original scientific paper

UDC 551.442(497.4 Dimnice)

THE CAVE ROCKY RELIEF OF THE DIMNICE CAVE

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ABSTRACT

The rocky relief cave passage surfaces helps to explain a complex genesis of a ponor cave. In this cave traces of the oldest water flow that had shaped the passages are preserved, the traces of faster streams flowing above the gravel and the water which shaped the rock surfaces as it flowed above the fine-grained sediments that filled up the cave. Today the water flow is found in the lower passage and the cave is shaped by the water that trickles down the walls of the entrance shaft and by the humidity due to strong air circulation. Slight weathering of the rock surfaces and flowstone is due to well-pronounced microclimatic conditions in this cave.

Key words: cave rocky relief, shape and development of karst caverns, the karst of Istria, Slovenia

INTRODUCTION

Describing speleological characteristics, I focused my attention on the central part of the cave and studied cave rocky relief in this part, as the other parts are of difficult access because of siphons. In Dimnice the cave rocky relief reveals several important periods of the cave development. I attempt to point out the characteristics of single cave features in the passages where the development was diverse. The origin of these features are described in detail elsewhere (Slabe, 1995).

Location and cave description

On the southern slopes of the flysch Brkini hills bordering the Materija karst lowland in the north, the waters join into a superficial network and at the contact with limestone, where blind valleys developed (Gams, 1962), disappear underground. At the end of the blind valley near Velike Loče, where two major streams and their tributaries from the area near Slivje to the west, Kovčice to the east and Sv. Štefan to the north join, the water sinks through several swallow-holes into the Dimnice cave; so far this is the longest explored cave of this lowland.

In front of the swallow-holes the stream is incised into older fluvial sediments, covering the bottom of the blind valley to a depth of about 5 m. To the north the floodplain above the limestone base gradually rises to the flysch slopes. Here and there the limestone is exposed on the surface in a narrow belt between the floodplain and the flysch background. The surface above the cave is 525 m a.s.l. at the lowest point, near the actual swallow-holes on the southern border of the blind valley; from there the limestone overlaying the cave rises westwards to a doline-pitted plateau, at about 580 m a.s.l. The cave passages explored so far are in their entirety accessible only to cave divers and they extend from below the blind valley to the elevation called Na Grižcah, which lies to the west of the entrance shafts being about 500 m north from Markovščina. The swallow-hole leading to the cave is not accessible as it is filled by breakdown boulders.

The area of contact karst consists mostly of the Cretaceous limestones; only in parts of the ponor and below the alluvial plain are there Paleogene Kozina limestones. The rock layers strike northwards and northeastwards, dipping by 30-60°, and make a part of the recumbent Materija anticline which is Dinarically trending and developed after deposition of the Eocene flysch beds (Pleničar, 1961, 95).

The cave (Figs. 1a and 1b) may be entered by steps cut into the sides of a shaft, 40 m deep; the cave consists of two levels. It reaches the surface also by another shaft above Male Dimnice.

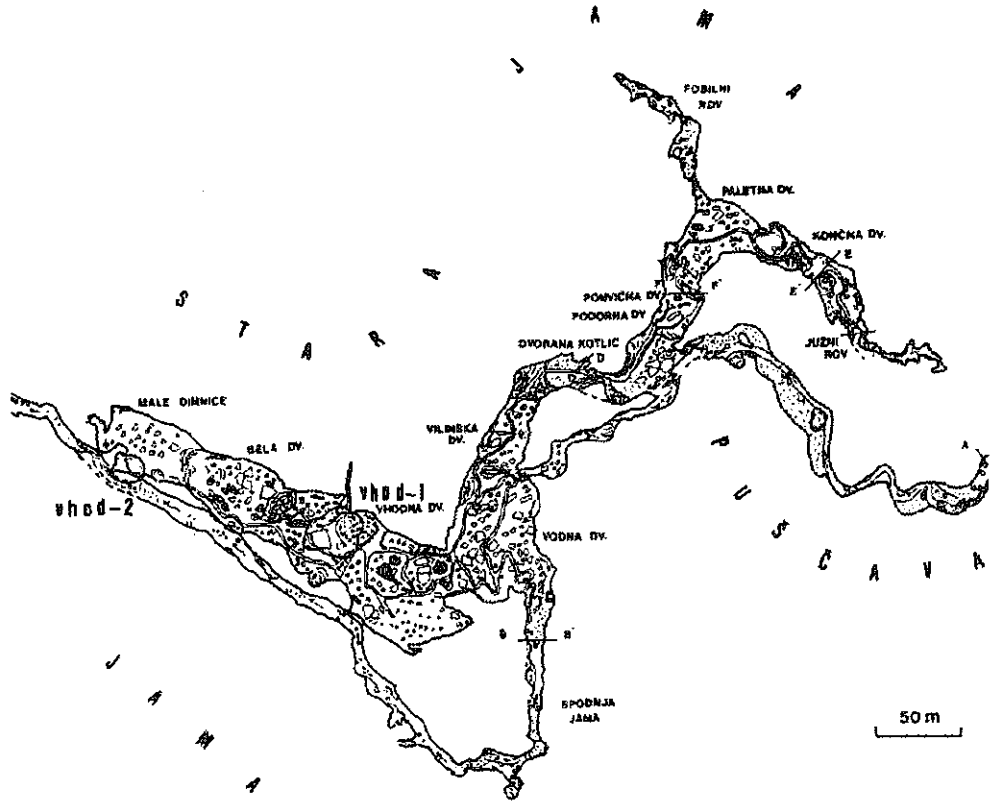

Fig 1a: The Dimnice cave plan.
Sl. 1a: Načrt Dimnic.

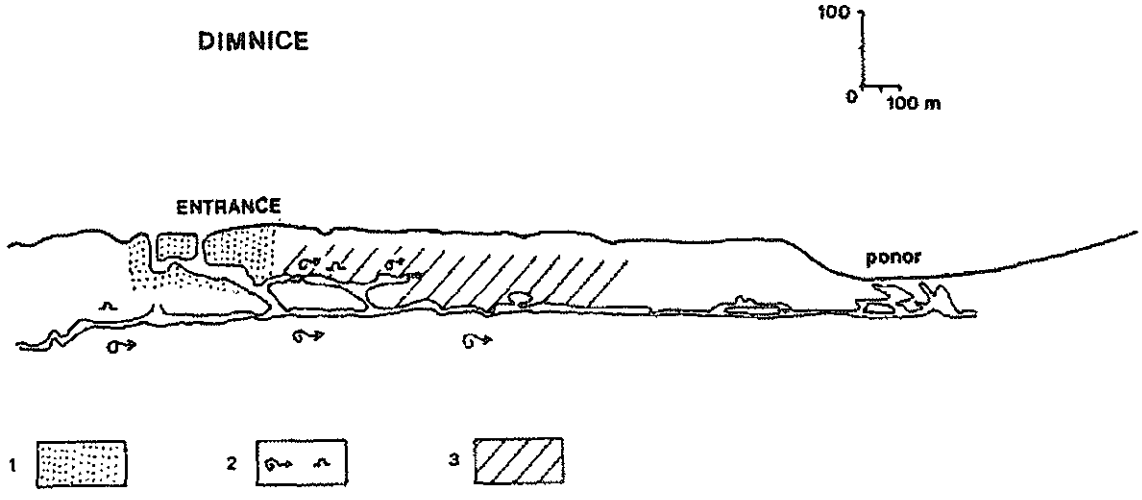

Fig. 1b: Longitudinal cross-section with rocky relief.
1. traces of water trickling down, moisture condensation and freezing,
2. traces of water flow,
3. along-sediment rocky features.
Sl. 1b: Vzdolžni prerez jame s skalnim reliefom.
1 sledi polzeče vode, kondenzacije vlage in zmrzali,
2 sledi vodnih tokov,
3 obnaplavinske skalne oblike.

Below the shaft, the upper dry passage opens. The biggest cave spaces are found just in the entrance part. Northwards the Vhodna Dvorana leads into Bela Dvorana, a 40 m wide and up to 20 m high chamber; it is separated from Male Dimnice only by speleothems; this is a 60 m long and 50 m wide passage from which the shaft leads to the surface. Eastwards the cave leads into the most spacious part of the upper level, Vodna Dvorana, 50 m wide and up to 30 m high; this chamber lowers eastwards to the contact of breakdown with the lower, active level. Northwards the passage is narrower and lower and it continues by Vilinska Dvorana, a 25 m wide and up to 15 m high chamber which lies 10 m above the level of the northern part of Vodna Dvorana. It is followed by Dvorana Kotlic, which is at first 15 m wide and of the same height and after an oxbow to the east it is only 3 m wide; the passage opens into Podorna Dvorana, a 30 m wide and 20 m high breakdown chamber; from there it lowers eastwards into a breakdown transverse where the lower level is reached for the second time. The chamber continues into Ponvična Dvorana and then Paletna Dvorana. Paletna Dvorana is 25 m wide and up to 10 m high. The main passage, 150 m long and 15 m high, runs south-eastwards, and is divided by flowstone into two chambers, called Kitajska Dvorana and Končna Dvorana, and from it branches off to Fosilni Rov, up to 10 m wide.

Through breakdown passages the lower level, where water flows, may be reached. Below Podorna Dvorana opens up the so-called Puščava, a passage 15 m wide and up to 20 m high that continues eastwards into a narrow passage called Thamesis; this one is separated by siphons into several parts. The right initial branch of the cave approaches the swallow-hole eastwards within 15 m, while the left branch collects water from several swallow-holes at the southern border of the blind valley. At the bottom of Vodna Dvorana lies Spodnja Jama; the water passage is 6 m wide and 2 m high downstream from the old water catchment. At first it leads southwards, and after 100 m it turns southwest. Between Puščava and Spodnja Jama there are collapse Dihalniki where water flows through breakdown boulders, and either stagnates or flows over cascades.

The upper level is about 500 m a.s.l. and is 2000 m long. In the entrance part of the cave the level of the larger chambers is some 10 to 20 m higher due to roof collapse and accumulation of breakdown boulders on the floor. The lower level, about 4000 m long, gradually descends westwards from the swallow-holes that are at 525 m a.s.l. to reach 430 m a.s.l. Particularly in the eastern part this level consists of two passages that are parallel at a vertical distance apart of 10 m and in several places connected by breakdowns. The upper passages of the cave below the swallow-holes are higher due to breakdowns.

The central part of the cave lies in the Upper Cretaceous Turonian and Cenomanian limestone. The beds dip towards northeast or north-northeast striking for 40-50°. The rock is densely fractured and fissured with prevailing NW-SE and NE-SW trends. The passages of the cave have the same direction. The levels connected by breakdown passages are parallel, indicating their origin along the same crushed zone of the rocks.

The rocky bottom is not seen as it is thickly covered by deposits transported into the cave and by breakdown boulders and rubble.

Loam covers the bottom and sometimes even gently sloping walls in Končna Dvorana, in Južni Rov that joins this chamber, and in Dvorana Kotlic on the upper level. Older loam may be traced also in cross-section of speleothems. At the lower level the loam is found on gently sloping walls in Puščava; at its bottom the stream flows over pebbles and they are found even 8 m above the actual river-bed. In Spodnja Jama also the stream flows over flysch pebbles, some of them are coated by carbonates and they are cemented into weakly consolidated conglomerate on the riverbank. Gravel is found in the upper level also. In Končna Dvorana it is seen in a hole at the north-west below the flood loam and in Južni Rov below the uncovered cross-section of fine-grained flood cover of the floor. Flysch pebbles are also along the flowstone that separates Končna Dvorana and Paletna Dvorana and on gently sloping walls of Fosilni Rov and Paletna Dvorana. Nadja Zupan Hajna (1994) studied the flood loams in Dimnice.

In the cave there are many flowstone cones and speleothems that divide otherwise uniform passage into several parts, large enough to be called chambers. In the lower level, old speleothems and flowstones are also preserved in a river-bed and now water flows through and above them.

A considerable part of the floor in the upper level, and in Dihalniki and Puščava of the lower level, is covered by breakdown blocks, in particular in sections that developed in more crushed rocks and are now higher due to breakdowns.

Due to distinctive breakdown, the rocky surface of the cave is also mostly shaped by collapses. Only the upper half of Južni Rov still bears a semicircular cross section with a distinctive corrosion notch below the ceiling. On the perimeter there are scallops. The rock surfaces shaped by water flow are also preserved in a part of the ceiling of Ponvična Dvorana and in Dvorana Kotlic. On the lower level there is a characteristic cross section due to water flow downcutting preserved in Vodni Rov and in the lower part of Puščava.

CAVE ROCKY RELIEF

Rocky features are to a large extent transformed by younger weathering and breakdown and partly covered by flowstone; the bottom of the cave is thickly covered

by sediments, breakdown rubble and larger blocks thus offering only a partial insight into speleogenetic phases. By the shape of the rocky perimeter one may distinguish:

a. rocky features due to fast water flow,
b. rocky features along the sediment,
c. breakdown due to weathering and collapse of the rocky perimeter,
d. traces of condensation corrosion and thin weathering of the rocky perimeter due to cave microclimate,
e. features due to water trickling down the walls of entrance shafts.

Rocky features due to a fast water flow

Scallops and ceiling pockets in the lower passage

Features due to a fast water flow on the lower level are traces of the youngest period of the cave development. The only exception is the wall above the river-bed in Puščava dissected by semicircular longitudinal notches. To the north-eastern side of the passage, some

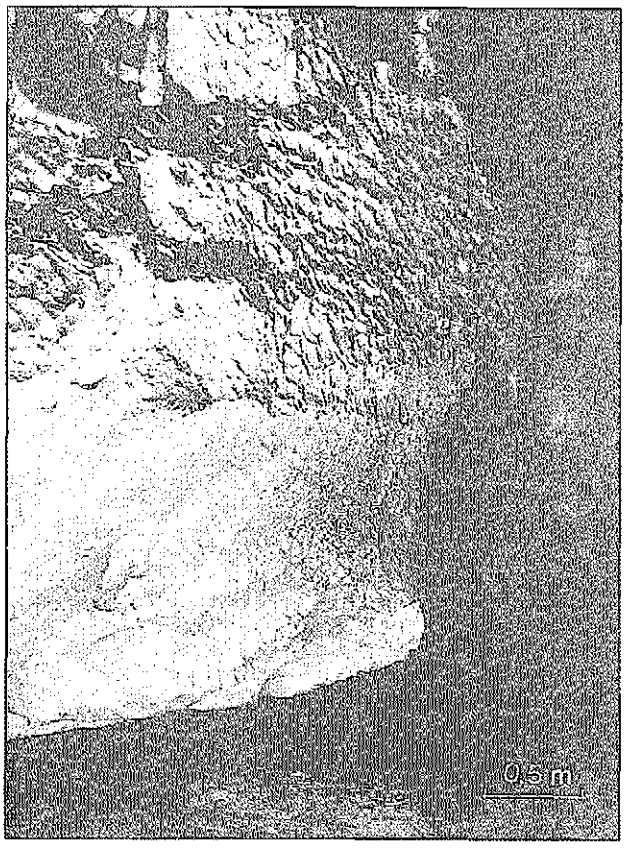

Fig. 2a: Scallops above the stream.
Sl. 2a: Fasete nad potokom.

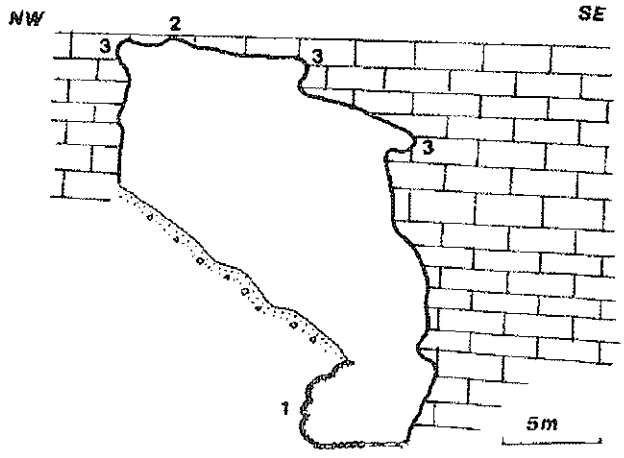

Fig. 2b: Cross-section of Puščava.
1. wall notches with scallops,
2. ceiling solution cup,
3. below-sediment wall notches.
Sl. 2b: Prečni prerez Puščave.
1. stenske zajede s fasetami,
2. stropna kotlica,
3. podnaplavinske stenske zajede.

20 m in front of the siphon, the river-bed is cut down deeper. The north-western perimeter of the river-bed is dissected into semicircular horizontal notches, about 1 m across, arranged in steps above the bed.

Scallops are on the walls of the river-bed. In the lower part they are smaller, from 30 to 50 mm across; higher up they are bigger, from 50 to 100 mm across. In narrow notches, about 0.15 m across, parallel to the water flow, wide flutes from 60 to 70 mm developed.

Similar distribution according to size is found everywhere in the river-bed of Puščava. In the middle of the passage there are scallops on the convex part of an oxbow (Figs. 2a, 2b) while on the other bank there is a gravel dam. Above the water flow of a medium discharge the scallops are 40 mm across, 2 m higher the diameter increases to 70 mm. About 0.1 m above the present water flow the longitudinal wall notch ends, and water flow shapes a new one. Water transports the gravel and deepens the river-bed.

Scallops are also on the rock perimeter and on rock blocks in the river-bed of Dihalniki. Above the water level of a medium water table their diameter is 50 mm; higher up, up to 5 m above the water level, the scallops are bigger, up to 100 mm across.

On the perimeter of Spodnja Jama (Fig. 3) the scallops are of the same size, being 50 mm across. The ceiling along the fissures is deepened into notches due to a typical turbulence of a slower water flow occurring when the passage is completely flooded. About 0.2 m above the level of the medium discharge the passage is indented into a new wall notch. There are potholes in

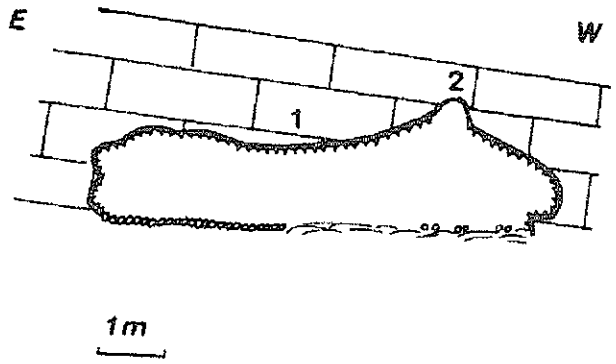

Fig. 3: Cross-section of Spodnja Jama.
1. scallops,
2. solution cup.
Sl. 3: Prečni prerez Spodnje jame.
1. fasete,
2. stropna kotlica.

the flowstone floor, 0.1 m across whirling small pebbles.

When flood water retreated from lower passages, water started to remove the loam and to cut into the older river-bed, covered by gravel.

The notches were uncovered due to changes in water level when the periods of downcutting into the rock bottom alternate with deposition and transport of gravel.

Bigger scallops preserved higher above the actual water level were excavated by a slower water flow. When there is a lot of water the passages are less permeable and the water flow consequently slower. Faster flows incise smaller scallops in the lower part of the river-bed. In Spodnja Jama the scallops are smaller over the whole perimeter due to smaller cross section of the passage; so the water flowed through the entire tube faster even when it was completely flooded.

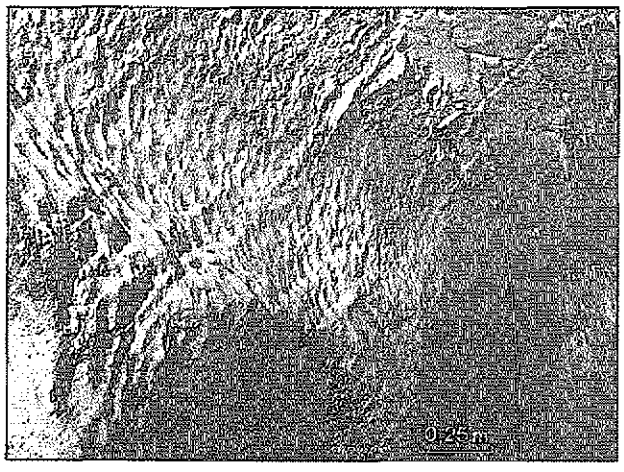

Fig. 4a: Old scallops in Južni Rov.
Sl. 4a: Stare fasete v Južnem rovu.

Today water is deepening its river-bed, removing gravel and downcutting into flowstone.

It is difficult to ascertain whether the flowstone in the river-bed had been deposited before the flood infill by fine-grained sediments or afterwards. The fact is that water pierced through the larger flowstone cones, and single speleothems are preserved in the middle of the water current; they were deposited at a time when the river-bed was dry.

Old rocky features due to water flow

On the perimeter of the upper old passages there are not many features left from the old water flow. Probably they are hidden below a thick cover of sediments; often they were removed by weathering of the rock perimeter or transformed by corrosion at the contact with flood loam.

Scallops, ceiling pockets and wall notches are the features due to fast water flow.

The scallops are best preserved (Figs. 4a, 4b) on the ceiling and on the eastern wall of Južni Rov where it joins Končna Dvorana. The size of scallops gets smaller upwards. The biggest, 50 or more mm across, are found at the lower part of the wall and also on a break-down block on the floor. In the central part of the wall the scallops are 30 mm across. The smallest are found in a semicircular notch on the upper part of the walls and on the roof; they are only 15 mm across.

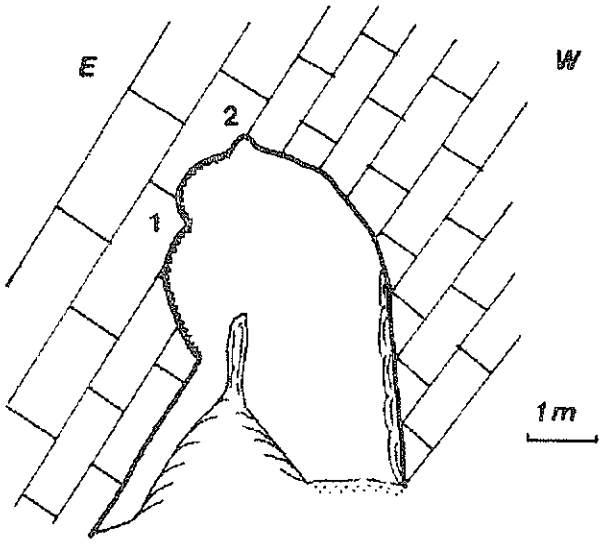

Fig. 4b: Cross-section of Južni Rov.
1. scallops,
2. above-sediment channel.
Sl. 4b: Prečni prerez Južnega rova.
1. fasete,
2. nadnaplavinski žleb.

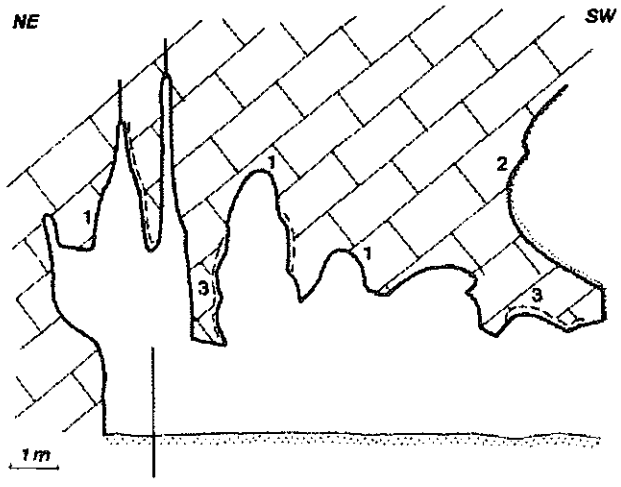

Fig. 5: Longitudinal section of Bar.
1. solution cups,
2. scallops,
3. above-sediment ceiling channels.
Sl. 5: Vzdolžni prerez Bara.
1. stropne kotlice,
2. fasete,
3. nadnaplavinski stropni žlebovi.

On the south-western wall of the Paletna Dvorana, close to the passage from Kitajska Dvorana, there are scallops in the wall of an overhang above the recent floor covered by flowstone. They are 30 mm across and partly blurred due to corrosion at the contact with loam infills in the passage. On the same wall the surface of a wall notch, which passes along the passage roof and has on the floor flysch pebbles coated by a thin layer of loam, is covered by scallops. These are 15 mm across; that is they are smaller than those at the lower part of the wall.

In the Fosilni Rov there is on part of the ceiling a network of not distinctive solution niches, 50 mm across. It seems that this is a part of the scalloped surface of a former water passage which was later reshaped due to corrosion above the loam infill and due to breakdowns. On the floor and even on the walls a small amount of flysch pebbles is preserved.

On the western side of Ponvična Dvorana there is a vault, about 2.5 m wide, incised into the roof. On the vaulted roof there are smaller scallops, 30 mm across.

A semicircular notch, about 3 m in diameter, in the south-western wall of Končna Dvorana, lying at the level of the southern passage, is probably a continuation of the same features due to the same water flow. But the surface of the wall notch was later transformed due to corrosion at the contact with loam.

In the lower part of the northern wall of Marmitna Dvorana is a relict of the best preserved water passage (Fig. 5) partly transformed below the loam deposits. The semicircular overhang Bar is 10 m long and 6 m wide, incised into the wall about 2 to 3 m above the passage floor; the whole north-eastern part of Marmitna Dvorana is covered by loam.

The upper parts of wall and roof of the overhang consist of big solution cups, up to 1 m wide and up to 2 m deep. Most of them developed along the fissures; the character of fissure influenced the shape of solution cup. Along distinctively vertical or only slightly inclined fissures, some deeper solution cups, narrowing downwards, developed. Along thinner fissures there are shallow solution cups of semicircular cross-section; some are composite, inside a larger one there is another one or several smaller ones. Solution cups that were not controlled by fissures are the most shallow. The solution cups are due to turbulent water flow in a leeward side of a wall notch where the rock was easily dissolved along a fissure. Due to the diversity of thin fractures the efficiency of downcutting was different and composite solution cups developed. It seems that the deepening and conical narrowing of deep solution cups was controlled by water disappearing through a fissure. On the outer surface of the overhang there are smaller scallops due to fast water flow, about 30 mm across.

There are two periods of old rocky features due to fast water flow. It may be concluded that different sizes of scallops on the upper part of the rim which are diminishing toward the ceiling are controlled by different water flow velocities. The rock type of the surface that also affects the size and shape of scallops, does not change in a cross-section of this passage. Such a case exists in Južni Rov of Končna Dvorana and in Paletna Dvorana. Also in the vaulted roof of Ponvična Dvorana there are small scallops preserved. Gravel remains in many places, also above older flowstone. One may suppose that water filled the passage with gravel and by diminishing its diameter the velocity of flow increased. This is a swallow-cave and water easily transported gravel into it. Horizontal wall notches in Južni Rov clearly mark the levels of gravel infill above which the water used to flow.

Solution cups and scallops in Bar and on the lower part of the wall in Paletna Dvorana are traces of older water flow that used to flow in lower parts of the passage which was at the time of formation of the upper part covered by gravel. The scallops and solution cups in Bar developed at the same time. The scallops are due to water flow strongly washing the exposed parts of the wall, and on the leeward side of a niche bigger local whirls developed, shaping solution cups.

Along-sediment rocky features

Prevailing traces in rock surface of the cave are due to water flow above the flood loam and to rock weathering at the contact with loam. They are found on both

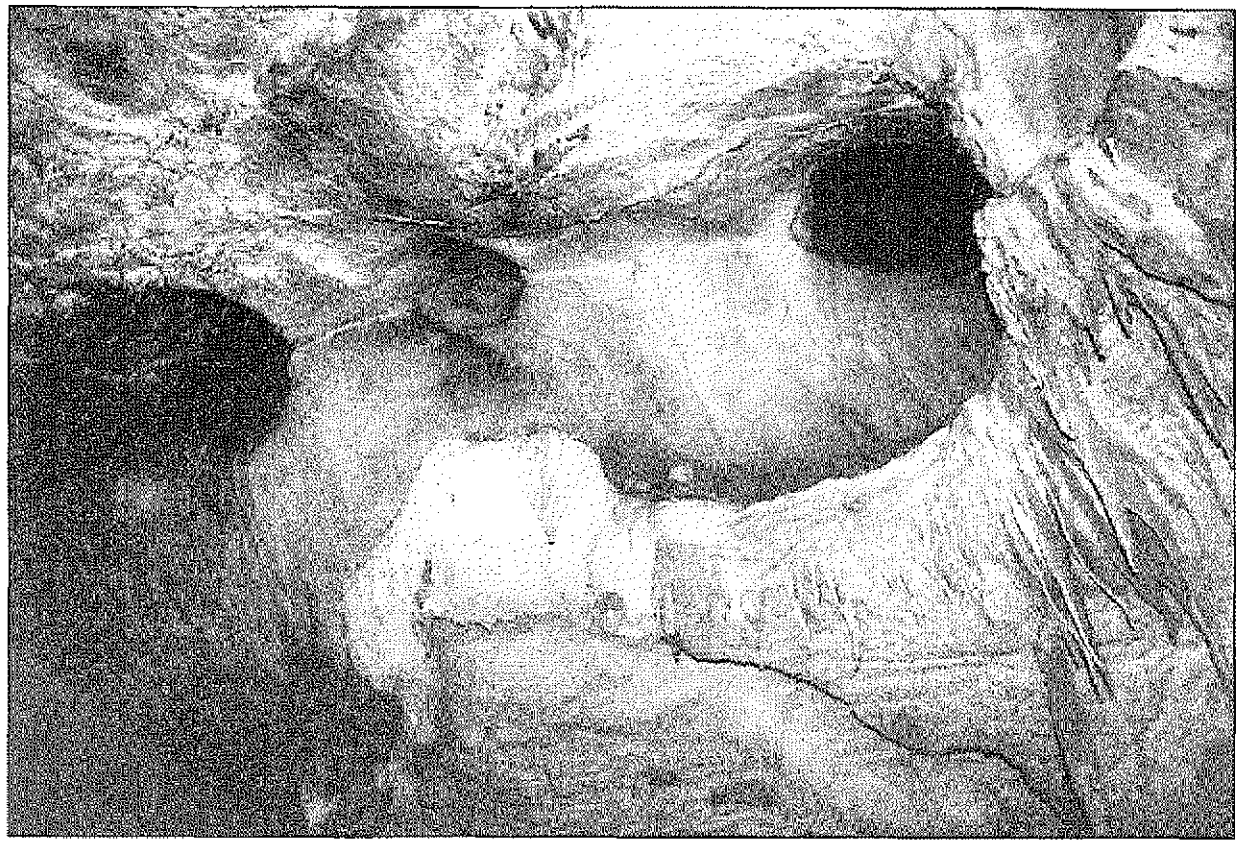

Fig. 6: Solution cups in Ponvična Dvorana.
Sl. 6: Stropne kotlice v Ponvični dvorani.

levels where walls and ceiling have not been transformed by later breakdowns and water flow.

Traces of slow water flow above the loam sediments in the passages

On the ceiling and upper parts of the walls above the loam sediments solution cups and large scallops, as well as water level horizons, are evidence for a slow water flow.

In the upper level of the cave solution cups are preserved in Končna Dvorana, in Paletna Dvorana near the passage from Kitajska Dvorana, in Ponvična Dvorana, in Dvorana Kotlic and in Vilinska Dvorana and also on the roof of the overhang in the south-western part of Male Dimnice. In the lower level they are found only in a high passage called Puščava.

Solution cups may be divided into two types:

1. semi-circular solution cups, 0.5 to 1 m across, are individual and developed along non-distinctive fissures. In relation to their diameter these solution cups are shallow. Some of them are composite. In a bigger solution cup there may be one or more smaller ones; this is controlled by the character of the fissure where they developed.

2. Solution cups of ellipsoidal openings (Fig. 6), narrowing downwards like a cone, developed along well-pronounced fissures. Their longer diameter is 0.5 to 1 m. It is typical that their depth is greater than the diameter of the opening. Often they appear in a series along a fissure or they are combined into acomposite solution cup of an undulatory cross-section. Ceiling cups developed in a water-filled passage with a slow water flow that dissolved and whirled along the fissures. It seems that they were deepened by a mixture corrosion as water may suck the water from fissures. The axes of cups are differently inclined depending on the fissure character and water turbulence.

At the place where Končni Rov joins Končna Dvorana there are big scallops, 0.3 m in diameter, incised into the roof and northern wall. Similar scallops are found on the roof of a narrower, the north-eastern part of Dvorana Kotlic. In the narrower part of the passage the water flow above the loam sediments was slightly faster and it shaped scallops.

Below-sediment notches (Fig. 7) along the wall developed at the time when the passage was for a longer period filled by loam and water flowed above it; they are preserved in Ponvična Dvorana where there are, in the south-eastern part of the passage, two parallel notches below the roof; in the north-western part of the passage there is a lower notch showing that the level of deposits changed. Also in Puščava there are two well-preserved wall notches 3 m below the ceiling on both sides of the passage.

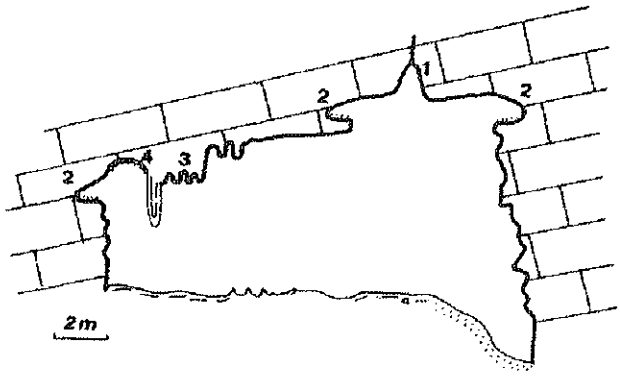

Fig. 7: Cross-section of Ponvična Dvorana.
1. solution cup,
2. below-sediment wall notch,
3. above-sediment ceiling channels,
4. scallops.
Sl. 7: Prečni prerez Ponvične dvorane.
1. stropna kotlica,
2. podnaplavinska stenska zajeda,
3. nadnaplavinski stropni žlebovi,
4. fasete.

Above-sediment ceiling and wall channels and anastomoses

About the anastomoses network in Paletna Dvorana (Fig. 8) I wrote in Acta Carsologica (Slabe, 1987).

In the north-eastern part of Ponvična Dvorana there are bigger ceiling channels, up to 1 m deep; most of them have omega-shaped cross-section. On flat bulge ends with square cross-section, 1 m across, lying between big channels, there are smaller channels, 20-30 mm across.

In the ceiling of a semi-circular notch in the south-south-western wall of Končna Dvorana there is two square meters of branching network with 50 to 100 mm wide channels with margin outflow channels directed downwards.

In Južni Rov near Končna Dvorana there are ceiling channels, 0.15 m wide and 50 mm deep, incised into scallops forming a smaller anastomosis network.

In Bar there are ceiling and wall channels, 50 mm across, even between the already mentioned solution cups and within them. This passage was filled by loam up to the roof and when flood water was flowing away it penetrated below the overhang and incised into the rock, outflow channels and flutes at the contact with loam. A part of water came through the fissures in solution cups at the final part of Bar; channels are seen in flanks of solution cups.

In the north-western part of Kitajska Dvorana there is in the north-north-eastern overhanging wall striking for 55°, a dense network of above-sediment wall channels. They are 20 to 50 mm wide and 0.1 m deep. Between the bends of incised channels there are conical wall pendants. A network of channels incised deeper into the overhanging wall is a transitional feature between the channels where water trickled down over vertical or inclined wall and ceiling channels and a branching network which develops in the overhanging of a local flood zone.

The features developing at the contact with loam infills are found on southern and north-western marginal parts of the Vodna Dvorana roof, on an overhang, close to the bottom at the northern part of Male Dimnice and also on walls and breakdown blocks in the passages between the levels.

Below-sediment channels are found on the walls of Puščava and Dihalniki in the lower level and they reach up to the river-bed where they are partly reshaped by a water flow.

In short, a branching network of anastomoses and channels are found on ceiling of lower passages and overhangs, and wall channels on gentle, vertical or overhanging walls of passages, but all of them below the level of a former loam infill.

The upper part of the wall which was in contact with loam is weathered.

In Južni Rov there are semicircular below-sediment notches on walls, 5-20 mm across. They are either independent or combined into a hollow of irregular shape. They too are due to corrosion below humid loam sediments.

On the south-eastern overhanging wall of Vodna Dvorana there are above-sediment solution cups along fissures which allowed the contact of fine-grained sediments and water.

In wet periods larger amounts of rain at the surface caused flooding underground and deposition of loam into passages. Water flowed through upper parts of the passages above the consolidated loam. When the floods retreated, water reached the contact of loam and rock. As shown by the shape of rocky surface in breakdown traverses, the levels were associated in a united system during floods. A similar vertical distribution of features as this appearing on the perimeter of passages of both levels is due to different flood and loam levels in the cave. Below the present lower passages there must be still lower passages; this is indicated by wall above-sediment channels preserved close to the present water flow.

Traces of weathering and breakdown of rock perimeter

The rock surface of the modern cave was mostly formed by weathering and breakdown; the only exception are rare traces of water flow.

In the cave one may observe breakdown according

to shape - block, slab, chip, plate and roof-fall.

Stone and boulder falls, rubble and blocks remained on the floor of the passages. Below faults, as for example such as those between Paletna Dvorana and Fosilni Rov and below Vhodno Brezno, block piles are preserved.

The features on the rocky perimeter evidence the time sequence of weathering and breakdown processes. They are divided into a period before the flood filled the passages with loam and a younger period when the passages were mostly empty. More evidence for the first period exists. A good example of passage formation along the bedding-plane is the north-western overhanging wall between Končna and Paletna Dvorana. The wall is intersected with below-sediment channels. Next to traverse from Kitajska to Paletna Dvorana there are above-sediment anastomoses on a break-down block, fallen from the scalloped wall. At prominent faults there are two breakdown squeezes between the levels and entrance shafts.

The stable arched roofs of Vodna and Vhodna Dvorana and Male Dimnice are the results of younger weathering and breakdown of a rocky perimeter. On vaulted roofs there are no signs of loam fills.

Due to the accelerated weathering and breakdown of rock perimeter in all the periods of cave's genesis the spaces became larger, the passages were moved upwards due to breakdowns and entrance shafts appeared.

Rock features due to microclimatic properties of the cave

The Dimnice cave represents a special speleoclimatic type of cave. This is a system of two, unequally deep interconnected shafts and horizontal passages. When the air outside is cooler than inside, the cold air enters through a deeper shaft, warms up underground and rises through the nearby shaft together with the air from horizontal passages. When warmer air from the shaft reaches the surface, mist appears if the atmosphere is humid (Gams, 1972, 35).

Habič (1985) observed the results of dynamic microclimatic factors in the cave. Due to the abundant exchange of cave air with external air, the influence of condensation corrosion is strongly seen on weathered speleothems. During the winter the condensed moisture even freezes. Condensation zone may be recognised in typical changes on speleothems far inside the cave, even in parts where there is no freezing. In general the external climatic influences are felt only in the entrance parts of the cave.

Features due to microclimatic processes in the cave may be divided into traces of condensation moisture, and collapses as the rocky perimeter weathered because of moisture freezing on the walls.

I explained the conditions relating to condensation moisture on the walls and its effects in the case of Komarjev Rov in more detail elsewhere (Slabe, 1988). Condensation moisture also affects rocks and flowstone in some parts of perimeter in Vodna and Vhodna Dvorana and in Male Dimnice.

Fig. 8: Anastomoses in Paletna Dvorana.
Sl. 8: Anastomoze v Paletni dvorani.

The intrusions of winter cold air through the entrance shaft may cause freezing of moisture in the entrance parts of the cave; most of the humidity is in fissures so the weathering of rock surface and flowstone is accelerated. The weathering is still a slow process and usually only smaller pieces of rocks are broken down.

Features due to water trickling down the walls of the entrance shafts

After percolating through the cave roof the saturated water may deposit flowstone when it reaches the cave, forming typical features. The best traces of aggressive trickling water are seen on the southern side of Vhodno Brezno where there are narrow and shallow flutes on vertical part of the wall and on the ceiling of the overhang some 10 mm long roof pendants from which water

falls in small drops. Similar features exist also on the northern wall of Male Dimnice.

THE IMPORTANCE OF ROCK FEATURES IN STUDYING THE SPELEOGENESIS OF DIMNICE

The rock surface of Dimnice cave may explain the periods and factors that led to its present appearance.

In relatively diverse climatic and hydrologic conditions in the Pleistocene the water from the flysch recharge area was sinking underground, downcutting into flysch landscape and creating a cave system on several levels. The periods of water level lowering and karstification alternated with floods and sediment deposition.

The oldest preserved features in the rocky perimeter of the upper level are traces of a fast water flow. At first scallops and solution cups on the lower part of the perimeter appeared. Scallops on the upper part developed when water again started to flow above the gravel sediments. The lower levels were already developed at that time as there are remains of gravel in the traverse from Kitajska Dvorana into Paletna Dvorana preserved above the flowstone and breakdown rubble which cover the rock bottom of the passage. Caves are filled with sediments in cold climatic periods (Kranjc, 1981, 77) and in one such period the water started to flow again through passages transformed by breakdowns. The former passages could probably be compared with the present in the initial part of Spodnja Jama; the latter is, however, in the phase of the river-bed deepening and the gravel is already transported out of the cave.

Most of the rock perimeter was later transformed by weathering and break-down. I attribute the breakdown connections between Podorna Dvorana and Puščava, and Vodna Dvorana and Spodnja jama, and Dihalniki, and the origin of entrance shafts which connected the cave with the surface, to the period before the passages were flooded. Older weathering and breakdown of the rocky perimeter before the last prominent flood infill of the cave with fine-grained sediments belongs, it seems, to the last Würm stadial. A distinctive weathering at the surface and underground was mentioned also by Gospodarič (1985, 27) as a result of very low temperatures at that time when the entrance shafts probably opened.

Climatic changes caused several floods and the cave was filled up by loam, leaving only some space for water to flow below the roof. When the floods retreated, the lower passages were emptied of loam first and water that remained above the loam flowed downwards at the contact of rock and loam. According to the distribution of rocky features I infer that the two levels of the cave were already connected at the time of high floods. Water that flowed before the floods in the present low or even lower passage filled lower and upper parts of the cave during high floods. Traces of water flow above loam fill are seen in the lower and upper parts of the cave. Traces of water trickling down at the contact of loam and rock are seen in the present river-bed. It seems that above-sediment rocky features developed at the time of the Upper Würm and Postglacial flooding. Younger loam fills are mentioned by Gospodarič (1976, 100, 112; 1982, 191) as appearing in other parts of our karst also.

In the Holocene, sediments were removed and deposition of flowstone and breakdown of speleothems started (Gospodarič, 1976, 81; Table 2); in the first place the loam was transported out of the cave and water flow started to incise into the gravel and flowstone and breakdown blocks that cover the floor of the lower level.

Most prominent is the younger weathering and breakdown of the rock surface in Vodna, Vhodna and Bela Dvorana and in Male Dimnice. The roof in these biggest spaces of the cave system is dome vaulted.

Weathering of rock surfaces and flowstone due to condensation corrosion, weathering of the rock surface due to freezing and trickling of aggressive water down the walls of shafts are the youngest processes of cave formation in the upper level.

Tadej SLABE: THE CAVE ROCKY RELIEF OF THE DIMNICE CAVE, 103-114

SKALNI RELIEF DIMNIC

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POVZETEK

Na južnem pobočju flišnih Brkinov, ki na severu obrobljajo kraško Matarsko podolje, se vode zbirajo v površinsko mrežo in na stiku z apnencem, kjer so nastale slepe doline, ponikajo v kraško podzemlje. Na koncu slepe doline pri Velikih Ločah, kamor se stekajo vode iz dveh večjih potokov s pritoki z območja med Slivjem na zahodu, Kovčicam na vzhodu in Sv. Štefanom na severu, skozi več ponorov ponikajo v jamo Dimnice, ki je doslej najdaljša raziskana jama v podolju.

Ponikalnica je pred ponori 5 metrov globoko vrezana v starejše rečne naplavine, ki prekrivajo dno slepe doline. Naplavinska ravnica, ki je na apnenčasti podlagi, se proti severu polagoma dviguje v flišna pobočja. Ponekod se apnenčasta podlaga pokaže na površju še v ozkem pasu med aluvialno naplavino in flišnim zaledjem. Površje nad jamo je torej najnižje s 525 metri nadmorske višine pri današnjih ponorih na južnem robu slepe doline, od koder se proti zahodu apnenčasti obod nad jamo dvigne na 580 metrov nadmorske višine v vrtačasti plato. Rovi doslej raziskane jame, ki so v celoti dostopni le potapljaško spretnim jamarjem, segajo izpod dna slepe doline do vzpetine Na grižcah, zahodno od vhodnih brezen, 500 metrov severno od Markovščine. Jamski ponor ni prehoden, saj ga zapolnjuje podorno skalovje.

Po skalnem reliefu Dimnic predpostavljam obdobja in njih dejavnike, ki so bili odločilni za današnjo jamsko podobo.

V razmeroma pestrih klimatskih in hidroloških razmerah v pleistocenu se je voda, ki se je stekala s flišnega zaledja in ponikala v apnenec, vrezovala v flišni rob in ustvarila večnadstropni jamski splet. Obdobja nižanja vodne gladine in zakrasevanja so se menjavala z obdobji poplavljanja in nanosov naplavin.

Najstarejše ohranjene oblike na skalnem obodu zgornjega nadstropja so sledi hitrega vodnega toka. Najprej so nastale fasete in kotlice na spodnjem delu oboda. Fasete na zgornjem delu oboda pa so nastale, ko se je nad prodno naplavino skozi rov ponovno začel pretakati vodni tok. Vodni tok si je pred tem že oblikoval spodnje rove, saj so ostanki prodnega nanosa na prehodu iz Kitajske v Paletno dvorano ohranjeni tudi nad sigo in podornim gruščem, ki prekrivata skalno dno rova. Zapolnjevanje jam z naplavinami je značilnost hladnih klimatskih obdobij (Kranjc 1981, 77) in v enem takih so skozi deloma že podorno preoblikovane rove zopet začeli teči vodni tokovi. Takratne rove bi verjetno lahko primerjali z današnjo podobo začetnega dela Spodnje jame, le da je slednja že v obdobju poglabljanja vodnega korita in tako odnašanja proda iz rova.

Večina skalnega oboda se je nato preoblikovala zaradi razpadanja in podiranja in zaobljene oblike vodnih rovov so le redki odseki med oglatimi površinami odlomov. Tudi podorne povezave med Podorno dvorano in Puščavo ter Vodno dvorano in Spodnjo jamo ter Dihalniki in nastanek vhodnih brezen, ki so jamo klimatsko povezala s površjem, pripisujem obdobju pred poplavnim zalivanjem rovov. Starejše razpadanje in podiranje skalnega oboda pred zadnjo izrazito poplavno zapolnitvijo jame z drobnozrnatim sedimentom je, kot kaže, iz obdobja zadnjega würmskega stadiala. Izrazito razpadanje tako na površju kot v podzemlju je omenjal tudi Gospodarič (1985, 27) kot posledice zelo nizkih temperatur tega obdobja. Takrat so se verjetno odprla tudi vhodna brezna.

Klimatske spremembe so povzročile večkratne poplave, ki so jamo zapolnile z ilovico, le pod stropom se je nad njo pretakala voda. V obdobjih umika poplav so se najprej izpraznili spodnji rovi, in voda, ki je obvisela nad ilovico, je odtekala navzdol ob stiku kamnine in ilovice. Po razporeditvi skalnih oblik sklepam o povezanosti jame v času poplav. Voda, ki se je pred poplavo pretakala v današnjem spodnjem ali celo nižjem rovu, je ob visokih poplavah z ilovico zapolnila spodnje in zgornje dele jame. Sledi pretakanja nad ilovnato zapolnitvijo jame se namreč ponovijo v obeh nadstropjih. Sledi polzenja vode ob stiku ilovice in kamnine pa segajo vse do današnjega vodnega korita. Nadnaplavinske skalne oblike so, kot kaže, nastale v času zgornjewürmskega in postglacialnega poplavljanja. Mlajše ilovnate zapolnitve omenja Gospodarič (1976, 100, 112; 1982, 191) tudi v drugih delih našega krasa.

V holocenu, za katerega je značilno izpiranje naplavin, odlaganje sige, podiranje kapnikov (Gospodarič 1976, 81; tabela 2), pa je bila najprej iz jame odnešena ilovica in vodni tok se je začel vrezovati v prodno nasipino in sigo ter podorne bloke, ki prekrivajo tla spodnjega nadstropja.

Najbolj izrazito je mlajše razpadanje in podiranje oboda v Vodni, Vhodni in Beli dvorani ter v Malih Dimnicah. Strop v teh največjih prostorih jamskega sistema se je kupolasto obokal.

Preperevanje skalne površine in sige zaradi kondenzne korozije, razpadanje skalnega oboda zaradi zmrzovanja vlage in polzenje korozijsko agresivne vode po stenah brezen so najmlajši procesi jamskega preoblikovanja v zgornjem nadstropju.

Ključne besede: jamski skalni relief, oblikovanje in razvoj kraških votlin, Istrski kras, Slovenija

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