations done by Jovan Cvijić). On the basis of the knowledge of that time, the karst of Eastern Serbia was determined as an example of the Jura type. In recent explorations, however, many entirely new facts were established regarding sorts, dimensions, frequency and development factors of karst features. That is to say that the main difference lies in the extent of exploration and level of knowledge of an area, or, in other words, whether the karst is explored or unexplored.

Key words: Eastern Serbia, karst types, karst morphology.

GEOGRAPHICAL PROBLEMS OF THE MINI HIDROPOWER PLANT KRAJCARICA IN THE TRIGLAV NATIONAL PARK, AS SEEN FROM THE ASPECT OF ENVIRONMENTAL PROTECTION

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Along its entire course, the Krajcarica with its immediate surroundings is a very beautiful and an indispensable environmental element of Trenta valley which should by all means be protected against reckless interferences. From its source at 700 m a.s.l. to its confluence with the Soča at 605 m, this brook is about 1800 m long (vertical drop 90-95 m, average radient 41 ‰, discharge 2m^3/sec) and abounds in water more than the Soča itself even during heavy droughts; therefore it justifiably attracts power engineers' attention. But it also attracts the attention of the visitors to Log in Trenta, and those who cross Zadnjica to climb the Triglav and Razor mountains, mostly in summertime.

The lower section of the Krajcarica served the purpose of power already in the past. Since the early eighties, initiatives have occurred, to make use of its hydro-energy; yet, they have all been turned down by the Public Service for the Protection of Natural heritage in the Triglav National Park.

The current investigation discusses the environmental problems of the two variants of mini HP on the brook. Either of them should additionally supply electricity to Trenta and thus make it energeticaly independent through the use of a local source of energy. Both variants plan to construct a run-off type of mini HP. The first, or the lower variant, proposed by Triglav National Park, with the installing discharge (Qi) of 2.0 m^3/sec and biological minimum (Bm) 0.30 m^3/sec, plans the annual production (E) of 1.93 GWh. Economically more profitable is the upper variant, advocated by the locals, with the installing discharge of 1.2 m^3/sec and variable biological minimum of 0.9-1.0 m^3/sec which would generate 3.8 GWh of electrical energy per year.

Either HP is planned to be located within the Triglav National Park (TNP) where 13 such plants are already operating. The TNP comprised 84,506 hectares (4 % of Slovenia); special regulations apply to it, besides the general ones, for the sake of additional environmental protection against the anthropogenic interference, which the planned mini HP on the Krajcarica undoubtedly is. Therefore, arguing began between the advocators of a slightly bigger and economically more profitable mini HP, and the protectors of nature advocating the standpoint that the exploitation of natural sources within the TNP is incompatible with the latter's purpose; however, they agree to the construction of a less powerful variant of a mini HP. The dispute spread over the local and minicipal borders and acquired state dimensions, above all because of all the permits which are required for the construction itself.

Either variant would represent only a minor interference into the landscape, which would met change essentially the existing situation; yet, there are some differences between the two. Construction works, such as felling trees and bushes, digging for pipelines and connection to power network, construction of access tracks, etc., would be just a minimum interference into the landscape, provided that the execution be extremely cautious. Since steep surfaces mostly prevail in the relatively intensely karstic limestone-dolomite river basin of 24.5 sq km, mechanical denudation could occur during the process of digging for pipelines, which would be intensified by aboundant precipitations (over 2400 mm). This certainly indicates that the digging should be started and completed already in early spring, and the turf should be preserved and after the works have been completed it should be immediately replaces and sown with grass. Such digging should therefore be carried out manually and would actually be short-lasting intervention; it would not affect strongly the fertile soil because this practically does not exist in this river basin, since only very shallow, stony rather dry soil of poor fertility is generated on the valley bottom. Besides, the fact is, that the use of water for a mini HP will change the water level in the lower section of the brook. It is of crucial importance that the amount of water used for the HP be as small as possible, particularly during the low water level, which, fortunately, occurs in wintertime.

As to the anticipated effects on the environment, resulting either from the lower or the upper variant of the planned mini HP Krajcarica, the greatest interference into the landscape would be construction itself, and the use of water during the operation of the mini HP. Because of a lesser use of water and a bigger biological minimum, then a minor and technically less demanding interference into the landscape (lighter and narrower pipes) and a less visible reservoir, and in spite of a longer distance along which the pipe-line would be laid, the upper variant seems nevertheless more acceptable from the aspect of environmental protection.

In forming a complex decision, the socio-geographical aspect should also be taken into account. Namely, the motion for building an economically more profitable mini HP which would generate more energy, originated from the locals of the valley; this valley ranks into the specific type of mountainous regions, and it also lies by the border, is remote from transport connections, and is economically less developed with the explicitly pronounced depopulation (in 1993). In spite of the fact that meither of the two planned mini HPs can supply enough power to the entire Trenta, the upper variant would provide a relatively steady supply to Trenta, especially in the case of increased power consumption which is planned for tourism and other activities. Anyway, this mini HP, as one of more important infrastructural facilities, would help to save the demographically endangered Trenta.

True, the Trenta locals will not live on the home-generated electricity of the mini HP, but rather on tourism. This, however, should be fostered at the beggining by the state through adequate investments. When Trenta reaches a certain level of development in tourism, it will already be able to buy electrical energy. Although being an important good, the electrical energy should be but a by-care of Trenta. It ought to be supplied by the state which, by establishing the Triglav National Park, has limited the use of this valley's natural sources in many aspects in this particular case, the hydroenergy of the Krajcarica. It is the national interest that the cultural image of Trenta not vanish; and by pondering the damages and benefits which would be caused through the use of clean, local source, i. e. the Krajcarica, conditions should be established to preserve it. Mass sale of abandoned farms and their rearrangement into vacation houses alone will certainly not preserve the life in Trenta.