ACTA CARSOLOGICA	XXVI/2	25	279-293	LJUBLJANA 1997

MEDJAME (SAMOBORSKO GORJE, CROATIA) - AN EXAMPLE OF SPELEOLOGICAL FEATURES FORMED IN UPPER TRIASSIC DOLOMITE

MEDJAME (SAMOBORSKO GORJE, HRVAŠKA) - PRIMER SPELEOLOŠKIH POJAVOV V ZGORNJETRIASNEM DOLOMITU

NENAD BUZJAK[1]

Izvleček UDK 551.44(497.5)

Nenad Buzjak: Medjame (Samoborsko gorje, Hrvaška) - primer speleoloških pojavov v zgornjetriasnem dolomitu

V Samoborskem gorju (SZ Hrvaška), na planoti Medjame, so speleološki pojavi v različnih razvojnih fazah, v triasnih in miocenskih kamninah. Deloma ali v celoti so zapolnjeni s podornim materialom. Ob vhodih in v podzemlju je opazno grezanje, povezano z rapokami. Okoli 500 m SZ od Medjam ponika potok Podzvir. Na dan pride v vznožju planote Medjame, na stiku neprepustnih spodnjetriasnih plasti in zgornjetriasnega dolomita.

Ključne besede: speleomorfologija, speleogeneza, kompleksne speleološke oblike, podor, onesnaženost, Hrvaška, Samoborsko gorje, planota Medjame.

Abstract UDC 551.44(497.5)

Nenad Buzjak: Medjame (Samoborsko gorje, Croatia) - an example of speleological features formed in Upper Triassic dolomite

The speleological phenomena in Samoborsko gorje (NW Croatia, Medjame plateau) are in Triassic and Miocene rocks. They are in different stages of development. They are partially or completely filled with falling rocks. Along entrances and underground there are subsidences that suggest the presence of fissures. About 500 m NW of Medjame area, the Podzvir stream sinks. It reappears at the foot of the Medjame plateau on the contact of impermeable Lower Triassic beds and Upper Triassic dolomite.

Key words: speleomorphology, speleogenesis, complex speleological features, breakdown, pollution, Croatia, Samoborsko gorje hills, Medjame plateau.

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INTRODUCTION

Samoborsko Gorje is a northeastern part of Žumberačka Gora mountain in north-west Croatia. It is a hilly fluviokarstic area with many exo- and endokarst features (dolines, uvalas, blind valleys, caves, pits) and hydrological features (karst springs, sinking streams).

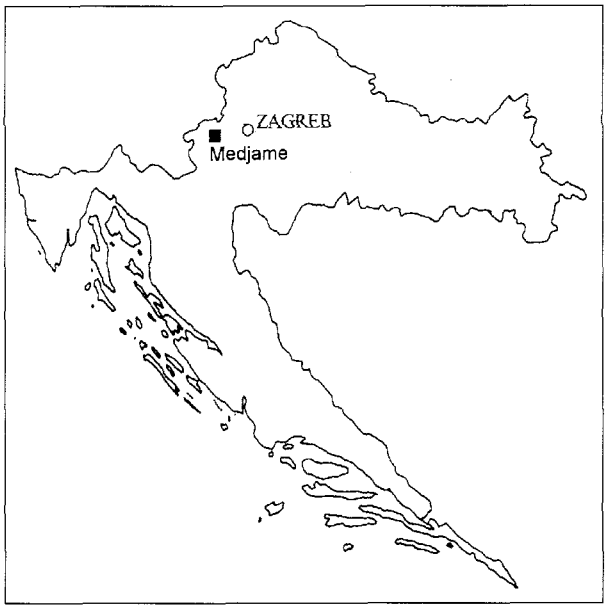

Fig. 1: Position map of the Medjame plateau.

The Medjame area is located between the villages of Dubrava and Rešetari near the town of Samobor, about 25 km NW from Zagreb (Fig. 1). It is a small karst plateau intersected by fissures along which entrances to five underground cavities of different dimensions were opened by breakdown. About 500 m NW from Medjame, the Podzvir creek sinks. After 500 m of underground flow its water rises at Podzvir cave at the foot of the Medjame plateau.

FORMER INVESTIGATIONS

Medjame was for the first time described by N. Reizer in his article about karst relief of Samoborsko Gorje. He describes three shafts (he also uses term "cave", probably because he noticed that their length is bigger than depth) which were originated by widening of fissures due to sinking of precipitation water from the surface. Therefore breakdown occures along the passages. Reizer classes these features as dry fissure caves. He also describes Podzvir cave, which he classes among caves developed by the activity of underground streams (Reizer 1911).

In 1933 J. Poljak described Podzvir cave in detail and published its plan. He classes it with geologically younger caves formed along a fissure (which was additionally widened by neotectonic movements) by an underground stream (Poljak 1933).

In 1950 Z. Dugački published the first sketch of the Medjame plateau. Its speleological features he considered a result of karst erosion and breakdown. He also described Podzvir cave as one originated due to the activity of an underground stream at the contact of Upper Triassic dolomite and impermeable Lower Triassic slate (Dugački 1950).

After Z. Dugački, these features were investigated in the 1970s and 1980s by cavers from Samobor and Zagreb, but they did not publish their results. New investigations made during 1995 and 1996 give new data about its genesis.

GEOLOGICAL AND HYDROGEOLOGICAL SITUATION

Many authors have written about relief, geological and hydrogeological conditions in Žumberačka Gora mountain and Samoborsko Gorje (Gorjanović-Kramberger 1894; Herak 1956; Herak et al. 1969; Prelogović 1970; Šikić & Prelogović 1970; Šikić et al. 1979; Šuklje 1938).

According to classification of relief in Croatia, Žumberačka Gora mountain was classed as a faulted-folded massive of Mesozoic folding of heterogeneous type (Bognar 1980). Its heterogeneity is conditioned by complexity of its geological constitution and tectonic structure. Investigated area of Samoborsko Gorje is a part of a tectonic unit, the Žumberačko-Medvednička nappe (built of Triassic, Jurassic and Cretaceous sediments), which was napped over autochthonous Paleozoic beds of eastern part of Žumberačka Gora mountain during the Sava orogenetic phase. This nappe was by additional movements divided into smaller structural units. In Samoborsko Gorje there are fault systems of NE-SW, NW-SE and N-S directions (Šikić et al. 1979).

Although on impermeable Paleozoic base in places crops out due to neotectonic movements and exsogenic modelling (Bognar 1980), fluviokarst relief predominates in the Samoborsko Gorje area, since most of its surface is covered by karstifiable rocks - Upper Triassic dolomite, Jurassic, Cretaceous and Miocene Lithotamnium limestone.

The Medjame area is built of Upper Triassic dolomite which, as the part of the above-mentioned nappe dominating in constitution of this part of Samoborsko gorje, covers impermeable Lower Triassic beds (clastites). The dolomite is of massive structure, unobservable stratification and low $CaCO_3$ content - less than 10% (Šikić et al. 1979). At some places (particularly in researched features) it is very fragile and crumbly, so dolomitic sand, rock debris and blocks often occur. Nevertheless, its karstification is, along with other relevant factors, accelerated owing to numerous fissures which intersect it. The southern edge of the Medjame plateau is a fault of NW-SE direction, along which the valley of Podzvir creek was formed. Its bed was, owing to fluvial erosion, cut into less resistent dolomite to the impermeable base. On the Medjame plateau fissures of NE-SW, NW-SE and N-S directions occur. It is supposed that its

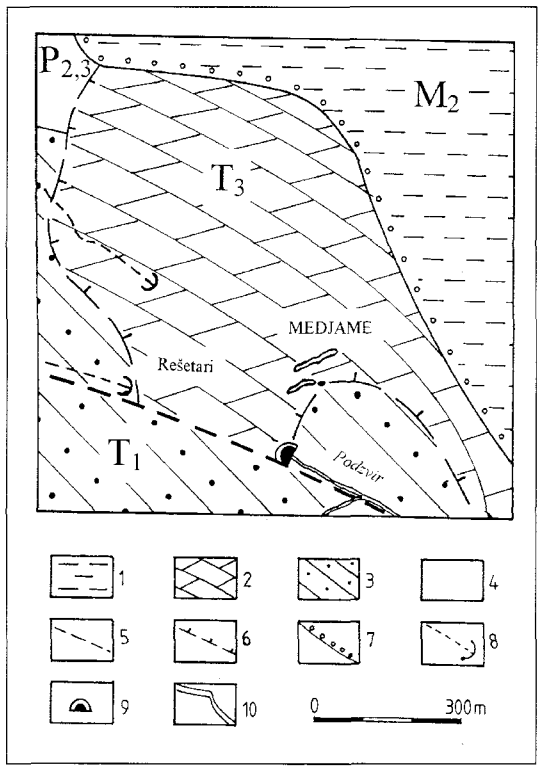

Fig. 2: Geological map: 1-Miocene Lithotamnium limestone, 2-Upper Triassic dolomite, 3-Lower Triassic beds (clastites and carbonates), 4-Middle and Upper Permian beds (clastites), 5-fault, 6-front of nappe, 7-front of transgression, 8-ponor, 9-cave, 10-creek.

origin is connected with tectonic movements on the abovementioned fault. Along them were developed the investigated speleological features (Fig. 2).

Due to the small thickness of karstifiable rocks, the depth of karstification is also small. Underground water flow is directed along the contact between permeable Upper Triassic dolomite beds and impermeable Lower Triassic beds at which the Podzvir spring cave occurs (Dugački 1950).

SPELEOMORPHOLOGY

On the Medjame plateau five speleological features of similar origin and morphology occur (Fig. 3). They mostly consist of one main passage of fissure cross-section without any longer branching passages. Its extension corresponds to extending of fissures which initiated its origin. Long and narrow entrances are result of ceiling breakdown along passages, which had a big part in the development of all investigated features.

The largest among them is called Duga Jama, entrance of which is 95 m long. According to results of investigation by cavers from Samobor and Zagreb, its branching passages are over 100 m long and 15 to 20 m deep. During their researches and specially today it was filled in by falling rocks and waste in most parts, so it was impossible to measure true dimensions. Its ceiling is completely fallen in along the whole passage, so its entrance chamber is of almost the same length as the passage. In the first part of Duga Jama falling rocks completely isolate one part of the passage, so it seems like a separate feature. In central its part the passage is partially blocked due to construction of a macadam road.

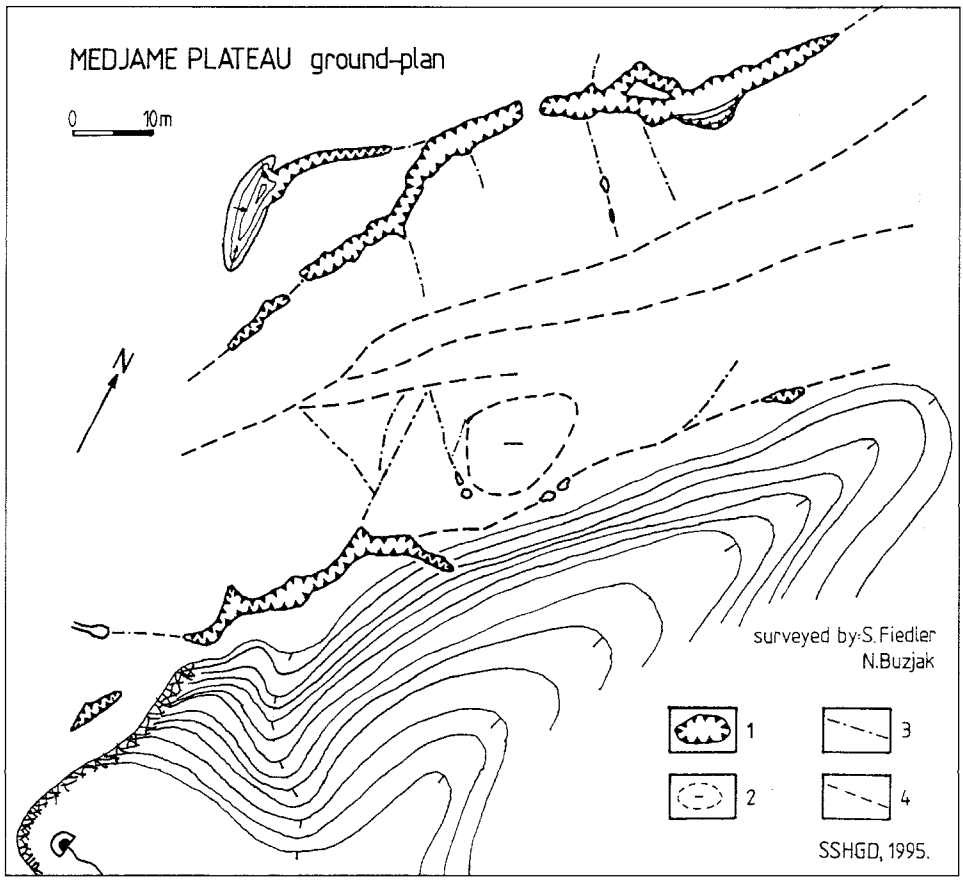

Fig. 3: Map of the Medjame plateau: 1-entrance, 2-larger subsidence, 3-fissures, 4-elongated subsidences.

Duga Jama was connected with a fossil ponor called Medjame ponor by a passage also blocked by breakdown (Fig. 4). This feature consists of one mostly horizontal passage with a funne-llike entrance. It is 15 m long and 6,5 m deep. The bottom is covered by rock debris, blocks and soil drifted from the surface. The water which probably formerly sank into Medjame ponor flowed into Duga Jama.

Another branch of Duga Jama is also a feature called Jamica, whose entrance is located 7 m south of the central part of Duga Jama. Its passage is 9 m deep, 11 m long and up to 4 m wide, and it ends in a narrow, impassable fissure. This fissure can be followed at the surface and it extends vertically toward the Duga Jama passage. Jamica's entrance is shorter and narrower than the entrances of other features (3 x 0,5 m) because no breakdown occurred along whole passage.

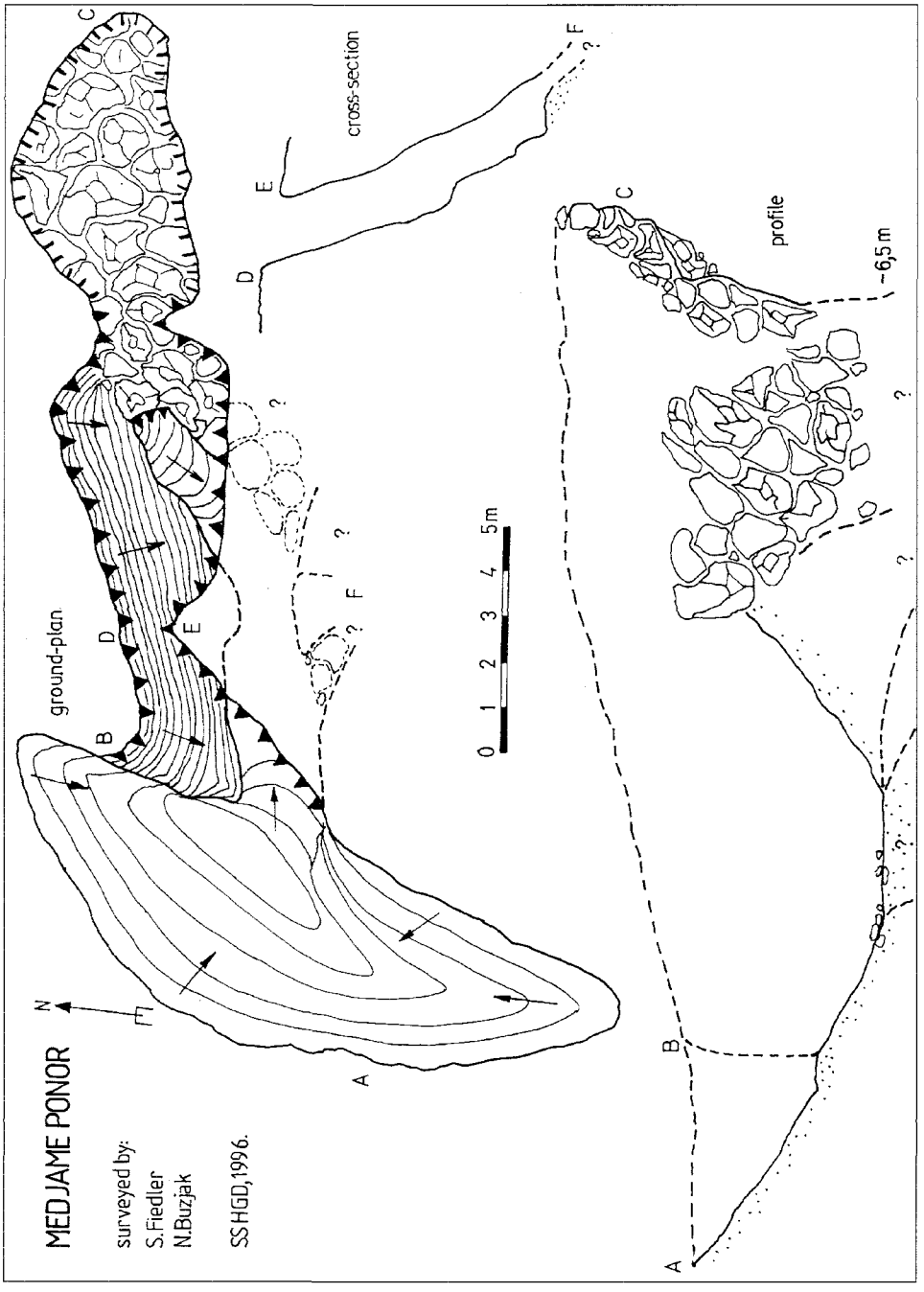

Fig. 4: Medjame ponor.

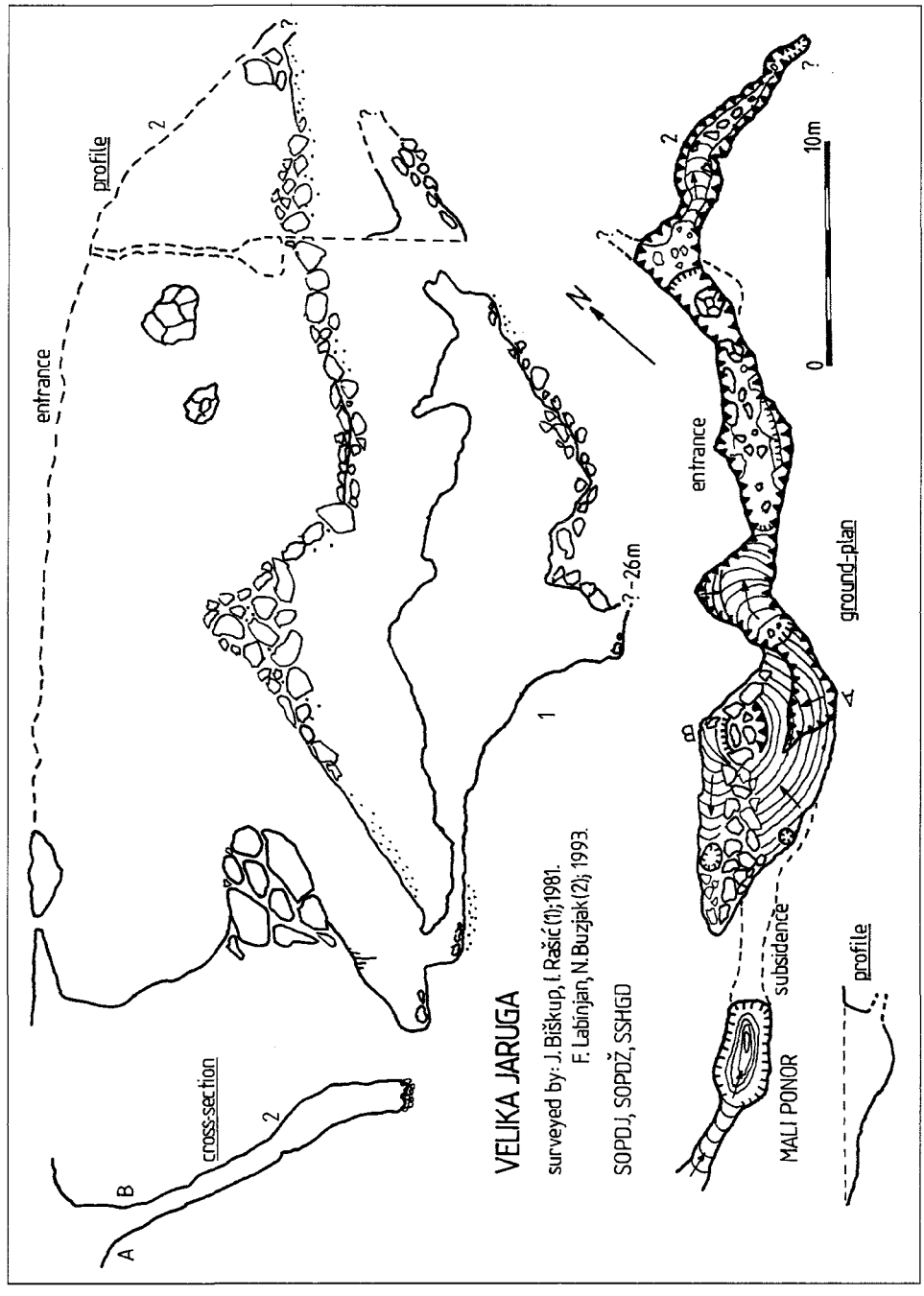

Fig. 5: Velika Jaruga.

Velika Jaruga is a feature similar to Duga Jama (Fig. 5). It is located at the edge of the plateau where it steeply falls towards Podzvir creek valley. Bouth have similar orientation and passage morphology (Phot. 1). According to earlier investigations made by cavers from Samobor, Velika Jaruga is 73 m long and 26 m deep. Today it is 45 m long, due to breakdown which blocked one part of the passage, and its entrance is of similar length (36 m) and width (1-3 m) as the passage. It is deepest in the part where breakdown did not occur (-19 m) and where it does occur it is up to 11 m deep (Buzjak 1994).

The main fissure along which Velika Jaruga occurs, continues towards NW and SE and one can follow it on the surface. One of the wider fissures from the passage, also clearly visible at the surface, continues toward the north but it is passable for only 4 m. Its end is narrow and filled in by falling rocks.

Along with this above-mentioned fissure, another one extends, along which Dubrava pit occurs (Fig. 6). It has two smaller entrances opened also by breakdown. Its passage also is of fissure cross-section and it extends vertically toward the main fissures. It is 11 m deep, up to 8 m high and 1 m wide. After 14 m of length it continue as a fissure too narrow for further exploration.

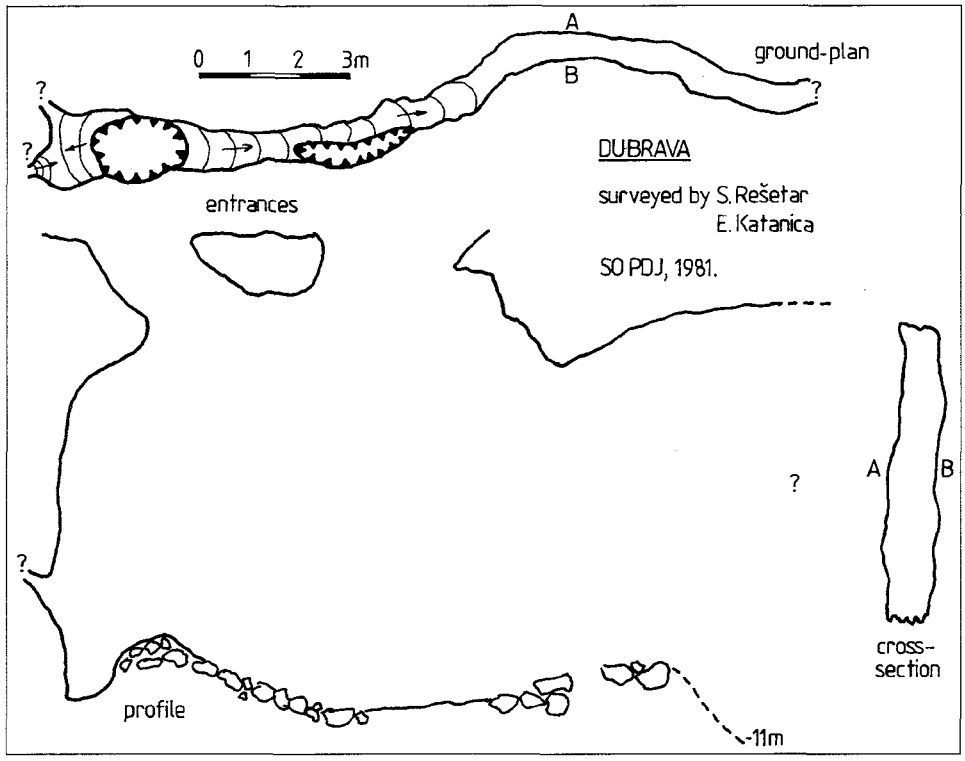

Fig. 6: Dubrava pit.

SPELEOGENESIS

The origin of speleological features on the Medjame plateau was, along with other relevant conditions, initiated by occurrence of fissures which are result of tectonic movements along a fault in its vicinity. But its origin must also be seen as a part of processes by which the relief of the wider area between villages Rešetari and Dubrava was formed.

About 500 m NW from the Medjame plateau, a short creek sinks in a Kaćnak blind valley located in Rešetari village at an elevation of 328 m. Its ponor occurs at the fault and contact between Upper Triassic dolomite and Lower Triassic beds. At that place a short cave formerly existed, but it was destroyed by breakdown (Reizer 1911). After 500 m of underground flow the creek issues from Podzvir cave, at an elevation of 255 m. The cave originated below a steep slope of Medjame plateau in the same situation as the ponor in Kaćnak blind valley. After 175 m of surface flow, the Podzvir creek flows into Ludvić creek.

The continuation of Kaćnak blind valley is a meandering step-like line of dolines, Duga Njiva (as Reizer called it). In his opinion it originated by the karstification of a former valley cut before the ponor in Kaćnak blind valley became active. Dolines are remains of former blind valleys (Reizer 1911). The contours of the former valley are still observable and can be connected with present Podzvir creek valley.

And what is connection of this theory with the origin of the Medjame plateau speleological features? Although Reizer probably visited some of this features himself, he did not associate their origin with his above-mentioned theory. He considers them to be the result of widening of fissures which drained precipitation water from the surface. The rock debris and blocks at passage bottoms he considers as the remains of fallen ceilings (Reizer 1911).

Z. Dugački accepts Reizer's theory about Kaćnak blind valley, the Duga Njiva doline line and Podzvir creek valley as being the results of fluvial erosion and karst process combination. He then unclearly connects the origin of Medjame speleological features with this theory. He considers that they originated along fissures widened by an underground stream which finally resulted in the ceiling breakdown. In his opinion Velika Jaruga was, before breakdown occurred, a cave similar to Podzvir cave (Dugački 1950).

These opinions of former researchers and the results of my own observations leads to the conclusion that the origin of these speleological features must be considered in the framework of the relief development of the whole area. It consits of a few linked and mutually conditioned phases.

As N. Reizer already stated and according to preserved traces, Podzvir creek was formerly the surface stream whose catchment area was (and still is) the terrain built of impermeable Lower Triassic beds west from Rešetari. In that phase fluvial processes predominated. They formed the still visible valley.

Since the creek flowed over Upper Triassic dolomite, karstification also occured. It was probably slower than the fluvial process, not only because of the previously mentioned characteristics of dolomite (massive structure, low content of $CaCO_3$), but also due to the fact that dolomitic sand originated by crumbling and creek alluvion transported from the impermeable catchment area blocked the fissures and so slowed down its widening.

The karstification process was fastest in the middle part of the valley, where tectonic movements crushed the dolomitic block and made a network of fissures across it. Its widening resulted in opening of ponors and therefore a blind valley formed. Its end was at the edge of the Medjame plateau and it is preserved at the bottom edge of the last doline of the Duga Njiva doline line. Two ponors were opened: Medjame ponor and Mali ponor. So, the former surface stream flowed underground from that point and formed the passages of Duga Jama and Velika Jaruga. The rest of the valley downstream remained occasionally, and finally completely, dry.

The position of entrances and passage dimensions of Medjame ponor and Duga Jama, compared with Mali ponor and Velika Jaruga shows that Medjame ponor is older (or opend earlier). Its entrance is 4 m higher than the entrance of Mali ponor and it is of larger dimensions (similar to the dimensions of Duga Jama compared with Velika Jaruga), which leads to the conclusion that is was active for a longer time.

The progress of karstification resulted in the opening of a new ponor upstream in Kaćnak blind valley. It developed, as already stressed, at the fault when the creek reached the contact between Upper Triassic dolomite and impermeable Lower Triassic beds. In the same conditions downstream, Podzvir spring cave occurs. According to J. Poljak, the cave was earlier formed by dripping water drained by smaller fissures from surrounding terrain. In that phase it deposited speleothems at the ceiling. Since they are broken, J. Poljak supposes that the fissure along which the cave originated was later widened by tectonic movements and after that time enlarged by the underground stream. This theory agrees with the relief development described above. Nearly fifty years after Poljak published its article, cavers from Samobor discovered a new narrow passage close behind the entrance, branching from the main one (Fig 7). It extends towards a wide fissure SW from Velika Jaruga. It is 26 m long and rises 19 m above the entrance level. The passage developed at the intersection of fissures of NW-SE and NE-SW directions, what also defined its direction. It branches in two directions. The shorter and narrower southern branch is connected with the surface by the small opening. The northern branch is longer and up to 5,5 m high. Water drained from the plateau flowed away by this passage. Inverse karstification is most intensive at the place of its highest concentration in the passage's northern branch, where it is closest to the surface. Therefore that part of the passage is of typical acutely cross-section.

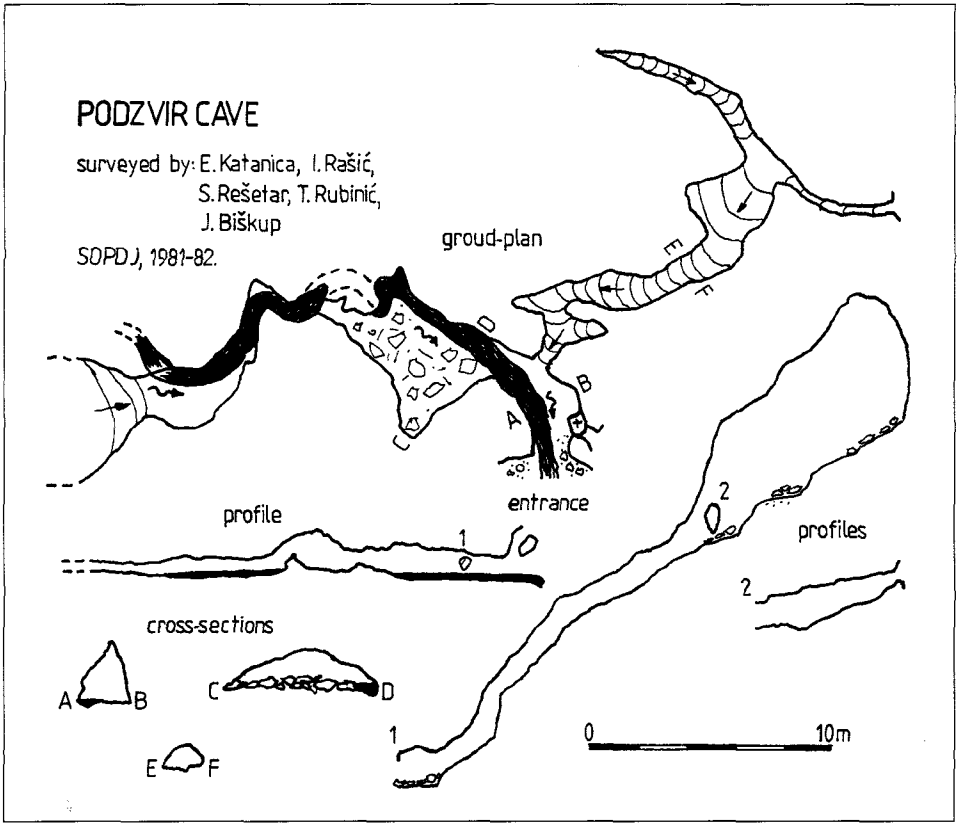

Fig. 7: Podzvir cave.

So, after the new ponor in Kaćnak blind valley became active, the blind valley at the edge of Medjame plateau and its underground passages remained dry. From that time the passages were enlarged only by dripping water. Due to the large quantities of falling material from breakdowns covering the bottoms or blocking the entire passages (for example, the rock debris pile in Velika Jaruga is over 6 m high), it can not be determined if the underground stream reached the impermeable base (which is about 30 m deep) during the cutting of its bed.

Finally, it can be concluded that speleological features on Medjame plateau originated as caves through whose passages Podzvir creek flowed underground. That is observable from its morphology and from the length/depth ratio. Nevertheless, due to its vertical entrances the inhabitants of neighbouring villages call them shafts (Medjame means "between shafts"). Although in all cases its length exceeds its depth, due to their particular morphology I class

them in the group of complex speleological features. Due to their morphology these features (often alternation of horizontal and vertical passages) can not be classed as caves or shafts (Garašić 1991). Because of the big changes of passages induced by breakdown, it is hard to affirm were they interconnected.

It is obvious that breakdown occurred at the final phase of passage development, when the underground stream found another route. If falling material preserved in passages had fallen into a stream, it would be transformed or dissolved and transported downstream. There can be few causes of breakdown: disturbances caused by lowering of water level, neotectonic movements or gravitational movements of rock mass at unstable base caused by retroactive cutting of Podzvir creek valley. At the edge and at the foot of the plateau one can find blocks which look as if they have slipped from above, curved trunks of trees and opened meandering fissures narrowed toward to the bottom. Proof of intensive disturbances can also be found at the entrance of Duga Jama whose northern edge is up to 2 m higher than the southern one and also in the plateau's steplike cross-section in N-W direction.

The breakdown process still occurs. It is visible from the "fresh" debris in some passages and also in the cases of tree roots growing over the narrower part of the Duga Jama entrance or smaller opened fissures. It is obvious that roots would not grow over such features in normal circumstances. The breakdown also shortens Podzvir cave. According to the rock debris and form of its entrance, the cave was probably much longer than it is today.

The crumbling of dolomite is also in progress. After large entrances opened, it was intensified by the more frequent changes of climatic conditions (like the accumulation and longer presence of snow and ice or a bigger influence of exterior air temperature, etc.) and biogenic processes. It is especially visible on the passage walls below the entrances.

The next characteristic of Medjame plateau is the occurrence of a few clearly visible parallel groovelike subsidences which are more than 100 m long, up to 2,5 m wide and in places up to 0,8 m deep. They extend between Duga Jama and Velika Jaruga and are interconnected by smaller fissures of different lengths and directions (Phot. 2). They show that there exist other similar fissures or even wider passages under the plateau. Very interesting is the subsidence of square ground-plan found near Dubrava pit.

CONCLUSION

The Medjame plateau located in Samoborsko Gorje (NW Croatia) contains several interesting speleological features. They originated in the Upper Triassic dolomite beds, along clearly observable fissures of NW-SE, N-S and NE-SW directions. They were widened by the activity of the underground stream and dripping water, so breakdown occurs in most parts of the passages. Therefore all features have narrow elongated entrances. Whose directions and dimensions

correspond to the directions and dimensions of passages. Besides the entrances there are some clearly observable groovelike subsidences that suggest the presence of similar fissures found underground.

At the foot of the plateau, Podzvir spring cave is located. It developed at the contact of Upper Triassic dolomite and impermeable Lower Triassic beds. The cave is the spring of the creek which sinks at the contact of same character in Kaćnak blind valley (NW from the Medjame plateau).

According to their morphological characteristics, speleological features on the Medjame plateau are similar to the features developed in Triassic dolomite in other Croatian karst areas. Their passages are of fissure cross-sections and access to some parts is often difficult as they become too narrow (Garašić 1995). Their formation is due in great part to breakdown process besides other relevant factors (Roglić 1965).

Since all features were partially or completely filled in by waste, pollution is due to the existence of many interconnected fissures, undoubtedly transporting to the underground stream of the Podzvir creek and then downstream. Due to specific movement of water in karst, the pollution of these speleological features would be fatal for wider area and its habitants.

ACKNOWLEDGMENTS

I wish to thank to Ilija Rašić and Tomislav Rubinić (SOPD Japetić, Samobor), Branko Jalžić and Mladen Kuhta (SOPD Željezničar, Zagreb) for data which made the preparing of this article easier.

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MEDJAME (SAMOBORSKO GORJE, HRVAŠKA) - PRIMER SPELEOLOŠKIH POJAVOV V ZGORNJETRIASNEM DOLOMITU

Povzetek

Kraški pojavi v Samoborskem gorju so vezani predvsem na zgornjetriasne dolomite in miocenske litotamnijske apnence. Najzanimivejše so oblike na planoti Medjame, pri mestu Samobor, ker so v različnih razvojnih fazah. Oblike v zgornjetriasnem dolomitu nastajajo tako, da se razpoke širijo v večje odprtine, vzdolž katerih prihaja do podiranja in imajo zato take votline podolgovate vhode. So različnih velikosti, vendar je težko določiti njihovo pravo globino, saj so zapolnjene s podornim kamenjem ali smetmi. Ponekod je ob vhodih moč najti žlebaste razpoke, ki kažejo na podobne razpoke tudi v podzemlju. 500 m SZ od Medjam ponika potok Podzvir. Ponovno se pojavi na površju v vznožju planote Medjame, iz jame Podzvir, na stiku neprepustnih spodnjetriasnih plasti z zgornjetriasnim dolomitom. Ker teče potok Podzvir pod planoto Medjame, odpadki, ki jih mečejo v brezna, onesnažujejo vodo. Sicer pa je potok onesnažen že prej, saj je tudi njegov ponor zatrpan z odpadki. Glede na značilnosti kraške hidrologije, je lahko onesnaževanje obravnavanih speleoloških objektov usodnega pomena za širše območje in za tamkajšnje prebivalstvo.

Photo 1: Velika Jaruga passage.

Photo 2: Subsidence near Duga jama.