

ŠKOCJANSKE JAME SPELEOLOGICAL REVUE

Peter Habič, Martin Knez, Janja Kogovšek, Andrej Kranjc, Andrej Mihevc, Tadej Slabe, Stanka Šebela, Nadja Zupan *

1. THE HISTORY OF INVESTIGATIONS AND TOURISTIC DISPLAY *

* Andrej Kranjc

1.1 Introduction

Karst presents distinctive type of earth surface with special (karstic) phenomena getting the name after the landscape Kras in the background of Trieste Bay. The name has Pre-indoeuropean origin (karra = stone) and in Antiquity it was used to be Carusardius. From 1177 the Slovene form "Grast" is known and from 1230 Croatian "Kras". In Italian and German form of the name the original base is preserved (Carso, Karst). In the international terminology the german version (Karst) remained, obviously after the place name Kras. The first professional descriptions of this characteristic earth surface on limestones descend from our Kras (Gams, 1973). Decisive merits go to Viennese Geographic and Geological Schools. From proper name for landscape the word widened into general conception and today it means international professional designation of landscape on carbonate rocks with typical superficial and underground features and phenomena. After this name relatively young natural history science is named karstology (karstologie, Karstkunde, krasoslovje, carsologia, karstskutatas, karstovedennije...) (Kranjc, 1989).

The landscape among Adriatic Sea and flysch Vipava valley, flysch Brkini and Friuli lowland, covering about 600 km² is considered as Kras in narrow sense of meaning. The landscape designation changed during the centuries, but to the entire complex of "Slovene Typical of Classical Karst" belongs the whole Dinaric karst between Ljubljana Marsh and Adriatic Sea.

* Inštitut za raziskovanje kraša ZRC SAZU, Postojna, Titov trg 2 66230 Postojna, Yu.

Before the Kras was known as "karst" particular karst phenomena were famous already: Timavo springs, river Reka and Škocjanske Jame, Cerknica periodic lake, and Postojnska Jama. In past two centuries on Kras (on slovene part of Kras there are about 800 caves enregistered now) several caves and other karst forms and curiosities were explored, presenting today the properties of "Classical Karst" from where not only the name for karstology derives but the roots of speleology are found.

1.2 The history of Karst investigations

The Timavo springs are mentioned by numerous antique authors, Valvasor (1689) cited 13 of them even, from poets (Vergilius) to scientists. Poseidonius from Apamea (135-50 B.C.) studied one of its springs in particular. Škocjanske Jame — the ponor of Reka (taking its spring as Timavo on the coast) — were known in Antiquity already. Poseidonius writes: "Timavus ... flows into abyss (= Škocjanske Jame) ...".

In New Age F. Imperato (1599) explored the connection between Reka and Timavo by help of flotters (Gruber, 1781). Reka, its ponor (Škocjanske Jame) and Timavo springs usually appear on the maps of the time, as f.e. on Mercator map in Novus Atlas (G. and J. Bleau, 1637) and they are mentioned by Cluverius too (1624). (Fig. 1)

The cave Vilenica near Lokve evidences that the voyagers and visitors were not interested for Reka and Timavo only — in second half of 17 century it was a "show cave" already giving the income from "tourism" (Habič, Kranjc & Kranjc, 1988).

Valvasor (1689) can be considered as the first seriously interested in our karst and he starts a new epoch of investigators and descriptors of karst. Among them men who ventured deeper in the underground are: Nagel (1748), Hacquet (1778-1789), Gruber (1781). Škocjanske Jame were the main curiosity in Trieste vicinity which is evidenced by the work of french artist Cassas. After the order of Joseph II he has made some illustrations for the book about Trieste curiosities and its vicinity: from the vicinity there appear the cave castle (Lueg) and Reka canyon with Škocjanske Jame (1782).

The virtual investigations on karst started in 19 century. The wells in Trieste were no more sufficient and alternative sources for water supply were searched. The underground Reka which probably flows near Trieste and other water caves and underground flows seemed to suit to circumstances.



Fig. 1: Part of the W. Lazius - A. Ortelius map "Gottische, Karsti, Charzeolae, Carniolae, Histiae et Windorffum Machae Descriptio", 1561, 1573", where the course of Reka, Skocjan village "ubi Recca flu. absorbetur, et in Tinaui fontibus erumpit," and the name Karst are drawn.

The investigations started by two points: J. Svetina organized the exploration through the underground Reka and F. Lindner the investigations of deep potholes. In 1839 Svetina as the first descended into Reka ponor from Velika dolina, and Lindner, his worker L. Kralj respectively, succeeded in 1841 to reach the bottom of 329 m deep Labodnica (Abisso di Trebiciano) pothole which remained the deepest pothole in the world for 60 years.

On Kras the explorations connected to water supply went on till the end of the century almost. I'd like to mention the tragic exploration of 264 m deep Jama v Griži (Abisso dei Morti) in 1866 when four natives from Kras met with death (Savnik, 1961). The last bigger water cave discovered during the efforts in 1889 was Kačna Jama (Hanke helped by the natives). The slovene cavers did not reach the virtual flow of the underground Reka in Kačna Jama until 1972 (Kenda & Petkovsek, 1974).

As I've mentioned there are on slovene part of Kras 800 caves known till now. Nevertheless numerous cavers from the area, on Kras and around there are several caving clubs (in Trieste, Gorizia, Udine, among them two slovenes, and in Koper, Divača, Sežana and Ilirska Bistrica) discover new caves or new parts in already known caves. Kras is specially noted for features of contact karst — blind valleys and big ponor caves as are Škocjanske Jame with several collapse dolines, for traces of fluvial surface transformation (dry valleys) and for big underground flows connecting the waters of Reka, Vipava and Soča with submarine springs, with springs on the coast and with Timavo springs themselves. Not only one of the oldest show caves in the worlds lies here but the entire spectrum of cave tourism development is preserved, from abandoned former show caves (Dimnice) to partly displayed and under special conditions accessible caves (Vilenica, Divaška Jama, Sveta Jama) to virtual show caves important in international scale as are Škocjanske Jame and Grotta Gigante.

1.3. The history of explorations and touristic display of Škocjanske Jame

Before the explorations connected to water supply, Škocjanske Jame were prepared for tourism: on 1 January, 1819 Mahorčič introduced the entrance and memorial book "Liber Cavernae St. Canziani", unfortunately the fascists burnt it in 1924 (Moser, 1886; Puc, 1987). In 1823 "Tominceva jama" was discovered - by the initiative of land councillor M. Tominc. The same year the stairs were built into Velika Dolina and to the cave. Svetina tried to penetrate deeper into the cave by Reka without success

Fig. 2:
A. Rieger: In der Reka - Doline,
a picture from Ill. Zeitung
1885 (photo reproduction J.
Hajna).



in spite of several attempts; his work was continued by A. Schmidl helped by miners from Idrija and natives. They came about 500 m far, discovered "Schmidlova dvorana" and the passage to "Rudolfova dvorana". (Fig. 2).

In 1884 the Littoral (Küstenland) Caving Section of DÖAV was founded and it holded on lease the caves and surroundings. The time of systematic exploration and cave arrangement started; in 1884 the 6th cascade (key problem) was surmounted, in 1885 Müllerjeva dvorana was discovered, in 1887 14th cascade is reached, in 1887 Ponvice (Giant Gours) were found, in 1890 the final siphon (Dead Lake) was reached (still today the last point of the cave), the 1904 climb to Tiha Jama presents the last great discovery in Škocjanske Jame.

For cave exploration without considering the exploration of river with boats, the then alpine, mountaineering technique was used: natural featu-

res in the walls were used to access to the holes in the walls and roof, the steps and stairs were cut, pitons hammered into rock, holders for iron ropes, simple wooden foot-bridges were placed. The first exploration pathes were at the same time the tourist ways, only that they were not convenient for all the visitors but for suitably equipped people only and the then note that the underground tourist must has "firm hand and firm leg without dizziness" was not the phrase only. Main touristic pathes were widened, later they were disposed to favourable position - the lower path f.e. was frequently flooded as it is still the case today in Mahorčičeva Jama.

In the first year of rent the local cave workers have constructed the way into Schmidlova and Rudolfova Dvorana, in 1885 they built the Tommasini Bridge and prepared the bellevue above Velika Dolina, in 1891 they built the "high way" to Müllerjeva Dvorana and the path to Martelova Dvorana, in 1902 the tourist path from Schmidlova Dvorana to giant gours, in 1902 Swida Bridge was made, and in 1909 the "cat's wooden foot-bridge", and the path under the ceiling of Hanke channel if I mention the important works only.

Under the italian administration the cave display started with more vigour: in 1931 Bertarelli Bridge in Mala Dolina was built, in 1933 Ponte della Vittoria (Hanke's Bridge), the bridge in Mahorčičeva Jama and the tunnel from the doline Globočak to Tiha Jama was get by digging.

The main changes in after war period are electrification in 1959 and elevator from Velika Dolina in 1986.

I have to mention arrangements and works in vicinity of the caves, essentially important for the development of cave tourism: "Belvedere" above Velika Dolina (1885) was mentioned already, about 1902 15.000 pine trees were planted, in Italian period the pathes under village Škocjan to Reka ponors were made, the most important novelty in last years is construction of new reception and administrative center above Velika Dolina. The plans about reconstruction of tourist pathes, display and protection of the caves are not yet fulfilled as the intervention to cave entrance and to the caves themselves is planned. International importance of Škocjanske Jame is evidenced by decree of Sežana Administration protecting them as natural and cultural monument in 1980 and in 1986 they were registered in a list of UNESCO natural and cultural world heritage.

Beside speleological explorations and underground discoveries the natural history science frequently went parallel with the explorations. The tracer experiments of Brother Imperato in 1599 and Gruber's notes (1781) about Reka present the first hydrological investigations. Later too hydrolo-

gical researches were important: the Brother Imperato water tracing belongs among the oldest in the world, as well as the tracing test with fluorescein in 1891 (Doria 1893). Between the two wars the most known hydrological studies are presented in Oedl's (1924) doctor thesis and Timeus (1928) and Boegan (1938) studies of Reka and Timavo. The studies of water connections continued after the 2nd War (Mosetti, 1963), extended from water budget calculations (Bidovec, 1956) to tritium studies (Eriksson et al., 1963), vertical percolation, autopurification and pollution (Kogovšek et al., 1983; Kogovšek, 1984; Rojšek, 1983; 1984).

Geological, mineralogical, sedimentological and morphological studies occupied Morlot (1848), and later Schmidl (1850), Martel (1884; 1897; 1904; 1909), Marinitich (1897), Timeus (1912), Boegan (1924), Gams (1968; 1983), Gospodarič (1983; 1984; 1985), Chiaramonti et al. (1973), Kranjc (1983; 1986; 1989). Geophysical investigations were carried on by Soler (1934), climate research by Vercelli (1983) and Petkovšek (1968), radion measurements by Kobal et al. (1979). Obviously this is just a summary review as the whole bibliography of Škocjanske jame is much bigger.

Serious and extensive researches are result of organized activity, either professional or amateur: Schmidl was engaged by Southern Railway Corp., between the two wars the influence of Italian Speleological Institute was strongly felt, after the war amateur conventions (6th Yugoslav Speleological Congress in Lipica 1972, Symposium on Karst Protection at 160 — anniversary of touristic development of Škocjanske Jame 1982) and activities of the Institute of Karst Research ZRC SAZU, concentrated on Kras in the period 1981-1985 mostly, were carried on.

2. THE PROPERTIES OF KARST SURFACE AND UNDERGROUND*

* Peter Habič

Škocjanske Jame present the biggest natural curiosity of the whole Classical Karst between Trieste Bay and Vipava valley. Together with blind valley of Vreme and Divaški Kras along the narrow ponor border of Notranjska Reka they make part of typical morphogenetical unit of contact karst, unique in Europe regarding its phenomena and dimensions (Gams, 1983).

The natural reserve Škocjanske Jame and vicinity was listed in 1986 as natural and cultural heritage of the world at UNESCO as the example of

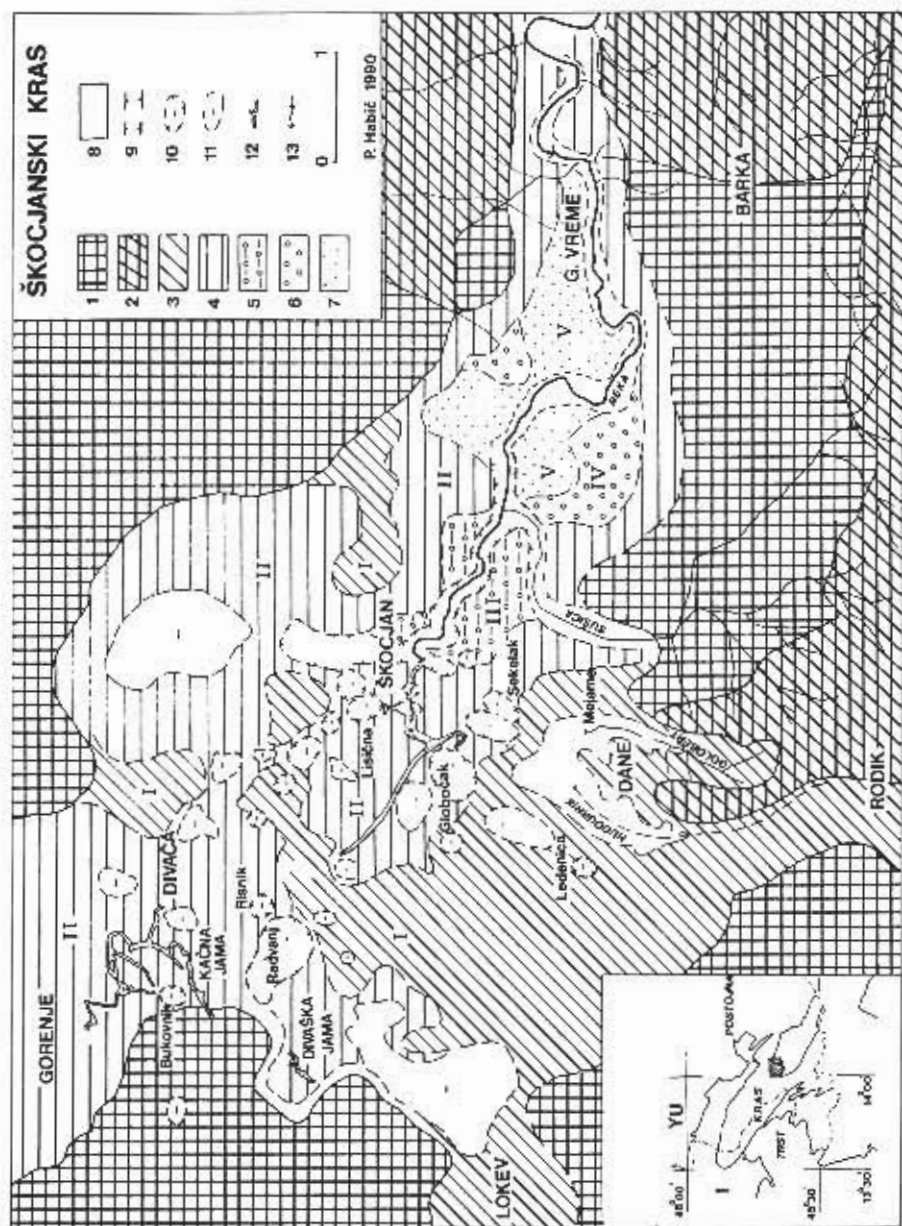
the caves of extreme dimensions and karst landscape with rich history and interesting cultural tradition.

The ponor Škocjanske Jame was formed by Reka which previously, supposedly in Pliocene, had flown on the surface from flysch Brkini across the whole Kras and left the traces in the relief and sediments (Radinja, 1967). To development of Classical Karst surface the tributaries from Vipava flysch and probably from Podgrad plain are relevant (D'Ambrosi, 1982). Local corrosional denudational processes were important too, contributing to corrosional applanation and pediplanation as well to the dissection of structurally generated ridges on both borders of carbonate plateau and on central ridge Taborsk Hrbet. After formation of two longitudinal fluviokarstic lowered surfaces, Nabrežina and Brestovica, still in the level of karst underground water there has been, as it is evidenced by morphological analyses, strong influence of young tectonic movements contributing to surface dissection beside vertical karst drainage in karstified rocks (Habič, 1983).

Thus the plain and plateau surface are uplifted from 10-50 m near Doberdob to 450-650 m near Divača and Lipica, the average inclination being $10^\circ/\text{km}$. After relief formation of carbonate and near flysch rocks we can conclude that the area between Vremščica (1027) and Artviže (817) was the most uplifted and inbetween lying valley of Vreme has maybe subsided a little even. Namely it is longitudinally crossed by regionally important wrench-fault, so called Divača fault of Dinaric direction where the series of opened fissures accelerated the runoff.

By gradual karstification starting after erosional or tectonical lowering of impermeable flysch border of Kras the valley of Reka on the transition from flysch to limestone incised more and more. At the ponors into the surface under 450 m a.s.l. blind valley, 130 m deep, 5 km long and up to 2 km wide, was cut in four terraces levels, which are Škocjan (430-440 m), Naklo (400-410 m), Zavrh (339 m), Vreme (365-370 m) and the recent on 320 m. (Fig. 3)

Ponor channels distributed in levels correspond to the terraces in blind Vreme valley. But the network in Divaški Kras, distributed in the altitudes between 400 and 160 m has not yet been completely paralleled with the mentioned fluvial terraces. The reasons are numerous, the former ponors are namely on several places filled up by fluvial sediments, the ceilings above the caves collapsed which is seen in numerous collapse dolines around Škocjanske Jame.



According to shape and situation the collapse dolines were classified by Gams (1983) into four generations. The bottoms of the collapse dolines of the oldest phase are on average altitude 430 m, second and third phase on 355 m and the youngest fourth phase on 296 m. The rate between the width and depth of the particular collapse doline generation is characteristic, from 9, 4,2, 4,0, to 1. On the base of morphometric classification Gams defined situation and development phases of ponor channels in Škocjanske Jame (Fig. 4) but they correspond with other speleological results partly only (Gospodarič, 1984).

Although the age of collapse dolines and ponor channels in Škocjanske Jame and in Divaški Kras is not yet absolutely dated we infer by the geomorphological signs to Quaternary development. Valley incision and underground hollowing were followed because of climatical changes by filling up, and maybe tectonic movements have influenced the changes in the underground.

Big permeability of contact karst near Škocjanske Jame, the volume of the biggest collapse doline Sekelak is more than 8.000.000 m³, and the biggest hall Martelova Dvorana more than 1.500.000 m³, is obviously the effect of favourable geological setting and big erosion and corrosion power of sinking river Reka in the contact area.

Reka gathers the water from more than 350 km² of the surface, from it 214 km² (60%) on impermeable flysch while the karst background on Snežnik (1797 m) and in the area of Slavonsko-Košanski Kras are not yet precisely defined. Reka takes its spring in flysch SE from Ilirska Bistrica on 720 m a.s.l., good 15 km distant from Kvarner Bay only, and flows into 73 km distant Trieste Bay. Near Ilirska Bistrica a strong lateral karst tributary joins it from right and near there the strongest superficial stream Molja comes from the left side. The confluence of waters in shallow Bistrica basin is connected to tectonic subsidence, the earthquakes with epicenter near Koseze are frequent and near Bukovica the Pleistocene loams are in relatively low position. The second tributary from right is Sušica draining high waters from Košanska Dolina only, where the water table in karst near Gabranca effluent lowers for more than 120 m, therefore low waters from this area are flowing under Vremščica (1027 m) into Timavo, as it was proved by water tracing of Sajčevski Potok. The minimal Reka discharge is 0,16, the medium 8,95 and the highest above 387 m³ /s. The relation between low and high discharge is 1:2.400 evidencing its torrential character. At the highest discharges the water is damed in the underground and floods occur in Škocjanske Jame. In 1826 the flood reached 346 m, in 1851 336

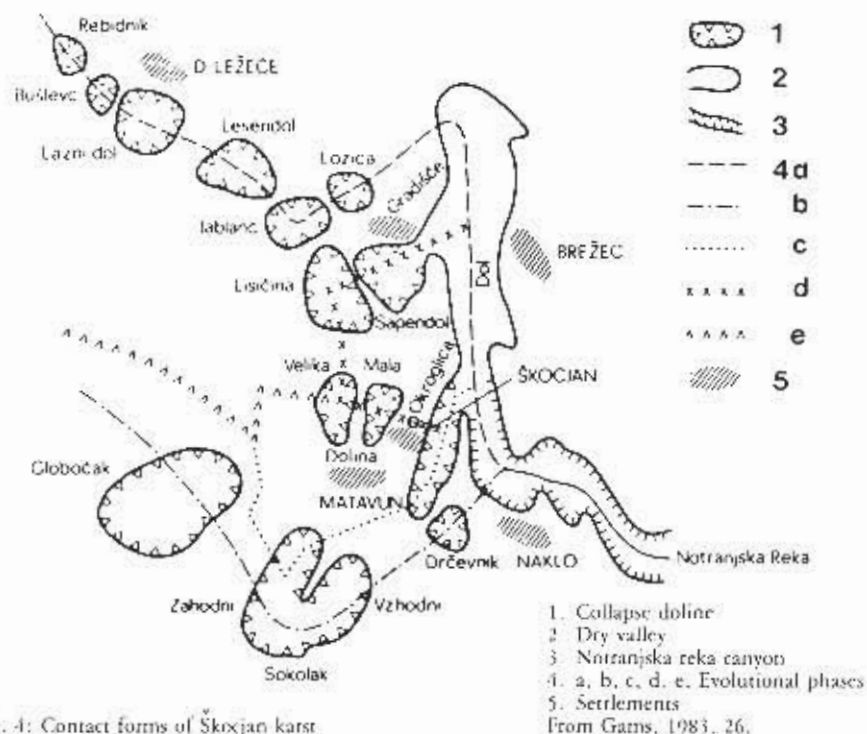


Fig. 4: Contact forms of Škocjan karst

m, in 1965 320 m. Thus the biggest differences in water level near Mrtvo Jezero is 150 m, in Hankejev Kanal 86 m and the flood comes deep into Tiha Jama interior. At drought Reka disappears in karstified riverbed 5 km before Škocjan already and at such occasion there are no traces of Reka water flow neither in Škocjanske Jame nor in near Kačna Jama. We infer, that under known caves the unknown water conduits exist. Reka swallow-holes in Vremska Dolina were filled up by millers in past already in order to have water in dry summer time. The last bigger sinkhole opened in riverbed near Gornje Vreme in summer 1982. Into 27 m deep and 5 m wide ponor all the waters of Reka disappear when the discharge lowers under $0,8 \text{ m}^3/\text{s}$ which is happening regularly during summer droughts.

Two kilometers before the ponor under Škocjan approximatively Reka flows through 60 to 80 m deep narrow canyon. It is sharply cut into plain of Naklo terrace on 400 m of altitude which origin is not yet well explained. Some think that it originated by the roof fall above the cave and others that it was formed by Reka superficial flow by the same manner as it

had cut its canyon riverbed into lower Vreme terrace. In canyon before Škocjanske Jame about 20.000.000 m³ of limestone is missed and in the whole Vremška Dolina if we don't take into account younger tectonic deepening, ten times as much (Jakopin, 1982).

The actual Reka ponor lies under 108 m high wall of Škocjan (425 m) on 317 m a.s.l. According to shape and situation it is relatively young as on the left and on the right of it older filled up steepheads are lying. The entrance passage is narrow and high developed along bigger fissure therefore the passages reach 50 to 80 m. The axis of Škocjanske Jame is presented by 2,5 km long underground canyon which has no lateral active water channels. The accessible part of water cave ends with siphon lake on 195 m a.s.l. The Reka inclination in Škocjanske Jame amounts to 45°/∞, while the inclination of superficial riverbed between Ilirska Bistrica and Škocjan is 2,8°/∞ only, the riverbed lowering on 28 km of distance for 80 m only.

There are several entrances to the underground. Under the village Škocjan between ponor and Mala Dolina is twisted channel with Mahorčičeva and Mariničeva Dvorana (cave). In Mala Dolina lies partly filled up passage of Brihta Jama, under the natural bridge between Mala and Velika Dolina is short passage called Okno. In Velika Dolina there are two lateral dry passages, Tominčeva Jama on the right and Prunker on the left side of the river, under precipiced west wall in Velika Dolina lies on the right above the water channel Schmidlova Dvorana, which is connected with Rudolfova Dvorana lower near Reka and Svetinova and Müllerjeva Dvorana above it. Through the last one Reka flows into narrow Hankejev Kanal. High under the ceiling on the left Reka side is the entrance to Tiha Jama which is connected with collapse doline Globočak by artificial tunnel. Now the tourist visit starts there and the visitors return from Velika dolina by elevator.

Underground continuation of Reka between Škocjanske Jame and Kačna Jama is unknown on the distance of 1,5 km, but probably water flow avoids the collapse doline Risnik near Divača. Unknown is also the flow between Kačna Jama and 30 km distant Timavo springs. Generations of cavers tried for more than 150 years to reach the underground flow from somewhere on the surface. They succeeded in 329 m deep Labodnica near Trebče only and in no other among almost 1000 explored caves.

Till now Reka underground flow was traced and proved by help of float load mineral composition, by salts, by organic dyes, by marked eels, by yeast bacteria and by isotopes (Timeus, 1928; Boegan, 1938; Bidovec, 1967). These researches have given important knowledge on hydrological

properties of Kras through which Reka and other waters flow feeding the Timavo springs by 0,5 to 10 cm/s velocity. In average Reka needs for the way from Škocjanske Jame to Timavo springs 9 days, its underground tributaries from Pivka border 2 months even at low waters.

Distribution of old water channels on Kras among Škocjan, Kačna Jama and Timavo springs is defined according to distribution of collapse dolines and bigger caves where fluvial sediments are preserved. The actual flow is indicated by rare blow holes as are near Povirje and Sežana where periodically the smell of polluted underground river is felt.

Picturesque karst vicinity of Škocjanske Jame attracted man in past. Today there are five small villages put into shelter among rocky precipices. Near there the traces of three old hamlets, four forts and five burial-places from younger and older Iron age are preserved. But man dwelled in caves from younger Stone age onwards evidenced by cultural remains in eight caves (Roška Špilja, Tominčeva Jama, Jama I na Prevali, Jama II na Prevali, Jazbina near Kačiče, Gorenja Jama, Mala Triglavca and Trhlovca) (Leben 1983). The motives for cave dwelling were different, some caves were climatically favourable as Tominčeva Jama f.e.

Škocjanske Jame are climatically divided into three main sectors:

A) Climatically statical passages of Škocjanske Jame. The air temperature is controlled by rock temperature. In Tiha Jama the temperature is mostly between 11 and 12,5°C (Kogovšek, 1983). A part of Tominčeva Jama belongs to this type.

B) The climate of water underground canyon. Through the hole above Reka periodically cooler air is coming, the connection with Schmidlova Jama in higher position rendering possible the escape of warmer air into Velika Dolina and out. In Dvorana Ponvic the temperature lowers in cold winters under 0°C. During strong winters lower parts of tourist path are frozen although they are about ten meters above the cave bottom and they have to be cleaned for safety. When the Reka water in the cave is warmer the mist occurs, which is frequent specially in the afternoon of the late summer and early autumn.

C) The climate of initial part of Škocjanske jame, including Mala and Velika Dolina. In cooler half of the year the temperature inversion prevails. It is interrupted by bora (eastern wind) blowing through ponor, through Mala Dolina and through Velika Dolina. In summer this part is warmed by warmer west wind. According to several measurements done by Petkovšek (1963, 1965) the bottom is for about 3°C cooler than the atmosphere, as the cave is of cold type with wide influx of night cold air. In-

side this climatical type there are the subvariants, cooler air near the floor in lower part of shady slopes, and warmer rocky sunny slopes (Gams, 1987).

Floristic properties of Škocjanske jame are interesting too. In Velika and Mala Dolina the symbiosis of plant species with different demands from meadows to glacial relicts are stated. There are 250 species of phanerogamme and 25 species of cryptogamme flora known. The symbiosis is composed by representatives of autochthonous Illyrian flora (*Ostrya carpinifolia* Scop.), mediterranean flora (*Cyclami purpureus* Mill.), Panonian flora (*Euphrasia tatarica* Fisch.), Baltic flora (*Viola mirabilis*) and very characteristic glacial relicts (*Primula auricula* L. ssp. *bauhinii*, Beck, *Saxifraga incrustata* Vest., *Viola biflora* L., *Silene saxifraga* L. and *Aconitum paniculatum* L.). There are more then 100 species of mosses known (Grom, 1959).

The vicinity of Škocjanske jame is worth to be visited in order to meet a part of not yet evaluated touristic richness. From Belvedere above Velika Dolina is nice view to Škocjan and to curiosities of Karst landscape. There are few arable surfaces around Škocjan, small fields are in the bottom of dolines, little more fields are on terraces in Vremška Dolina, otherwise the former rocky karst surface was intended for grazing and now it is more and more grown over by pines and prickly bushes.

3. GEOLOGY OF DIVAŠKI KRAS*

* Stanka Šebela

In the sense of geotectonical distribution of Slovenia (Buser, 1988) Kras belongs to Outer Dinarids making part of Dinaric carbonate platform (Fig. 5).

The oldest rocks of Divaški Kras are limestones of miogeosyncline facies of Cretaceous age. They are followed by Paleocene limestones developed in miogeosyncline facies too. Younger flysch rocks occur in eugeosyncline facies of Eocene age (Fig. 6).

The rocks of Lower Cretaceous developed as bituminous limestones and dolomites laterally passing to each other. Turonian age (K^2_1) is dark grey, dense, bedded limestone alternating with rudist limestone. In these rocks the majority of surface and underground features on Divaški Kras are developed. The caves Vilenica, Divaška and Kačna are situated in Turonian limestones, while Trhlova cave partly in Turonian and partly in Senonian

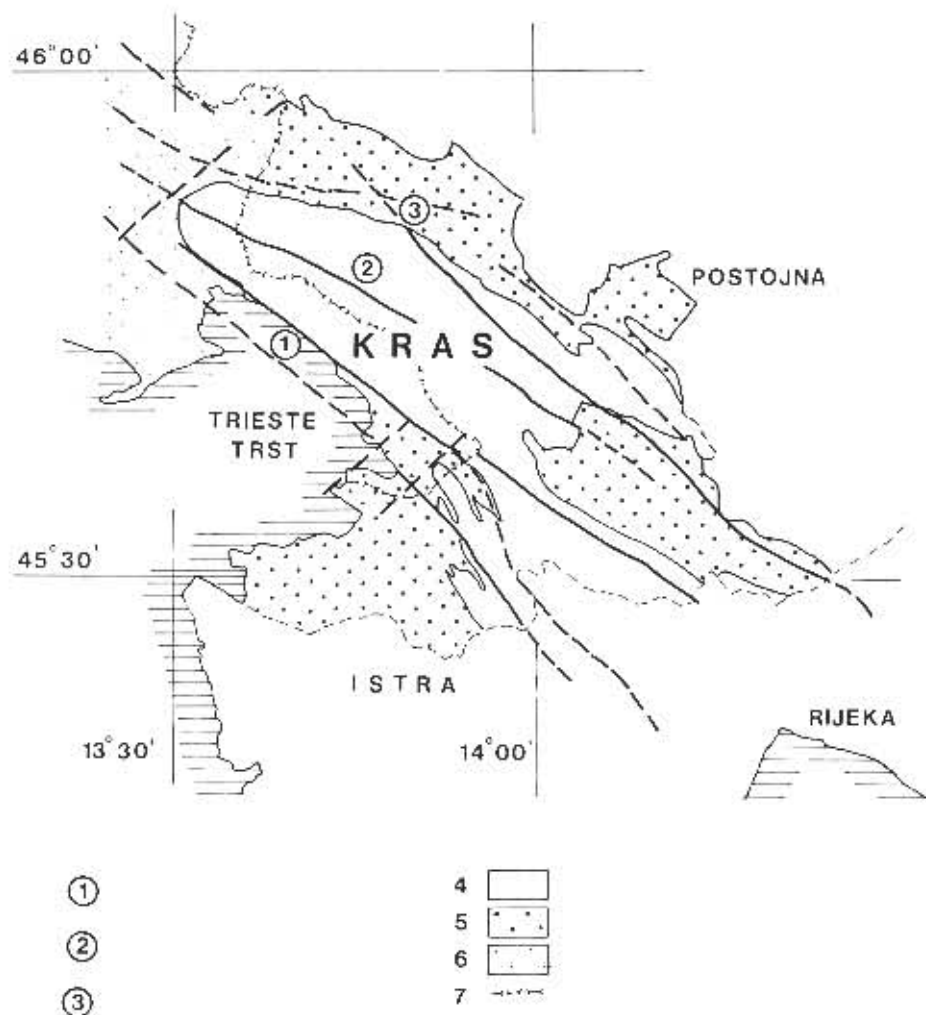


Fig. 5: Structural sketch of Karst. From Habič, 1983

1. Trieste fault
2. Divača fault
3. Raša fault
4. Carbonate rocks
5. Flysch
6. Alluvial sediments
7. National border

limestones. Senonian block (K^2_1) is composed by lower and upper part. In lower part there are rudist limestones, the upper part is built by lower Liburnian beds. The developed in form of dark grey micritic bedded limestone lithologically differing from other Cretaceous rudist limestones. The karst phenomena are there less intensively developed (Buser, 1972). Nevertheless in Senonian limestone lies Lipiška Jama. The youngest Cretaceous rocks (K^2_1) are grey-brown, partly fresh water and partly marine limestones.

Marl limestones and limestones of Paleocene age are shallow-sea and brackish rocks, developed in unequal depth. In Paleocene hollow north from Divaca to Sezana they are strongly eroded. Stratigraphically these rocks are well dissected containing rich Foraminifera fauna.

The Paleocene rocks block starts by dark dense limestone containing in upper part shells *Gyropleura* sp. and *Haracea*, sometimes there are in limestone base pinky limestone breccias. According to age these rocks are classified between Cretaceous and Paleocene ($K^2_1 + Pc^1$).

Lower Paleocene part (Pc^1) corresponds to upper part of Liburnian beds. The layers developed as dark grey micritic partly marl Kozina limestone containing snails *Cosinia*. Sheets of greyish and brownish limestones including some cherts follow. Because of clayey alloys this limestone is much less karstified than Cretaceous beds.

Middle Paleocene is built by Milliolid limestones (Pc^2), which are usually dark grey and their structure is similar to upper part of Kozina limestones. In general they are defined according to their position between Kozina and Alveoline limestones where they lie entirely concordantly and because of great number of Milliolids.

The Alveoline-Nummulitic limestones presenting sea layers belong to Paleocene and partly Eocene age. Alveoline limestone (Pc, E) are usually brownish. They are either well or bad bedded containing typical Foraminifera. Nummulitic limestones (Pc, E) are mostly brown, partly yellowish-grey. These limestones are in upper part frequently in form of breccia. Compared to Alveoline limestones Nummulitic limestones are more compact with bad expressed bedding. Nummulitic limestones are capped to Alveoline ones continuously by successive passages.

Lower part of clastic Paleogene sediments is deposited continuously to limestones with Foraminifera. These are mostly flysch rocks. At first marls with crabs and Globigerinae were deposited (E^1) followed by marls, clays and sandstones, calcarenites, breccias and conglomerates ($E^1, ^2$).

Quaternary sediments on Kras are poor. Some alluvial plains are found where the superficial waters from impermeable flysch are flowing.

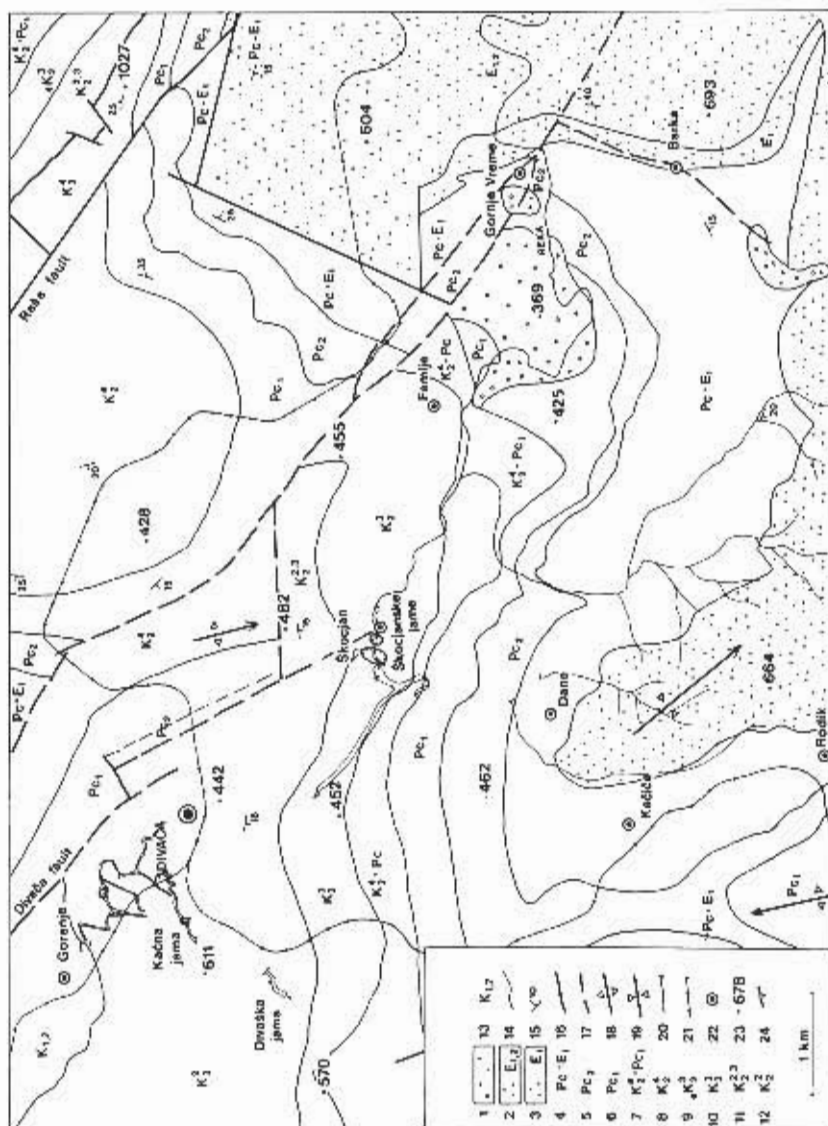


Fig. 6: Geology of Divača karst (after geological map sheet Postojna, Gorica, Trst and Ilirska Bistrica, 1:100000, adapted by S. Šebela, IZRK ZRC SAZU, 1990).

3.1. Tectonics

Geological setting of Divaški Kras has all the properties of autochthonous and parautochthonous tectonic zones of Dinarids between the Adriatic Sea and the unit of High Karst (Sikošek c Medvenitsch, 1969).

The area between Sežana and Vremska Dolina belongs to two tectonic units mostly: Trieste-Komen anticline and Reka Paleogene synclinalorium.

Trieste-Komen anticline is composed by several smaller anticlines and synclines with dinaric folds direction. Near Vojštica the fold axes and the main anticline axis turn westwards (Buser, 1972).

In a part of Trieste-Komen anticline two expressive dinaric faults along Raša (Raša fault) and between Divača and Sežana (Divača fault) are passing. Along Raša fault the limestones are tectonically crushed in a wide zone. From main fault several lateral ones are divided, uniting and dividing again. Divača fault is oriented along the rocks direction and dips steeply towards NE. On both sides it is accompanied by milonite zone in limestones and dolomites (Buser, 1972).

Such geologic setting obviously influenced to the direction of Notranjska Reka underground flow from the ponor near Divača to Timavo springs.

Reka Paleogene synclinalorium starts near Lipica and passes further towards SW into Brkini area. The whole region is folded in several smaller or bigger synclines and anticlines (Buser, 1972).

4. GEOLOGY OF ŠKOCJANSKE JAME*

* Martin Knez

Geological investigation evidenced (Gospodarič, 1983; 1984) that accessible channels of Škocjanske Jame developed in Turonian and Senonian, mostly thick-bedded limestones (K_2^2 , K_2^1) with exception of Tiha Jama, built in thin layered Cretaceous and Paleocene limestones. This lithostratigraphic difference in limestones is reflected in the channels morphology. Along rare bedplanes and along fissures and faults of Upper Cretaceous limestone the canyon-like water channels from Reka ponor to the beginning of Hanke channel developed. Huge entrance to Mahorčičeva Jama and Mariničeva Jama in the continuation are directed towards NW and towards SW. In the left wall of Mahorčičeva Jama on 330 m opens the pas-

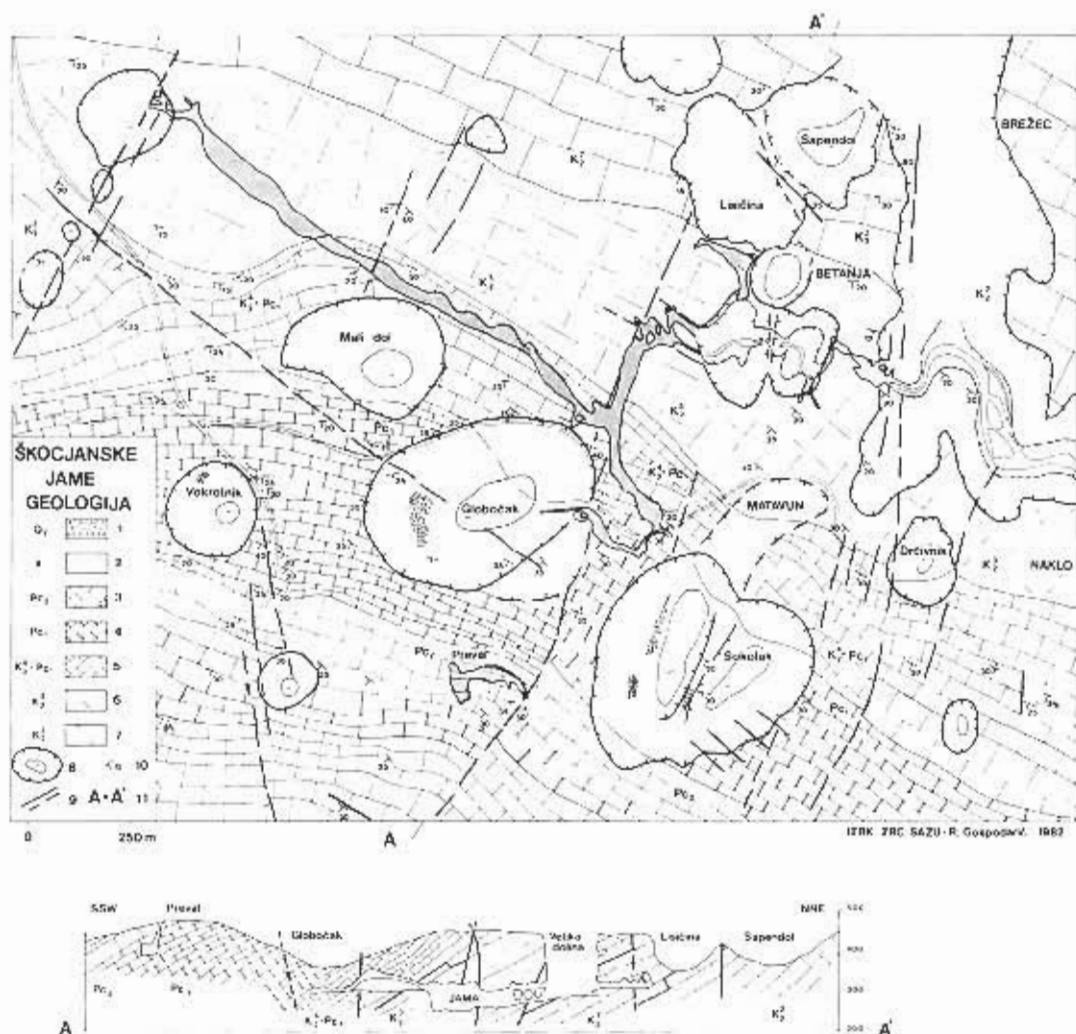


Fig. 7: Geologic Map of Škocjanske Jame Karst.

sage the rocky bottom of young collapse doline Okroglica, on the same altitude in Mala Dolina lies the bottom of filled up cave Brihta Jama. Both present the remains of former higher lying smaller and more meandering ponor channel than is the actual (Fig. 7).

In initial part of Czoernigova Dvorana 40 m high ellipse shaped profile with erosional step 5 m under the roof approximatively is seen. In the continuation this rocky passage developed in thick layered Senonian lime-

stone filled up by 15 m thick deposit of loam, sand, gravel and breakdown rocks. The deposit is partly covered by flowstone and partly by flood loam to 345 m a.s.l. The upper final passage part is fissured and covered by flowstone. The composition of the entire deposit between the rocky bottom 330 m high and ceiling 345 m high cannot be seen as it is covered by recent sediments and material falling from the roof and from upper part of the deposit.

The rocky bottom built in Senonian limestone in Brihta Jama is covered by 5 m thick deposit, here and there covered by flowstone. Somewhere the flowstone as erosional remain is preserved on the walls 1,5 m above the floor, evidencing that once the channel was filled up by sediments higher.

The collapse doline Mala Dolina is on the top elongated in N-S direction and at the bottom transversally to this direction narrowed and canyon-shaped. From here the river flows into 40 m deep gravitational canyon under Okno into collapse doline Velika Dolina where the vertical walls are 140 m high. Mala and Velika Dolina developed in thick layered Senonian limestone.

Okno (between Mala and Velika Dolina) presents the remain of horizontal, 15 m wide passage with rocky step 330 m a.s.l. Some flowstone is preserved in it. Reka has lowered its river bed into continuous underground channel after the collapse of Mala and Velika Dolina down to the actual rocky bottom 270 m high. In upper, wider part of Okno collapse blocks are seen, older flowstone and agglomerated gravel. The flowstone was deposited in time when this passage was connected to others of the same altitude.

The roof of Tominčeva Jama smoothly passes to walls and rocky bottom in Senonian limestone as the rocky space is filled up by 7 m thick deposit. The rocky bottom of Schmidlova Dvorana on 300 m of altitude can be morphologically connected with the bottom of Tominčeva Jama into common development level. The bottom of Schmidlova Dvorana is covered by 6 m thick deposit composed by breakdown rocks and loam.

Above the flowstone in Dvorana Ponvic there is the flood loam preserved to 340 m a.s.l. It was deposited in Holocene. Except recent sediments in the river bed and in erosional forms in canyon-like Šumeča Jama there are no sediments preserved. Šumeča Jama lies in unbedded Senonian limestone. It is formed in wide fissure zone noticed in Senonian limestones at the beginning of Tiha Jama already.

Suhi Rov of Tiha Jama is composed by two elongated breakdown halls (Velika Dvorana and Paradiž), and between them is narrow and low 100 m

long passage on the altitude of 340 to 350 m, the rocky bottom is presumably on 310 or 315 m. The longitudinal section of Tiha Jama shows that three quarters of otherwise 40 m high passage are filled by breakdowns and sediments. In particular final part lying in thin-bedded Vreme (Maastricht) beds in collapsed and there lies the collapse doline Globočak (with artificial entrance into the cave).

From Suha Jama 1,5 km long Hanke channel continues in fissure zone of non-bedded Senonian limestone. It ends at the cross fault where Martclova Dvorana terminates with 100 m high wall above outflow siphon.

5. CAVE SEDIMENTS IN ŠKOCJANSKE JAME*

* Nadja Zupan

In Škocjanske Jame fluvial sediments as gravel, sand, loam and some rubbles and flowstone are preserved.

The gravel in Reka river bed is recent. In entrance Mahorčičeva Jama there are several flysch pebbles, near the siphon in Hankejev Kanal the limestone pebbles prevail (Kranjc, 1983). Fossil gravel is found in Czoernigova Jama deposit only. In lower part cherts and in upper part flysch and limestone pebbles prevail. This fossil gravel is four times more rounded than the recent one. Similar gravel was not found anywhere else in Škocjanske Jame but on the terraces before the Reka canyon. In other channels of Škocjanske Jame loam sands and loam together with rubble and flowstone compose the stratigraphic series. In some erosion forms these sediments are recent; in Tomičeva Jama and in Schmidlova Dvorana above the rocky bottom in the altitude 308 to 300 m they are Holocene, similar are found among the flowstone and above it to 350 m of altitude in Dvorana Ponvic and in Tiha Jama; sediments supposed to be Würm age were found among the flowstone layers and breakdown rocks in Velika Dvorana and in Paradiž in Tiha Jama. The treated loams are composed without regard to their age by 10% of carbonates without organic material. According to colour they do not essentially differ, they are all in shades of dark yellowish-brown. These properties show that the loams origin from weathered flysch transported to the underground. Thin layers and regular granulation evidence the deposition from turbid water overflowing the underground channels.

Stratigraphic position of loams among rubble and flowstone, in-between and above them show that the floods were more permanent before the Würm 3 and in the beginning of Würm and that in Holocene the high flood waters periodically deposited flysch loam in Tiha Jama even as the loam is found between the flowstone layers from this age. Breakdown rocks and rubbles are preserved in Velika Dvorana and Paradiž of Tiha Jama, in other channels, nearer to the underground canyon they are mostly preserved on the roof, elsewhere they are eroded. Recent stalactites, stalagmites on the top of deposits in Dvorana Ponvic and in Tiha Jama are Holocene or Late Glacial. They were radiometrically dated to 1500, 8900 and 10.300-12.300 B.P. These datations chronologically helped to define the flood loams and the recent phases of the underground development. The oldest flowstone in Tiha Jama belongs to Würm or is even older. It is layered and cone-shaped, among the flowstone beds the sediment layers are deposited.

According to deposit and flowstone investigations and their radiometric datation R. Gospodarič (1988) elaborated temporal and climatic scale of Škocjanske Jame development.

6. ŠKOCJANSKE JAME - RECENT FLUVIAL SEDIMENTS*

* Andrej Kranjc

In accessible underground of Reka there are all categories of recent fluvial sediments, from big boulders to cave loam and clay.

According to Austrian data the maximal turbidity of Reka is 1930 g of suspension load per m^3 of water in the Timavo springs and approximatively 2000 g/m^3 in front of the ponor to Škocjanske Jame. The average suspension quantity for the years 1909-1911 was 22,8 g/m^3 (Boegan, 1938). Mean value calculated for the recent period is 17,3 g. Regarding the mean discharge we can calculate that Reka annually transports into the underground about 6000 tons of suspension load, this presenting 12% of loose slope material in the Reka river basin, 25% of the material coming annually into the river bed respectively (ZVSS, 1978). So annually about 30 t/km^2 of fine grained material is loosened from the flysch part of the Reka river basin.

During the low water level the ratio of organic material in the suspension load was 70% - organic particles are in great extent the consequence of anthropogeneous pollution.

Fig. 8:
Rock-mill with gravel in Reka
riverbed in Škocjanske Jame
(photo J. Hajna).



The finest sediment deposited by actual Reka waters belongs to silt, mud, muddy sand, and sand (classification after Shepard 1954). The ratio of sand and silt oscillates very much (between 10-80%) while the clay ratio is pretty equal (8-22%).

Petrographic gravel composition strongly and essentially changes along the Reka. In the superficial riverbed mostly flysch sandstone and chert are prevailing. After the transition of Reka to limestone relief the rate of limestone pebbles increases quickly and correspondently the rate of flysch sandstone pebbles diminishes. Under Škoflje the limestone pebbles reach 20%, in Mahorčičeva Jama (Škocjanske Jame) 30%, and in Kačna Jama they surpass 60%. If the same trend remains downwards Kačna Jama then there must be in the underground Reka riverbed 5-10 km downstream limestone pebbles only.

According to data of ZVSS (1978) in the Reka river basin 395 m³/km²/year of rock debris is loosened on impermeable relief. In addition man have to reckon with another 20% of traction load (gravel) from carbonate rocks. Relief deficit of carbonate rocks is relatively small compared to this one in flysch.

The underground along Reka river is an example where the changes in granulometry and morphology of recent cave fluvial sediments are well seen and at the same time the return effect is seen well too, the effect of sediments and their transport to formation of underground channels (Fig. 8). Results, obtained by study of recent sediments show that the development was similar in past confirmed by testimony of suitable older, fossil sediments (Gams, 1968; 1983).

7. PRECIPITATIONS PERCOLATION AND FLOWSTONE DEPOSITION IN ŠKOCJANSKE JAME*

* Janja Kogovšek

7.1. The precipitations percolation through the roof of Škocjanske Jame

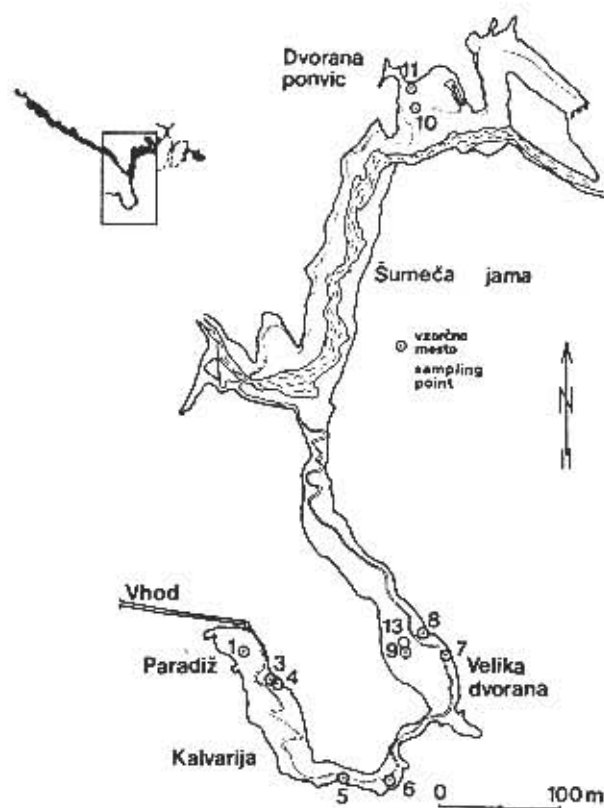
In the area of Škocjanske Jame (meteorological station Matavun near Divača) about 1000 to 1700 mm of precipitations fall annually. In 1982 1523 mm of precipitations have fallen, in dry year 1983 1052 mm only. The surface is covered by grass, bushes and pine-trees. Frequent wind bora accelerates the evaporation and diminishes the percolation water quantity compared to this in Planinska Jama (Kogovšek, 1984; 1986).

Two years of regular observations (1981, 1982) in Škocjanske Jame included percolated waters in Tiha Jama where the ceiling is 55 to 90 m thick and in Dvorana Ponvic where the ceiling thickness is 100 m. Sampling points are evident from Fig. 9. Discharge, temperature, specific electrical conductibility were measured each week and beside definition of carbonate, total and calcium hardness, the chlorides, nitrates and o-phosphates contents were measured (Kogovšek, 1984).

The precipitations are reflected in Škocjanske Jame in two types of percolation, by permanent thin droppings and by abundant periodical trickles.

In the case of thin permanent droppings the discharge and hardnesses oscillate seasonly. The point 1 and 4 belong to this type (Fig. 10). The droppings are connected to less permeable conduits impeding quick water

ŠKOCJANSKE JAME - DEL TLORIS - PLAN



NARIS - SECTION

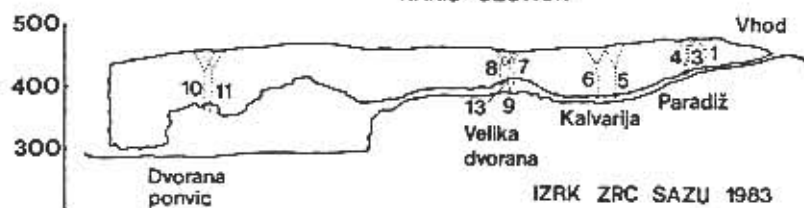


Fig. 9: The situation of observed points Škocjanske Jame.

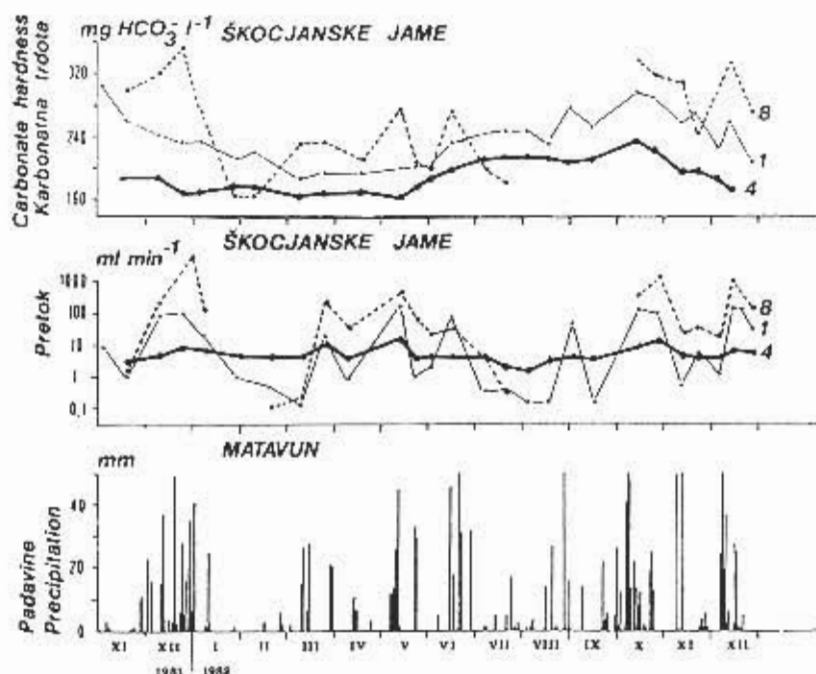


Fig. 10: Characteristic trickles in Škocjanske Jame (1, 4, 8)

discharge through the cave roof. Watering of background is permanent and influences to water homogenisation reflected in small hardness oscillations during the year.

More abundant trickles, even drying up in longer dry periods present a specific case. We suppose that water flows through more pervious conduits. Thus partial homogenisation in the background is the greatest. In the period of modest or irregular precipitations the background watering changes quickly and periodically diminishes therefore the trickles dry up. These important changes in trickle background probably influence the jumping discharge and hardnesses changes. Increased trickle discharge is followed by increased water hardness. The representative of this group is trickle 8 (Fig. 10). But in Planinska Jama the opposite relation of discharge and carbonate hardness was stated at abundant, permanent trickles.

Trickles carbonate hardness in Škocjanske reaches the values from 80 to 300 mg/l CaCO_3 , similar is total hardness. The calcium content is high, there are only few milligrams per liter, of magnesium only. The percolated waters contains low content of chloride (some mg/l Cl), to 1 mg NO_3 and

under $0,05 \text{ mg/l PO}_4^{3-}$. The exceptions are the water from chimney (point 3) and near lying drippings (point 4) only with increased nitrates content (up to 30 mg/l NO_3^-). Higher nitrates values can be explained by manuring the field in doline on the surface above the observed points 3 and 4.

In Planinska Jama and in Pisani Rov of Postojnska Jama the percolated water reaches the carbonate hardness up to 190 mg/l CaCO_3 . The exception is trickle 1 in Planinska Jama where the precipitations percolate through the beds of lime dolomitic breccia and thus the water reaches higher magnesium and carbonate content than the percolated waters elsewhere in the cave. Higher water hardnesses control bigger corrosion in cave roof. The annual corrosion calculations are not possible without continuous discharge measurements.

7.2. Flowstone deposition

In most cases the percolated water in Škocjanske Jame is oversaturated. In Tiha Jama the flowstone is deposited all over. In general two groups could be distinguished. When droppings are thin and permanent the flowstone deposition is quite regular, similar as in Pisani Rov of Postojnska Jama. Around abundant trickles in Velika Dvorana the flowstone is deposited in bigger quantity.

In the case of small trickle 1 (discharge from $0,1$ to 360 ml/m) in Paradiž during the whole year regular flowstone deposition was recorded, from 15 to 60 mg CaCO_3 from 1 liter of percolated water. For the annual calculation of percolated water flown through this trickle and carbonates quantity deposited in one year out of it, we have used the measurements of two weeks. In one year through this trickle 16 m^3 of water have flown and 600 g of flowstone were deposited. Similar deposition was established in Pisani Rov of Postojnska Jama (Kogovšek, 1983). The annual quantities of deposited flowstone depending on annual quantity of percolated water are presented on Fig. 11.

As an example of flowstone deposition from abundant trickle we have chosen the trickle 8 in Velika Dvorana having extreme oscillation of discharge and hardness and drying up periodically even. The percolated water trickles down on 10 m high speleothem Orjak. From 1 liter of this water 37 to 170 mg CaCO_3 were deposited, giving 23 to 65% of carbonates of percolated water. Parallel to discharge and hardness oscillations the flowstone deposition oscillated too. As higher hardnesses of percolated water

Pisani rov 23, 24, 25, 29
Škocjanske jame 1 x

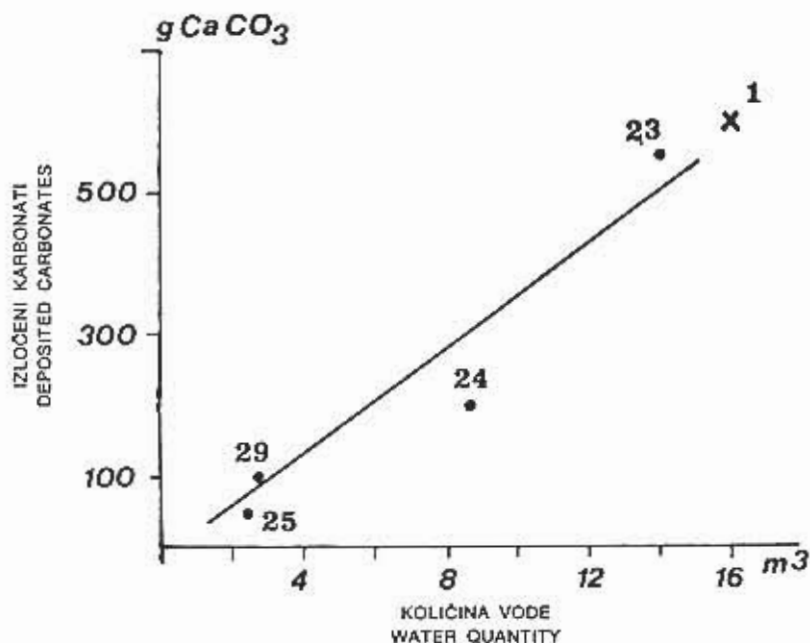


Fig. 11: The intensity of flowstone deposition in Škocjanske Jame compared to Pisani Rov in Postojnska Jama.

occur during bigger discharges and the quantity of deposited flowstone is the product of both factors, the maximal effects of flowstone deposition occur during bigger discharges. Although during the summer drought the flowstone deposition stops for four months on the base of weekly measurements we estimate that the annual quantity of deposited flowstone in Velika Dvorana of Škocjanske Jame overpasses the deposition in Planinska Jama and in Pisani Rov of Postojnska Jama. The flowstone deposition on point 8 in Velika Dvorana is presented on Fig. 12.

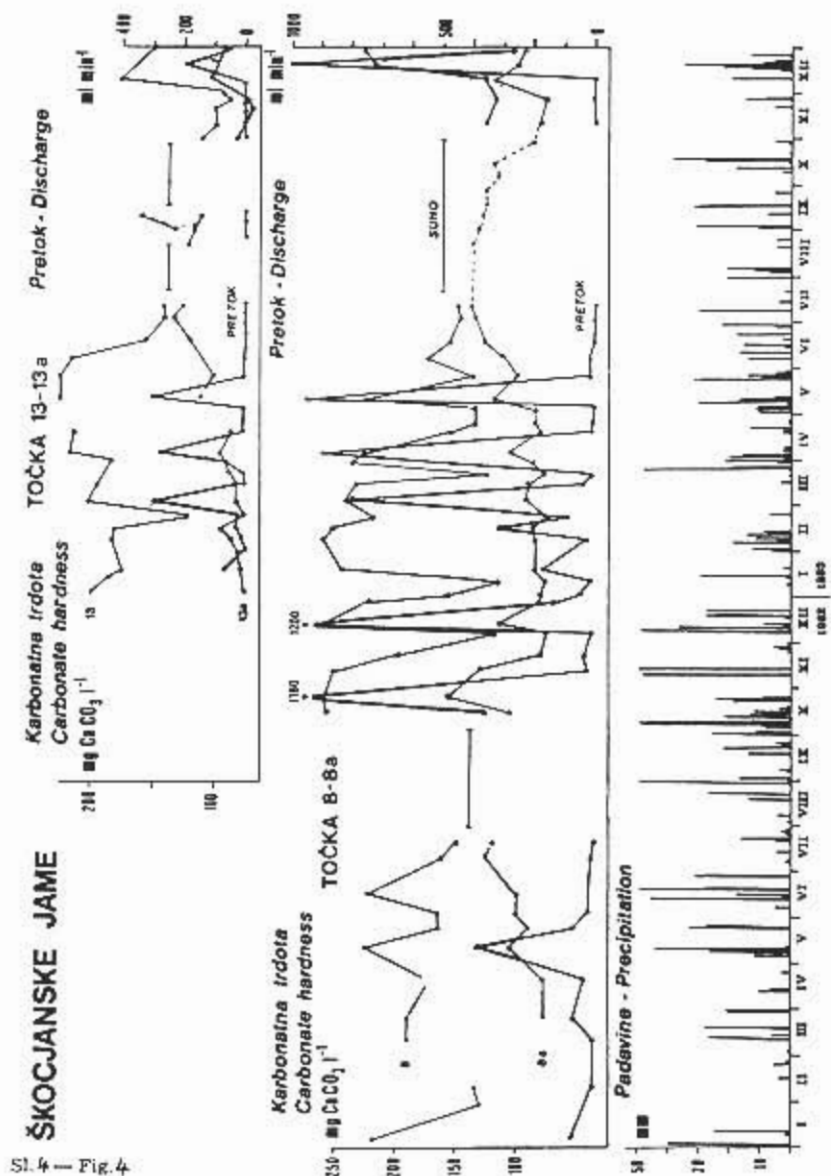


Fig. 12: The flowstone deposition on point 8 in Velika Dvorana.

8. SPELEOMORPHOLOGY AND SPELEOGENESIS*

* Tadej Slabe

Reka is one of bigger sinking streams in the world (Gospodarič, 1983) and it excavated huge underground caverns. Škocjanske Jame are about 6000 m long all together, the total altitude difference is 225 m. The caves are composed by several separated upper dry passages and by uniform low water level, both interrupted and at the same time connected by two big collapse dolines.

Lower water level lies near the ponor on the altitude 317 m, the bottom of Velika Dolina is at 260 m, the final siphon Mrtvo Jezero on 195 to 200 m a.s.l. It is canyon-type with steep walls along the river bed. Canyon-like Hankejev Kanal is expressive in particular, at the beginning the riverbed is 5 m wide, 77 m high under the roof the channel is widened to 15 m. Before the final Mrtvo Jezero the channel widens to 70 to 100 m being more than 100 m high. The inclination of Reka riverbed between ponor to Mahorčiceva Jama and Martelovo Jezero before the siphon is $45^\circ/\text{km}$. After heavy rains the water stagnates in this channel and water level starts to increase. In the entrance part up to Šumeča Jama the riverbed is cut in solid rock, the parts with cascades and falls alternating with lakes. In several places solution cups are cut into solid rock. In Šumeča Jama and in Hankejev Kanal Reka flows among the breakdown rocks. In them and in the rocky riverbed bottom characteristic small facets and rock mills are incised resulting from quick and strong water flow. On the bottom of big Martelova Dvorana there is a lot of gravel, breakdown rocks and loam. In Mrtvo Jezero flood wood and other floating materials are found which were not transported by the water into the siphon.

On several places the levels are connected by breakdowns as the ceiling collapsed above the big channels and strong water flow simultaneously transported breakdown rocks away. This is the genesis of collapse doline Okroglica, Mala and Velika Dolina, the results of breakdowns are also huge caverns as f.c. 70 m high Šumeča Jama.

Upper level lies on 310-330 m a.s.l. It is composed by Czoernigova Jama, Brihta Jama, Okno, Dvorana Ponvic and Tiha Jama. The passages of this level are smaller, more meandering having smaller inclination as those presenting the actual water level. Gospodarič (1984) considered as independent level Tominčeva Jama too which was excavated by sinking stream, sinking under the village Gradišče and flowing into the channels near Sa-

pen Dol and Lisicna, while from Tominceva Jama it has flown under the then Velika Dolina into Schmidlova Dvorana.

We suppose that the remains of higher and the oldest levels are presented by Luknja v Lazu and Roška Špilja 370-390 m a.s.l. and distant inclined caverns with horizontal passages as are Jama I and 2 "Na Prevali", which are above the actual Škocjanske Jame. The flysch gravel in collapsed cave near Matavun belong to it too. It was found while digging the sanitary dump for new touristic center. Still higher, on 420 m a.s.l. there are remains of Prelušova Luknja, Jama na Škrljici, Jama v Sapendolu passages and channels filled up by sediments in the wall of Sekelak collapse doline.

The origin and development of upper level on 370-390 m a.s.l. belongs according to Gospodarič (1984) to Middle and Old Pleistocene period. From this period or even from before Pleistocene phase remained the traces of erosional passage in Prelušova Luknja on 420 m, Jama na Škrljici and Jama v Sapendolu. The sediments in these caves evidence different climatic, hydrographic and morphological conditions of the time. To this oldest period belong filled up fossil caves as are the caves near Fernetiči or on Koblak near Dane.

According to sediments Gospodarič (1984) concluded that maybe in the last interglacial, but in any case before last glacial, in Middle Pleistocene phase respectively (2) water level on 310-330 m was active, it means from Czoernigova to Tiha Jama. From the same period are roof solution cups in Mariničeva Jama, big current markings in south-eastern wall of Mala Dolina and ceiling solution cups in Dvorana Ponvic and maybe also the solution cups in the roof of entrance part of Hankejev Kanal, as the water, flooding the cave had more conduits to flow through at the same time. The then water channels were less steep, more wide than high and more meandering. The sinking flow was less torrential, probably sinking on several places and upwards in the Reka canyon (Gospodarič, 1983). We can infer that later the collapse of Globočak Doline closed the way to water through Tiha Jama. At first Gams (1967/68) supposed that Tiha Jama was formed by Brkinski Potok, a tributary of Reka, but later he contributed it to meandering of Reka itself (1983). Progressively upper part of Hankejev Kanal became the main conduit and when the new direction was again penetrable for all waters for short time the filled up channels of second level were regenerated, evidenced by small current markings in Czoernigova Jama and Brihta Jama. Water quickly flowed on the old sediments in vadose zone this time. To this Young Pleistocene period belong Tominceva Jama and Schmidlova Dvorana (Gospodarič, 1984) which are connected with

ponor near Sapendol and Lisična and later they remained hang above the actual water channels. Quick incision followed and the role of main conduit in the initial part of the cave was taken over by Mahorčičeva and Mariničeva Jama. In the same time the breakdown scree in Mala and Velika Dolina is supposed to be transported away. The central cave's part and Hankejev Kanal were quickly incised too. Water channels tended to be more direct and canyon-like lowered. To the period of quick erosional incision Gospodarič (1988) contributes upper and middle Würm glaciocustatal changes in Adriatic Sea and thus to changeable hydrological and climatical conditions. In cold top of Würm (W 3) the ceiling of Mala and Velika Dolina is supposed to be collapsed and then the cave was connected by the surface (Gospodarič, 1983).

Anastomoses above the sediments in Tominčeva Jama, in upper part of Hankejev Kanal and in Tiha Jama, it means in cave's parts which are not genetically connected present the secondary forms. Probably they developed above the Holocene fine grained sediment which is found in other cave's passages to the 350 m a.s.l. (Gospodarič, 1984) and once filled up the cave entirely. The floods are seen in the flowstone in Tiha Jama which is out of erosion activity for 13.000 years at least (Gospodarič, 1983). In this period the riverbed in the cave was incised, older higher passages weathered and collapse dolines above them were formed. But the speleogenesis of Škocjanske Jame is not yet entirely explained, the temporal and space relation between hollowing and filling has to be enlightened more in detail and the influence of climatic oscillations and tectonic movements in the whole Škocjanske Jame and Kras have to be studied.

9. KAČNA JAMA*

* Andrej Mihevc

Kačna Jama is the biggest cave system of Divaški Kras and Notranjska Reka in the continuation of Škocjanske Jame. The entrance lies on the border of karst plain west from Divača 435 m a.s.l. The total passages lenght amounts to 8470 m, they are distributed in two levels (Mihevc, 1984). The upper level is about 180 m, and the lower from 250-270 m under the surface. The upper level is dry, periodically reached by Reka flood waters as it increases up to 100 m. In the lower level the actual underground flow of Reka is met.

The first explorations of Kačna Jama are connected with search of Reka underground flow, but because of pretentious entrance pothole they started relatively late when Škocjanske Jame were in general explored already. In 1889 according to order of A. Hanke the cave workers and guides from Škocjanske Jame G. Rebec, A. Rešaver and G. Žiberna have equipped the upper 80 m of the pothole by wooden ladders and the remaining 100 m by simple winch. Thus A. Hanke was able to explore about 800 m of the cave. After his death J. Marinitsch continued his work.

The access through the entrance pothole was made better and in the following years the cave was explored in detail. Marinitsch was stopped by impenetrable narrowness, siphon lakes and breakdowns (Marinitsch, 1895; Müller, 1900).

The continuation of the cave which led to the underground Reka flow was discovered in 1972 only by cavers from Logatec. Behind narrow, hardly noticeable passage they discovered and explored 0,5 km of new passages in the upper and 6 km in the lower level (Kenda and Petkovšek, 1974).

Bigger part of the cave lies in bedded Upper Cretaceous rudist limestones dipping southwestwards. Cretaceous dolomite lying on the surface north-west from the cave occurs in lower cave level only.

Bedding and dip of strata in the cave morphology are not strongly expressed. Fault and fissure zones are more important, oriented in approximative direction N-S. Passages developed in this direction are narrow and high. Where the faults cross the passages bigger halls developed connecting them with the entrance pothole. Along the fissure zone big collapse doline Bukovnik appeared, lying above the cave and 140 m deep pothole Košava Jama which bottom ends 100 m above the Ozki Rov in Kačna Jama.

The entrance pothole developed along the fissures by uniting the parallel potholes. (Fig. 13)

The upper cave level is formed by fossil Reka channels which has flown through a part of channels with free surface and part of them developed in the zone of siphon water flow evidenced by their cross sections, direction and network. Later the breakdowns changed the channels in big halls in fault zone. By lowering the water level in karst and by deepening the flows into underground this level became fossil, flood waters periodically deposited flysch sand and loam, and percolating water flowstone.

Through the channels of the lower level Reka flows at normal water conditions in the distance of 1500 m, at higher water table the passage is completely inundated. There are two genetic types of passages, their form

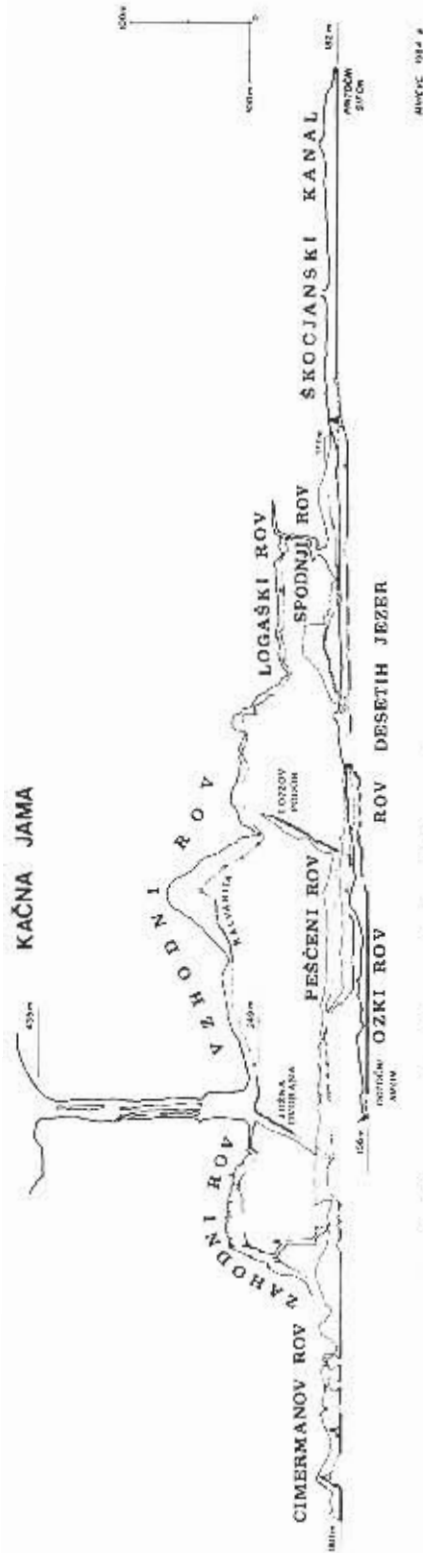


Fig. 13: Cross - section of Kačna Jama (Abisso dei serpenti) From Mibevic, 1984a.

generated by tectonic structure, permeability of tectonic zones respectively (Fig. 14).

Older passages of lower level have small inclination and general direction NW. In detail they correspond to structure and usually their profile is box-shaped. These are the main conduits of high water, big quantities of recent non-carbonate and carbonate gravel are found in them. Strong erosion influence is seen, the passages are washed off, on leeward places fine floating material is deposited only.

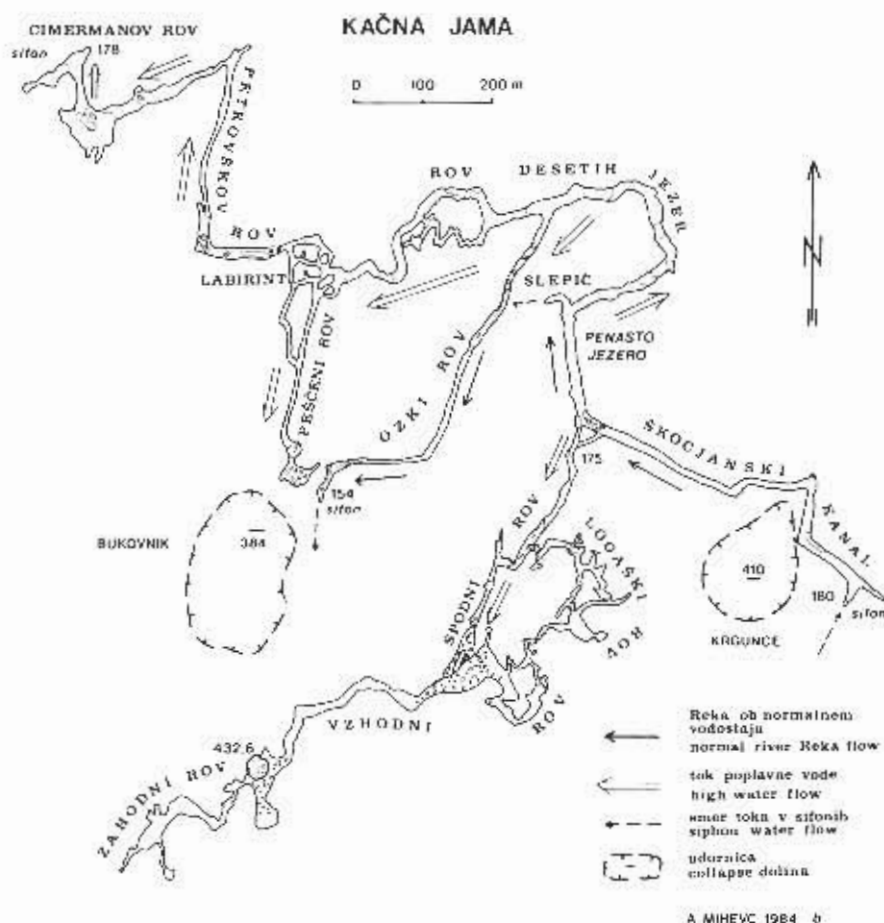


Fig. 14: Kačna Jama, plan. From Mihevc, 1984b

Studies of recent gravel in Škocjanske Jame and in Kačna Jama have shown that the share of limestone autochthonous pebbles increases by the distance and the share of flysch pebbles decreases for 8,5 % per 1 km of Reka flow. Thus theoretically 3 km downwater from Kačna Jama all the flysch pebbles would be grinded into sand (Kranjc, 1982).

Younger passages are oriented N-S or NNE-SSW, having bigger inclination and they are narrower and higher. Medium and low waters flow through them and they have smaller capacity. Flood water deposits in them floating material, sand and mud. They have their origin along tension fissures and the rock around is strongly crushed on some places. These channels frequently end by breakdowns.

Water conditions in particular cave parts during different hydrological conditions are not yet studied in detail. According to different traces, and way of gravel, sand, mud and floating wood sedimentation we can infer to permeability of particular conduits and to frequency and height of floods. Three main hydrological situations are distinguished in the cave.

During the medium water Reka flows into the cave through the inflow siphon 182 m a.s.l. across huge channel to the outflow siphon in Škocjanske Jame. In the distance from outflow siphon in Kačna Jama to the Timavo springs there are 30 km of unknown underground.

During the discharge increase the water in the channels rises very quickly as the permeability of lower channels is limited. Water starts to flood higher levels and the underground Reka flow extends to the extreme NW point of Kačna Jama. 20 m high water floods more than 4,5 km of the cave.

For 10-15 m Reka rises after each heavy rain already and for 50 m, according to traces in the cave, each year at least. The highest water till now was seen in 1895 by G. Žiberna (Marinitsch, 1896), it was about 90 m above the normal water table of Reka in Kacna Jama.

During extremely low waters when Reka sinks before Škocjanske Jame already its flow entirely avoids Kacna Jama. Just the filtered water, caught into lakes and some smaller tributaries with some liters per second is seen. During the lowest waters swallow-holes and ponors have opened in the bottom of riverbed, and there is no water for some ten meters under normal Reka water table. Obviously during the low waters Reka changes into hanging sinking stream.

Expressive seasonal temperature oscillations are characteristics for Kačna Jama and essential differences between passive and active passages.

In lower level the temperature corresponds to Reka temperature changes. The highest measured Reka temperature was 15°C, the lowest 3,5°C. The air temperatures in the passages near Reka were 14°C, 5°C respectively. The passages distant from Reka have smaller temperature oscillations in the span between 10° to 12°C.

Bigger temperature oscillations were observed in the cave's entrance part, as during the winter the temperature falls under 0° C on the bottom of 186 m deep entrance pothole.

The part of the cave where Reka flows at normal water conditions is the most polluted. In leeward parts of channels floating material is deposited.

After floods the ponds of caught smelling water and plastic objects remain all over the cave. In the extreme NW cave's part we have even found several lorries pneumatics transported from the surface through Škocjanske Jame (Mihevc, 1982).

Higher lying, periodically flooded channels are less polluted.

10. DIVAŠKA JAMA AND TRHLOVCA*

* Martin Knez, the description is entirely taken from R. Gospodanč, 1985a study.

Divaška Jama and Trhlovca take a special place in Divaški Kras as their accessible passages are lying 200 m above the flow the actual underground Reka. There are several different sediments in both caves, more flowstone generations and two groups of laminated loams, which are relatively stratigraphically dated to middle and upper Quaternary. Thirty meters thick brown laminated loams are interesting paleohydrologically, presumably they are of Mindel age, and red complex of flowstone and deposits from Riss glacial probably. It is supposed that the cave Trhlovca was active at the beginning of Pleistocene, Divaška Jama in older Pleistocene whereas the upper parts of Škocjanske Jame and Kačna Jama did not develop before medium, and lower channels of these caves in upper Pleistocene and Holocene. Terra rossa on the surface of Divaški Kras was probably formed in Mindel-Riss interglacial.

Wider area of Divaška Jama is built by micritic and sparitic limestones of Turonian age, the same as our part of Trieste-Komen anticlinorium, Reka synclinorium respectively. The beds dip for about 20° towards S and SW and near Lokva they pass into Paleocene limestones along Divaca fault. Treated beds are transversally jointed and broken but not crushed.

Accessible underground of Divaška Jama lies in bedded limestones which are in the first part of the cave inclined for 15 to 20° towards SW, and in the second part for the same degree towards S except in the channel where the narrow passage is parallel to ridge and almost parallel with faults oriented N-S. This relation to structure corresponds to upper visible parts of breakdown deformed accessible spaces between rocky bottom and floor covered by sediments and flowstones only. How filled up, lower parts of the cave correspond to structure is not yet known. The rocky profiles of Divaška Jama are nowhere entirely exposed therefore it is difficult to recognize the extension and form of rocks cavernosity.

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