PHREATIC CHANNELS IN VELIKA DOLINA, ŠKOCJANSKE JAME (ŠKOCJANSKE JAME CAVES, SLOVENIA)

FREATIČNI KANALI V VELIKI DOLINI (ŠKOCJANSKE JAME, SLOVENIJA)

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Martin Knez: Freatični kanali v Veliki dolini (Škocjanske jame, Slovenija)

Tekst poroča o prvi fazi raziskav lezik v Veliki dolini (Škocjanske jame, Slovenija). Na podlagi maloštevilnih podatkov v literaturi je uspel zbrati dovolj trden temelj za poglobljene geološke raziskave oziroma aplikacijo že znanih podatkov na lezike, ki so v Veliki dolini.

Ključne besede: krasoslovje, geologija, lezika, podzemni vodni kanal, Škocjanske jame, Slovenija

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The author gives an account of the first phase of bedding planes research in Velika dolina (Škocjanske jame, Slovenia). Based on scarce data in literature he succeeded to gather enough solid theoretical foundation for in-depth geological researches, application of known data respectively of bedding planes existing in Velika dolina.

Key words: karstology, geology, bedding-plane, underground water channel, Škocjanske jame, Slovenia

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INTRODUCTION

From the beggining of the speleological science the researchers devoted attention to relation between geological facts (rock, structure) and forming of underground channels. Researchers map tectonic elements on the cave maps a long time already. But very few works were made from litopetrologic or stratigraphic aspect for the aim of the cave research till now.

Today's knowledge of the relation of forming underground channels and surface karst features and tectonic phenomenon is much greater.

Different authors (Čar 1986; Šebela 1992) stress today the signification of the fracture zone dinaric or transverse dinaric direction (NE-SW and NW-SE) especially, by which numerous underground water channels in Postojnska jama and Planinska jama, for instance, formed. Litopetrological characteristics were in this way put into the background.

Other authors (Čar & Gospodarič 1984; Garašić 1986, 1989) frequently refer to water channels along the bedding or else the active water channels are directed perpedicularly to folded beds. Such orientation of water channels, at least in Postojnska jama (Gospodarič 1976), was not yet satisfactory explained. Such connections were mostly interpreted from the tectonical point of view by the researchers (Habič 1982).

SOME DATA ON THE CONTRARY

The counter-evidence is also the fact that in the area of Mala gora Dinarically oriented fissures do not predominate although in the caves the Dinarically oriented passages do prevail (Kranjc 1981, 44).

During the mapping of Najdena jama (Šušteršič & Puc 1970; Šušteršič 1982,1991) it was indicated that the passages are much more conformed to the strike and dip of bedded limestone and dolomite than to the faults orientation (Gospodarič 1982, 169).

Karstification should depend mostly on the permeability which results on structure. According to this base some authors infer that more porous biomicrites and biosparites are more soluble than micrites, sparites respectively (Sweeting 1972, 18). White (1988) and Ford & Williams (1989) quote that in general the medium-grained micritic limestone is the most suitable for the genesis of the underground passages.

On Dolenjska it was stated (Kranjc 1981, 36), that in biomicritic limestone which dissication cracks are filled up by dolosparite the bigger and longer passages developed while in the area of pure dolomites they are more scarce. Some Italian researchers infer that

on Kras the limestones with high rate of secondary sparitic calcite are less soluble than the dolomites.

In general in the Dinarids the limestones are far more pure than elsewhere in the world (White 1988). They have 1-2%, frequently even less than 1% of unsoluble particles (Gams 1974, 73; Knez 1989). However some authors quote that completely pure limestones are the best for the karstification (White 1988), and the others express the opinion that the most suitable for karstification are the limestones containing 70% $CaCO_3$ (Ford & Williams 1989). The limestones on Dinaric karst contain various ratio of $CaCO_3$ in respect to their age: from the Lower Triassic, having from 80 to 95% $CaCO_3$ to Lower Cretaceous (95-98% $CaCO_3$), Upper Cretaceous respectively with 98 to 100% $CaCO_3$ (Herak 1972, 28).

BEDDING-PLANE RESEARCHES IN VELIKA DOLINA

Geological data of the Škocjanske jame show that underground channels are formed in Turonian and Senonian thick-bedded limestone and in thin-bedded limestone of Maastrichtian and Danian (Gospodarič 1984). This litopetrologic difference of limestone reflects in morphology of the channels. The same author (1986, 22) accentuates that from the karstification

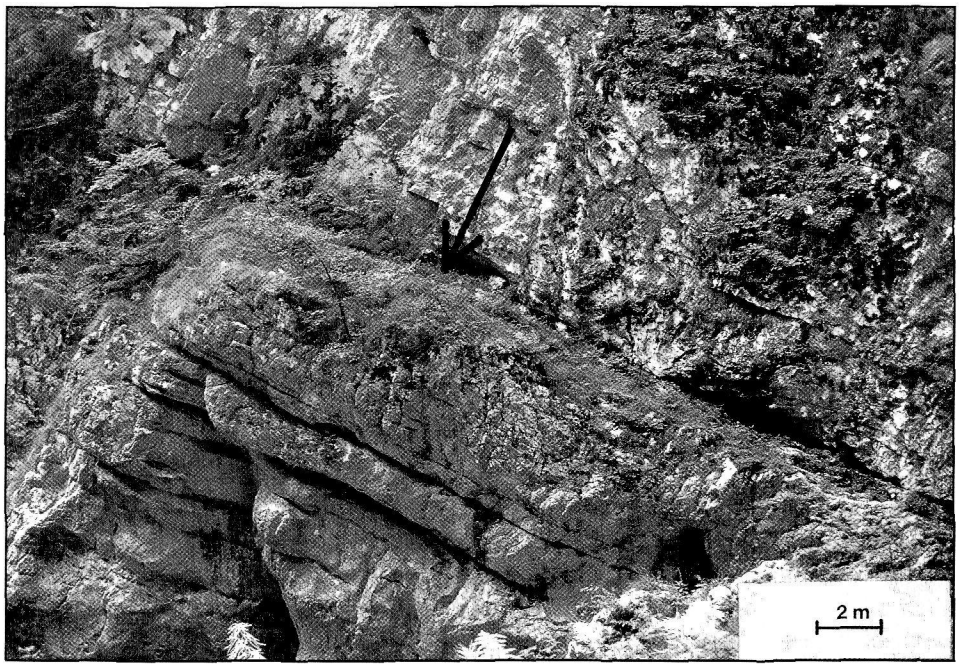


Fig. 1. Bedding planes in the limestone on the left bank of the Reka riverbed. The arrow points the bedding plane labelled 500 (Photo by M. Knez)
Sl. 1. Lezike v apnencu levega brega struge reke Reke. Puščica kaže leziko z oznako 500. (Foto M. Knez).

point of view the lithological-petrological composition of mostly Cretacoues beds is interesting. Similar properties of Cretaceous beds are referred to by the Croatian geologists too (Garašić 1986).

But by the side of the genetic relation underground channel - fracture zone, some authors for the forming of the underground channels mention also the bedding-planes (Figs. 1, 2) as a significant element (Waltham 1971, 1981; Ford & Ewers 1978; Čar 1982; Dreybrodt 1988).

Bedding-plane anastomoses (braided solution tubes) which are in Velika dolina in Škocjanske jame phreatic channels, occur in many sizes and appear to form a continuum from channels several millimeters in diameter to diametres of some tenth of metres (Figs. 3, 4). Bedding-planes where phreatic channels can form are common in areas of poorly jointed limestone (Fig. 2) and appear mostly on the undersides of the strata. The features extend over large areas of a bedding surface and often influenced by minor fractures. Bedding-plane anastomoses in Velika dolina are unquestionably phreatic in origin and often certainly predate adjacent or confluent cavern passages. In many cases it appears that a cavern passage results either from an extension of the anastomoses along a route predetermined by the presence of a minute fracture or from the breaching of a stratum by growth of anastomoses from below where two or more sets exist superimposed on adjacent bedding surfaces.

The definition of Ewers (1966) says that bedding-plane anastomoses are braided, freely interconnecting, networks of solution tubes which appear on the undersides of soluble sedimentary strata.

In general the smallest of these tubes are roughly circular in cross section with diameters as small as several millimeters. In Velika dolina in Škocjanske jame mostly the cross section with diameter of at least 5-10 cm appear. In world literature we find that these forms form a continuum with the largest type, which are channels of ovoid to trapezoidal cross section having broad bases and narrow tops, occasionally exceeding several feet in width. In Velika dolina largest cross sections of channels reaches 20 metres (Fig. 4).

In some places anastomosing solution tubes of intermediate size are usually charac-

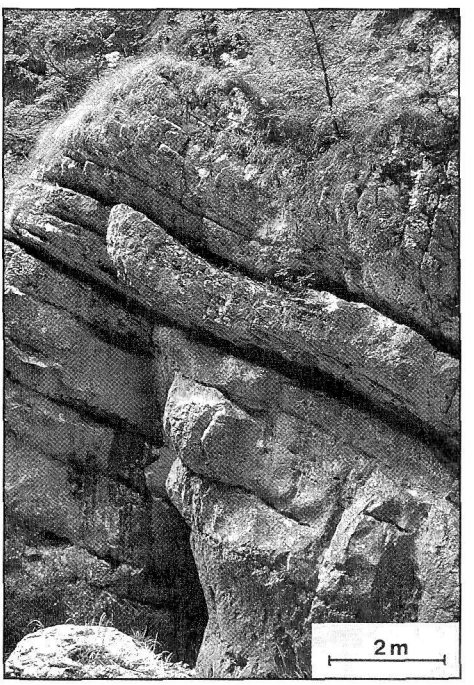


Fig. 2. Detail on the left bank of the Reka riverbed with distinctive bedding planes (Photo by M. Knez)
Sl. 2. Detajl levega brega struge reke Reke z močno izraženimi lezikami. (Foto M. Knez).

terized by vertically elongated cross section with narrow basses and broad rounded tops. Such types of channels Slabe (1987) named omega anastomoses chanels.

Bedding-plane anastomoses most frequently occur in areas of poorly jointed limestone where subsurface drainage is dependent upon bedding-plane-oriented routes for lateral percolation. In the cavern situation they are most often found as small, lateral extensions of meandering tubular passages. These extensions follow bedding planes which intersect the passages.

How a freely interconnecting network of similar-sized tubes can be developed, preserved and enlarged with the evolution of no large-scale integration is an important question. The answer (Ewers 1966) to this question seems to lie in the assumption that the enlarging process must be operating uniformly throughout the system, regardless of the position of a tube in the network. If the hydraulic head and flow rate were extremely large and remained so in spite of the growth of the system, considerable flow would be induced in all of its parts, and conditions at the interface between the ground water and rock would be similar throughout.

An alternate and more likely circumstance involving very slow ground-water movement may also produce uniform enlargement. Where the water movement in the system is

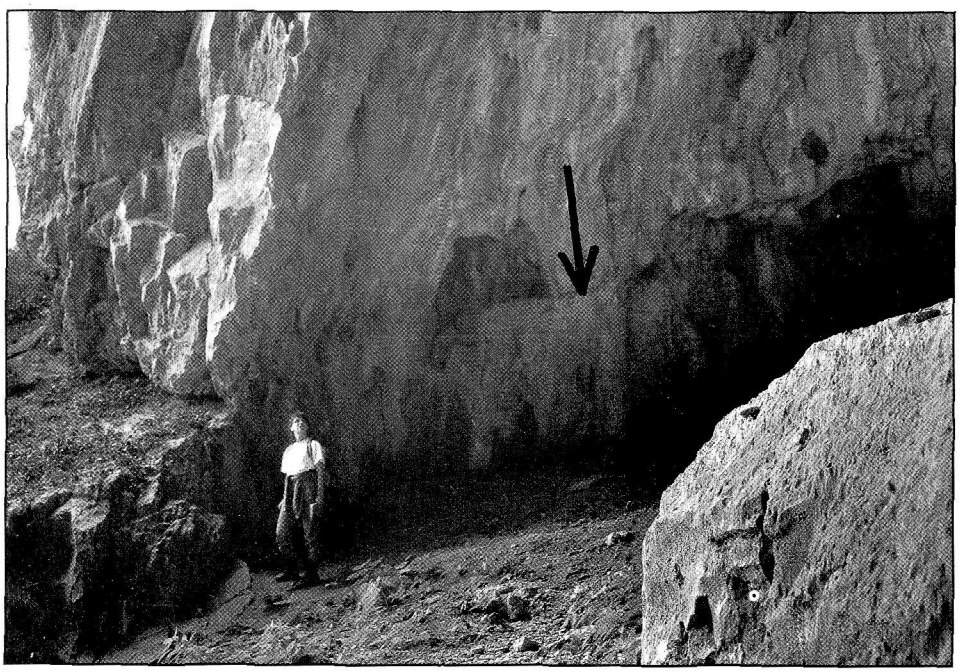


Fig. 3. Bedding plane labelled 400 (marked by arrow) above which variously large phreatic features are seen (Photo by M. Knez)
Sl. 3: Lezika z oznako 400 (označena s puščico) nad katero so različno velike freatične tvorbe. (Foto M. Knez).

sufficiently slow, the difference in resistance of the various paths may become insignificant, leading to similar rates of flow in all parts of the system.

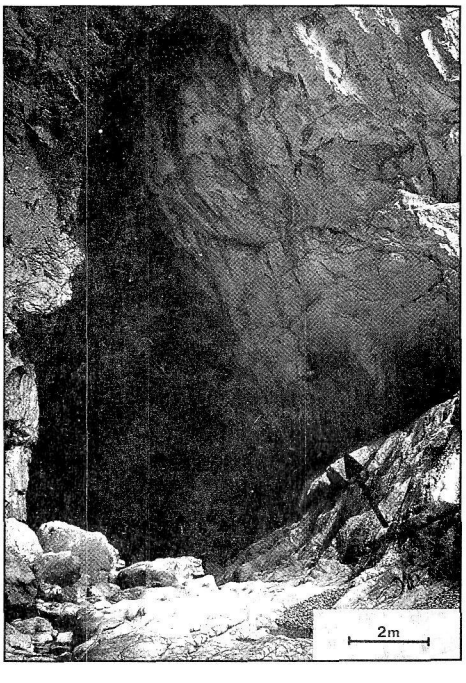
In their relation to the stratum in which they are developed, a series of anastomoses exhibits a similarity to the cycle of stream erosion, and it is often convenient to speak of them in terms of their youth or maturity (Ewers 1966). In their early or youthful stage the tubes are small and cover a small fraction of the bedding surface. As they mature, they may cover nearly all of the under surface of their stratum.

A part of the under surface of the stratum is still clearly seen in the small remains of the former large scale "cheese-like structure" on the left side of the river Reka just in front of the ponor.

With the onset of old age their stratum is largely unsupported and in the case of thin or thick strata, breaching and collapse may occur (White 1988). Where anastomoses exist superposed on adjacent bedding planes, breaching and collapse may play an important role in the development of cavern passages or collapse dolinas as we have very illustrative example in Škocjanske jame.

On the basis of natural evidence and salt-block model experiments Ewers (1966) made some interesting conclusions which seem to be very similar to till now observed facts in Velika dolina (Škocjanske jame):

(1) Bedding-plane anastomoses are probably among the earliest solutional openings in soluble sedimentary strata. (2) They form in strata where bedding planes provide the most important avenues for ground-water percolation. (3) They continue to develop while flow rates are very small and the hydraulic head is large. (4) They cease to grow significantly when the system resistance becomes low. (5) Efficient flow paths through anastomoses may develop into cavern passage after head loss in the system. (6) Long, relatively straight tubes, resulting from the presence of minor fractures (joints), often provide the most efficient flow paths. (7) Anastomoses superposed on adjacent bedding planes may contribute to the formation of cavern passages through breaching and collapse.



In the literature one may find a similar

Fig. 4. Some of largest cross sections of channels reaches 20 meters. Ponor of river Reka. The arrow points the bedding plane labelled 500 (Photo by M. Knez)
Sl. 4. Nekateri preseki kanalov dosežejo 20 metrov. Ponor reke Reke. Poščica kaže leziko z oznako 500. (Foto M. Knez).

mechanism taking place, where you have horizonal beds, which the weight above tends to bend down, causing stress on the underside of the bedding. Then under solution, anastomoses would be formed. Some experiments with plaster of Paris were made and found out that solution is very definitely also stress dependent, if we talk about a total geologic system.

Therefore, cave segments may be guided by bedding planes, joints, faults, or intercepts of such fissures. Faults are surprisingly unimportant in many systems, stressed Ford and Ewers (1978)!

Whether bedding planes or joints plus faults are quantitatively the more important quides of cave segments can not be said. A priori, bedding planes should be more important, pointed out Ford and Ewers (1978), because they are continuous to the boundaries of the limestone mass or more nearly so. Joints are discrete features. In a great many cave systems there is a complex alternation of bedding plane-guided and joint-guided segments and it is apparent that the system could not have been created were not both simultaneously available for the transmission of groundwater.

I must agree with the observation remark of different authors who say that in any bedded limestone formation there are a great many bedding planes but only a small proportion are utilized during cave formation. This is very expressively seen in Velika dolina in Škocjanske jame.

In Velika dolina the lithostartigraphic column is aproximately 200 m thick. In this column 46 clear seen bedding-planes was found till now (There is not exact number because in the 164 m high vertical wall we didn't deffine all of them yet). But there are only three (3) "trace bedding-planes" by which cave segments were guided before the colapse. So, only in not more than 6,5% of bedding-planes in Velika dolina important phreatic channels occur. We expect interesting results of proposed detailed researches.

Translated by Maja Kranjc

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FREATIČNI KANALI V VELIKI DOLINI (ŠKOCJANSKE JAME, SLOVENIJA)

Povzetek

Že od začetkov speleološke vede je pogled raziskovalcev usmerjen v odnose med geološkimi danostmi (kamnina, struktura) in oblikovanjem rovov. Raziskovalci slovenskega

kraškega podzemlja že dolgo beležijo na načrte jam tudi tektonske elemente, medtem ko je bilo pri proučevanju tvorbe rovov v kraškem podzemlju z vidika litopetrologije in stratigrafije narejenega malo. Delno so nakazani le nekateri parametri, večina pa je slutenih. Dejanski vpliv kamnine na razvoj podzemeljskih prostorov v prežeti coni (F. Šušteršič, 1991) bi bilo potrebno šele ugotoviti.

Sedanje poznavanje odnosov med tvorbo jamskih rovov in površinskih kraških oblik ter tektonskimi pojavi je znatno večje.

Različni avtorji (Čar 1986; Šebela 1992) danes poudarjajo pomen prelomnih con dinarske in prečno dinarske smeri (NE-SW ter NW-SE), ob katerih so se izoblikovali številni vodni rovi, kot naprimer v Planinski in Postojnski jami. Sedimentološke značilnosti kamnine so trenutno postavljene v ozadje.

Drugi avtorji (Čar & Gospodarič 1984; Garašić 1986, 1989) večkrat omenjajo vodne rove, ki potekajo po plastnatosti ali pa so aktivni vodni rovi usmerjeni pravokotno na nagubane sklade. Takega poteka vodnih rovov, vsaj v Postojnski jami (Gospodarič 1976), doslej ni bilo možno zadovoljivo pojasniti. Raziskovalci so tudi takšne povezave večinoma interpretirali le iz tektonskega zornega kota (Habič 1982).

O nasprotnem govori tudi podatek, da na področju Male gore ne prevladujejo dinarsko usmerjene razpoke, čeprav v jamah prevladujejo dinarsko usmerjeni rovi (A. Kranjc 1981, 44).

Ob kartiranju Najdene jame (Šušteršič & Puc 1970; Šušteršič 1982) se je pokazalo, da so rovi mnogo bolj prilagojeni smerem in vpadnicam skladnatega apnenca in dolomita kot smerem prelomov (Gospodarič 1982, 169).

Geološki podatki sistema Škocjanskih jam, ki jih predstavlja Gospodarič (1984, 30) kažejo, da se nahajajo dostopni rovi v turonijskem in senonijskem, pretežno debeloskladnatem apnencu ter v drobnoskladnatem apnencu maastrichtija in danija. Avtor meni, da se omenjena litološkostratigrafska razlika apnencev odraža v morfologiji rovov. Isti avtor (1986, 22) poudarja, da je s stališča zakrasevanja zanimiva litološko-petrološka sestava predvsem krednih skladov. O podobnih značilnostih krednih skladov pišejo tudi hrvaški geologi (Garašić 1986).

Poleg genetske zveze podzemni kanal-prelomna cona številni avtorji kot pomemben element oblikovanja podzemnih kanalov omenjajo tudi lezike (Sl. 1, 2; Waltham 1971, 1981; Ford & Ewers 1978, Čar 1982, Dreybrodt 1988).

Torej, deli jam se lahko oblikujejo po lezikah, vzdolž razpok, prelomov ali stikov posameznih elementov. Ford in Ewers (1978) poudarjata, da so prelomi v mnogih jamskih sistemih nepomembni!

Litostratigrafski stolpec v Veliki dolini (Škocjanske jame) je debel okrog 200 m. Tam je bilo do sedaj določenih 46 jasno vidnih lezik (natančno število lezik v 164 m visoki navpični steni še ni znano). Vendar od teh so samo tri (3) "vodilne lezike" v katerih so se izoblikovali pomembnejši jamski rovi (Sl. 3, 4). Torej, pomembnejši freatični kanali v Veliki dolini so se izoblikovali v ne več kot 6,5 % lezik. V nadaljevanju podrobnih raziskav pričakujemo zanimive rezultate.