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NOTION AND FORMS OF CONTACT KARST

POJEM IN OBLIKE KONTAKTNEGA KRASA

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Ivan Gams: Pojem in oblike kontaktnega krasa

Te oblike so prebojna dolina, slepa dolina, kraški ravnik, jama z alogeno reko, pretočno kraško polje, jama na vododržni podlagi, podledeniški kras in jama v sendviču. Vloga klime in naplavine za zaprte kotanje je prikazana s primerjavo semiaridnega Wombijskega krasa v Avstraliji in Velega polja v Julijskih Alpah (Slovenija). V zmerni alpski humidni klimi je intenzivno mehanično preperevanje na strmem in golem pobočju nad Velim poljem (1580 m), ki se dviguje do 2200 m. Po nalivih ponika občasni Velski potok na 400 m široki naplavni ravnici polja in pri tem odlaga grušč, pesek in organske delce. Ta proces traja od zadnjega umika ledenika pred 9 - 10.000 leti. Kljub starosti več milijonov let in sotočja dveh vodnih tokov iz okolice iz magmatskih kamnin na južnem koncu 3,6 km^2 obsežnega otoka iz čistega wombijskega marmorja, prevladujejo soteske, jame in ozke slepe doline brez širšega naplavinskega dna in uravnav. Vse kaže, da je za razlike kriva predvsem semiaridna klima in odsotnost naplavine, ki drugod povzroča širši in dolgotrajnejši vlažni stik naplavine z apneniško podlago.
Ključne besede: kras, kraška geomorfologija, kontaktni kras, kraške oblike, najglobja brezna, korozija, Dinarski kras, Slovenija.

Abstract UDC: 911.2:551.435.88

Ivan Gams: Notion and forms of contact karst

These forms are through valley, blind valley, karst plain, cave with allogenic river, overflow polje, cave on the impermeable rock, subglacial karst and interstratal karst. Emphasized is the role of climate and alluvium for closed basins by comparing Wombeyan cave area in Australia with polje Velo polje in Julian Alps (Slovenia). In the temperate humid alpine climate is intensive mechanical weathering on the steep and bare slopes above Velo polje (1680 m) and steep dry valley rising up to 2200 m. After heavy downpour the periodical brook Velski potok is sinking on the 400 m wide bottom and depositing new sheet of rubble, sand and organic particles. This process lasted since last glacier retreat 9 - 10,000 years ago. Despite age of many hundred million years and confluence of two rivers from surroundings built of igneous rocks on southern corner of 3,6 km^2 large isolated Wombeyan marble there prevail gorges, caves and narrow valleys without large alluviated bottoms, and the surface is not levelled. The main reasons for the difference are in this view the semi-arid climate and the absence of alluvium causing larger and longer moist contact of alluvium with limestone basis.
Key words: karst, karst geomorphology, contact karst, karst forms, deepest potholes, solution, Dinaric Karst, Slovenia.

HISTORICAL INTRODUCTION

Conception of contact karst is in the world karst geomorphology partially covered by the name karst of allogenic rivers. Its forms are mostly limited to blind valleys and dry valleys (Ford - Williams, 1989). In Slovenian karstology allogenic rivers are called mostly sinking rivers. In the fifties of the last century the longest caves in Slovenia were attributed to them. The conception of contact karst, first explained and classified in 1974, was elaborated after measuring the solution rate within the 14 drainage areas of Dinaric and Alpine karst of Slovenia.. The rate was calculated on the basis of mean total hardness of the river water and its yearly run-off. By comparing the rates with grade of karstification (meant density of closed basins) on the karst surface no positive relation was stated. As the solution measures proved a nearly uniform lowering of the surface, the generation of closed basins was attributed to the accelerated corrosion which means the additional solution to the general surface lowering.

From the closed basins in Slovenia blind valleys have been researched at first. As their lengths in limestone compared with their part in impermeable or semi-permeable rocks is greater at the rivers with lower total hardness, solution was recognized as the main process. A remarkable knowledge on the blind valleys in Slovenia has later been contributed by Andrej Mihevc. Further studies resulted in recognition of the factors generating the contact karst forms. They can be a consequence of the horizontal or vertical disposition of impermeable and permeable rocks. Both of them are controlled by altitudinal differences, water quantity, chemistry, river load, depth of piezometric level, permeability of karst rock, age of process and tectonics. From this point of view some most prominent karst features in Dinaric Karst and in the world have been explained as a combination of many favourable conditions (Fig. 1). Less known in the world are contact forms caused by vertical litho-hydrological contact (cave river on impermeable base, subglacial and proglacial karst, endokarst under perforated impermeable cover, interstratal endokarst). In this paper some of them are explained more in details.

The role of the tectonics is especially evident in the Dinaric karst. Only three rivers cross the mountains behind the Littoral Dinaric karst as tributaries to the Adriatic Sea. Their springs are in the impermeable sediments (Triassic dolomite, sandstone, shales, marls, magmatic and metamorphic sediments) on the watershed between the distant Black Sea and the close Adriatic Sea. They formed in the limestone magnificent, for river traffic important through valleys (gorges of Morača, Neretva, Butišnica - Krka). Their continuation on the Adriatic coastal area is dependent on the Neogenics and Quaternary tectonics mostly. The Morača spread alluvial (now conglomeratic) fan in the tectonically sinking Basin of Zeta, the Neretwa reaches the sea in a moist valley bottom below Metkovič. Between Krka (Dalmatia) and Soča (Isonzo) neotectonic uplifting was week what made the levelling of the surface possible. The Krka (in earlier phase together with Zrmanja) levelled the classic karst plain of Kistanje (Roglić, 1975) (Fig. 2). Pazinščica as an effluent of the Trieste flysch syncline indicates with direction of its dry valley the tectonic inclination of Istrian peninsula. In the sinking coast at Umag seams to develop recent formation of a new fluviokarst plain. The role of flow concentration is evident in the 11 little blind valleys at the southern foot of Brkini hills compared with the biggest blind valley of Vreme which ends with Vreme-Divača karst plain and huge Škocjan Caves (Gams, 1959, 1962, 1965, 1966, 1974, 1986, 1992, 1994. Mihevc, A., 1991, 1993).

The role of solution for contact karst forms was tested with sporadic measurements of water chemistry (Postojna Cave, Škocjan Cave, in some blind valleys and border poljes). Water hardness along rivers in the through valleys has been measured in the gorges of the Kolpa, Kokra, Bohinjska Bistrica, Paka, Hudinja in Slovenia and in some gorges in Austria (in Karinthia, Inn gorge between Bischofshofen and Salzburg). But in the big rivers flowing in the long and deep gorges the hidden springs bring water with different, mostly higher hardness which makes the measurements of the hardness in the main river uncertain. The measured increase in the small streams with hardness below 75 mg $CaCO_3$/l (at it the pCO_2 in water and in free air is almost equilibrated) was later confirmed with standard limestone tablets exposed for some years (case study Pasjek, Gams, 1995). A longer systematic measuring of chemistry of the little sinking stream Predvratnica (at Velike Lašče, SE Slovenian Dinaric Karst) which flows from a blind valley underground for 1150 m (and there through two caves) resulted in 61,5 tons of dissolved limestone and dolomite in one year (Kogovšek, J., A. Kranjc, 1992).

SOME SPECIAL AND LESS KNOWN FORMS OF CONTACT KARST

Contact of ice cover and limestone

The contact karst exists also if glaciers covers carbonatic rocks. At the front of glaciers are developing forms of horizontal contact karst. The rocky basins under the glacier are usually contributed to ice erosion and not recognized as solution features (Fig. 3). More known are deep potholes. At the end of small Triglav glacier in Julian Alps in Slovenia are between the slope and little hill Glava three openings of the Triglav pothole, 280 m deep, as stated at first exploration in the year 1961. In the year 1962 an increase of total hardness of the percolating water in pothole was measured. After l5 m of percolation through limestone the total hardness of 2,3° Germany degrees = GD (carbonate 2,15° GD, 14,3 mg/l of oxygen) was registered, at the temperature 0,2 °C. After percolation through the Triglav pothole the water rises after 23^h 1220 m lower and 1250 m distant spring at the beginning of the Vrata Valley (dye test in the year 1964). Its total hardness was 4,3 °GD. (Fig. 4). That is to say,

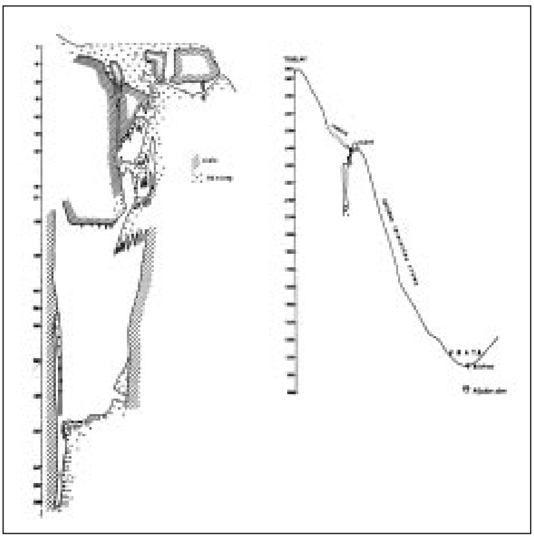

Fig. 4: Profile and situation of Triglav pothole. Hatched is limestone, small crosses indicate ice. Right side is the situation of pothole at the end of glacier and behind the Triglav northern wall.
Sl. 4: Presek in lega Triglavskega brezna. Šrafiran je apnenec, križci označujejo led. Desno je lega brezna na koncu ledenika in za Triglavsko severno steno.

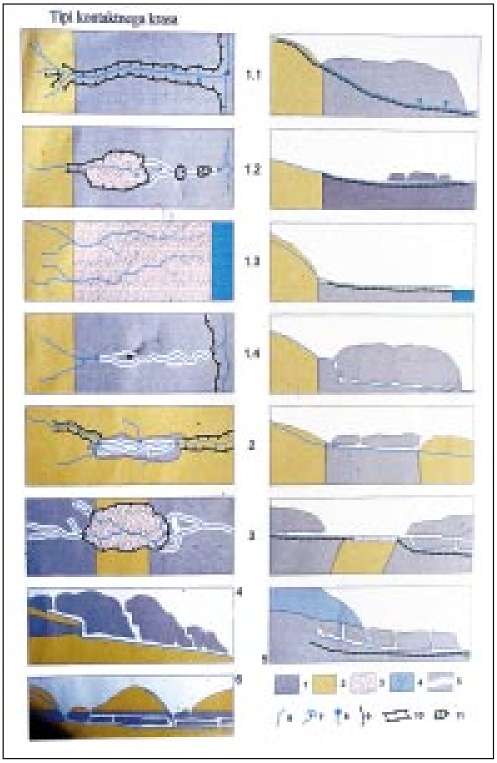

Fig. 1: Types and forms of contact karst. 1 - impermeable sediments, 2 - permeable soluble sediments, 3 - alluvium, 4 - glacier, 5 - valley, 6 - closed basin, 7 - direction of water flow, 8 - ponor, 9 - spring, 10 - piezometric level, 11 - cave.
Sl. 1: Tipi in oblike kontaktnega krasa. 1 - neprepustni sedimenti, 2 - prepustni topni sedimenti, 3 - aluvij, 4 - ledenik, 5 - dolina, 6 - zaprta kotanja, 7 - smer vodnega toka, 8 - ponor, 9 - izvir, 10 - piezometrična gladina, 11 - jama.

Fig. 2: Karst plain of Kistanje (Dalmatia, Dinaric Karst). Inclined surface, cutting the limestone strata, indicates the plain development with action of flowing river depositing its load.
Sl. 2: Kistanjski kraški ravnik (Dalmacija, Dinarski kras). Nagnjena površina, ki reže apneniške sklade, nakazuje nastanek ravnika s površinsko tekočim vodnim tokom, ki je odlagal svoj tovor (Photo I. Gams).

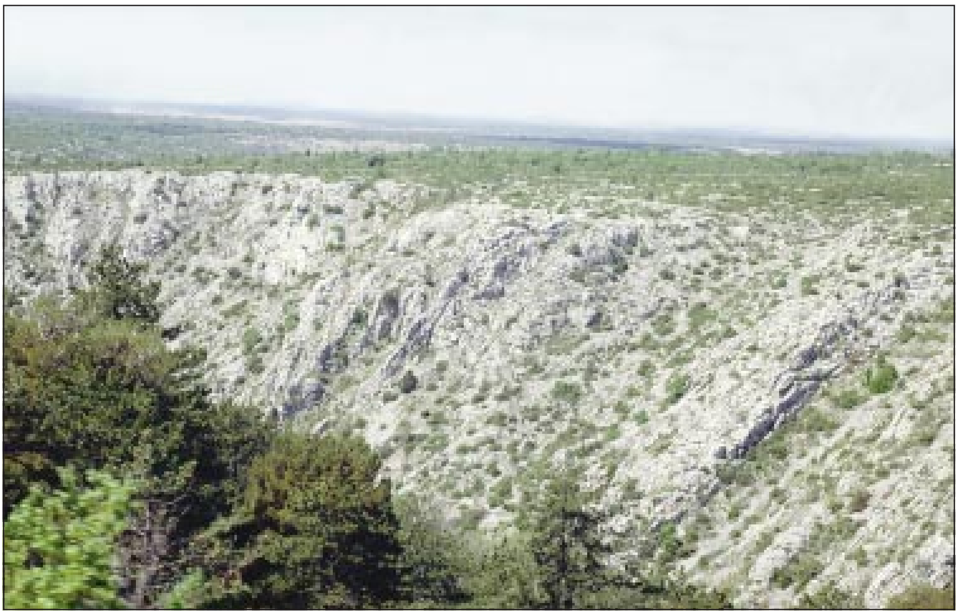

Fig. 3 - Text on page 39; Sl. 3 - Besedilo na strani 39.

Fig. 6 - Text on page 39; Sl. 6 - Besedilo na strani 39.

Fig. 3 (on page 38): Solution forms at the end of Triglav glacier. In the middle of the picture is an elongated depression with snow field. In it sank water from ice field till the last decade when the glacier fell to pieces. Between the slope (left) and the hill Glava (background) are entrances to the Triglav pothole. Shallow basins in limestone (one is seen on picture) developed by solution under glaciers after their retreat usually proclaimed as ice abrasion features (Photo I. Gams).
Sl. 3 (na strani 38): Korozijske oblike na koncu Triglavskega ledenika. Sredi fotografije podolgovata kotanja s snežiščem. V njej je ponikala voda z ledenika do zadnjega desetletja, ko je ledenik razpadel Med levim pobočjem in gričem Glava (v ozadju) so vhodi v Triglavsko brezno. Plitve kotanje v apnencu (ena je vidna na sliki) nastale s korozijo pod ledeniki, po njihovem umiku navadno proglašamo za abrazijske oblike (Foto I. Gams).

Fig. 6 (on page 38): Velo polje after new alluvium sheet spread by "torrente" from mountain on right side. Seen are the filled up and the new dam, on the other side and left side of the polje bottom buildings of the mountain pastures, behind Malo polje. Picture from sixties years of the 20th century (Photo I. Gams).
Sl. 6 (na strani 38): Velo polje po svežem nasipu hudournika z gorovja (iz Velske doline, desno). Vidna zapolnjeni in novi zadrževalnik grušča , na zadnji in levi strani naplavnega dna planinski stanovi, v ozadju Malo polje. Fotografija iz šestdesetih let 20. stol. (Foto I. Gams).

after percolation for 15 m through limestone in the pothole water is dissolving less than 39,1 mg $CaCO_3$/l and after percolation to the 1205 m lower spring further 34 mg $CaCO_3$ /l. With the total hardness of 4,3 °GD the PCO_2 in water in the spring is nearly equilibrated with the PCO_2 in the free air. As evident, the capability of melting water for solution lasted deep in the endokarst. This is why the alpine plateau glaciated in the cold phases of Pleistocene reveal the dense and deep potholes. In the Slovenian part of the plateau Kanin (Julian Alps, 1000 - 2400 m) the Slovenian cave register contains 370 caves (potholes), their density is 14,8 potholes/km^2. On the Slovenian and Italian part of the same plateau five potholes are deeper than 1000 m, the deepest is -1370 m. Many potholes in the once glaciated high Alps, Pyrenees and Caucasus are among the deepest in the world.

Part of the melting water from high mountain glaciers is flowing also through crevasses in ice and reaches the limestone basis far behind their end. Known worldwide is the inactive 387 m long Castle Guard Cave under the Columbia icefield in Canadian Rocky mountains. Far below the cave is the hypothetical course of melting water which begins probably under the central part of the glacier (Ford, 1980). Where glacier moving stops, dolines underneath have been enlarged by solution of melting water. On the plateaux (1400 - 1500 m of altitude below Mt. Snežnik, 1696 m (Dinaric karst in Slovenia), in the locality Planinc 264 m closed basins developed. One half of them are larger than 100 m and deeper than 20 m, with volume between 50.000 and 72.000 m^3 (Habič, 1991).

Two types of poljes - case of Wombeyan and Velo polje

Wombeyan Caves Reserve is situated SW of Sydney in the Eastern Uplands. It is 3,9 km^2 large isolated karst built of Silurian (Wombeyan) marble (92 - 98 % $CaCO_3$) compounded by

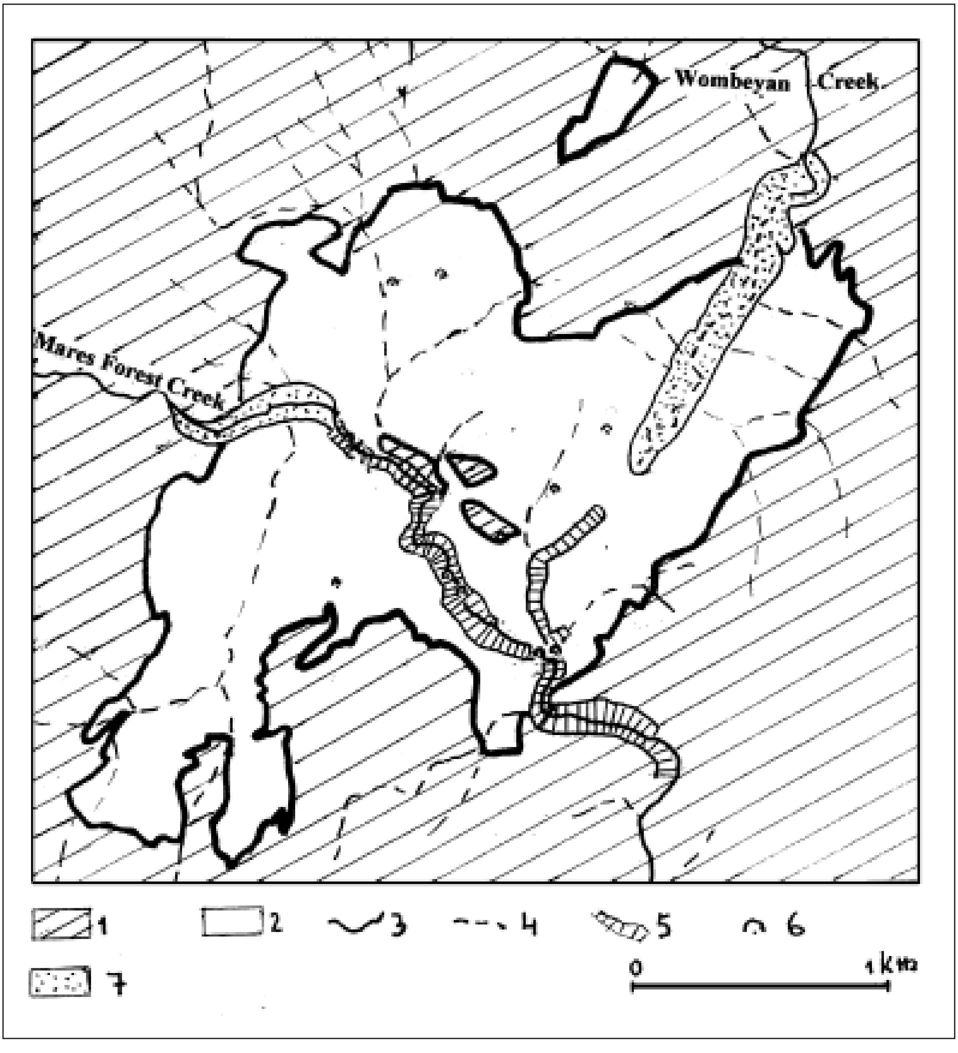

Fig. 5: Wombeyan isolated karst (Australia). 1 - igneous rock, 2 - marble, 3 - perrenial stream, 4 - intermitent stream and dry valley, 5 - gorge, 6 - cave, 7 - alluvium (Reduced from a sketch in the paper Jennings et al., p. 48, monograph Wombeyan Caves, Sydney, 1982).

Sl. 5: Wombijski izolirani kras (Avstralija). 1 - vulkanske kamnine, 2 - marmor, 3 - trajni vodni tok, 4 - presihajoči tok in suha dolina, 5 - soteska, 6 - jama, 7 - aluvij (Poenostavljeno po skici v članku Jennings et al., str. 48, v monografiji Wombijski kras, Sydney 1982).

impermeable igneous rocks (granite, felsite, porphyry, quartz, gabbro, tuff). Two streams from surroundings cross the karst and join at the southern corner before entering in the igneous rocks. In limestone prevail gorges, dry and blind valleys and about 20 caves, some of them open to tourists. There are many collapse dolines, rare solution dolines and other closed depressions. The crests built of marble are lower than the relief in the surroundings (s. map in the monograph Wombean Caves, p. 84, Fig. 5).

We compare the Wombeyan with the polje called Velo polje in Julian Alps, Slovenia. Its altitude is 1690 m, the size of the level bottom is about 0,2 km^2, rocky divide with Malo polje is about 10 m high (Velo and Malo polje mean in local language Great and Little plain). It is situated at the northern end of a dry valley like wide and 2,6 km long depression between Triglav (2864 m) mountain and much lower river valley Voje (Bohinj).

Figure 5 is taken from the monograph Wombeyan Caves (Sydney 1982) and from there published articles J.N. Jennings, J.M. James, N.R, Montgomery: The Development of the Landscape, 65 - 64, and The origin and Evolution of the Caves, 83 - 120). The temperature in station near Wombeyan Reserve is 12,3 °C (July 4,5, January 19,0 °C). Mean rainfall is 760 mm, potential evapotranspiration 800 mm (!). The nearest and higher meteorological station, Kredarica, has yearly 1994 mm of precipitation, potential evapotranspiration in Velo polje is presumable 300 mm, yearly temperature is about 1 °C (January about -6, July 10 °C). Snow cover lasts half of the year. Tectonic rising of Wombeyan and begin of Wombeyan basin occur in late Carboniferous times, in Tertiary times (50 - 35 millions years ago), and twice in Miocene. The recent solution in Wombeyan between the ponor of Wombeyan Creek and when it comes out of underground is 7 ppm $CaCO_3$/l (as increased of total hardness from 40 to 47 ppm). But 750 mm of precipitation permits a weak solution activity. The surface is not levelled despite the long development. Mechanical weathering in Wombeyan is weak, and river load limited to the short distance at the entering of streams on limestone. In Velo polje were measured two springs in bare karst in the altitude about 1900 - 2000 m. Their water jointly flows mainly below soil and scree on the slope - rock is there less permeable - and reach Malo polje (it is close to Velo polje)

	Total	Carbonate hardness in °GD
Spring below Bohinjska vratca*	4,8	4,3
Spring below Kozji graben	6,8	6,4
Main spring in Malo polje**	6,1	5,7
At its sink in Malo polje	7,0	6,7

* *This spring is used for pipeline for the hut and its water is artificially joined with the second spring.*

** *This perennial spring is the only one at the rim of rhe polje. Evident is the solution of 15,3 mg $CaCO_3$/l during the flow on Malo polje. Its narrow plain is built of pit, in the bed mixed with some rubble.*

Increase of hardness of streams flowing from barren to covered karst have been found also at some other parts of the Alps. In Velo polje the water flow was not measured and solution quantity is therefore unknown. In the surroundings of Velo polje the tree line is at the altitude 1850 - 1950 m, but patches of stony surface also appear lower.

Behind the upper end of Velo polje, the 2,5 km long dry valley Velska dolina begins rising to the peaks above 2200 m. Mechanical weathering in the steep slopes and walls causes fall of broken stones. During the snow melting and after downpour the “torrente” transported them dawn and spread in form of a thin alluvial fan on the polje bottom, which is used in summer for mountain pasture for cattle. To protect the pasture the herdsmen in the last century built two dams to stop the river transport before the plain (see Fig. 6). Recently they are abandoned. The sheet of rubble, sand and organic particles are in the coarse of 1 - 2 years overgrown again by new grass. High water from valley sinks in the alluvium and never forms a lake. Despite of often new accumulations the plain is not rising. Contrary, in the local rocky slope 2-3 m above the bottom are in some places seen subsoil forms proving the lowering of the accumulation plain. In some years migrated collapse doline occurred and proved the active solution of the rocky base.

The solution in Velo (and Malo) polje is much more intensive than in Wombeyan, and its rocky basin is much younger. Retreat of the glacial from Velo polje in the higher mountain has been about 9 - 10,000 years ago. After that the present accumulation of alluvium began. During the percolation of stream and precipitation water the PCO_2 in the soil increased their PCO_2 in the water thus rising additional capability for solution.

During the last glaciation in the higher mountainous Dinaric karst behind the Adriatic Coast (and elsewhere in the higher mountains in Europe) vegetation consisted of rare coniferous trees and cold steppe (Šercelj, 1996). This climate was convenient for alluviation of the polje bottoms and other closed basins of contact karst, so as today it is in Velo polje. In Wombeyan the alluvium is limited to the first parts of gorges in the limestone and closed basins are therefore without larger levelled bottoms.

Role of interstratal more soluble beds for caves

The solubility of gypsum in water is about 200 times greater than the solubility of limestone. Therefore there is no wonder that the longest cave of Podolia - Bukovina (western Ukraina, left side of the Dnester) is hollowed out in Tortonian gypsum. It is 10 - 30 m thick, based on Litotamnian limestone; above are gypsum, Tortonian limestone (up to 8 m), homogeneous limestone of Ratin (1-2 m), clays and loam, and somewhere alluvium on the surface. On our sketch (acc. to Dublanski, Lomaev, 1980 - Fig. 7) is shown the plan and lithologic profill for the maize cave Mlinki (19.100 m) developed in gypsum up to 16 m thick. In its western part passages with profile 0.2 x 1.5 m and in SW part rounded profiles predominate, in the rest of the cave are higher chambers. The stream which generated the cave is lost and the cave is inactive. In Podolia is in gypsum also the second longest cave of the world, the maize cave Optimističeskaja (165 km), with channels in three levels, all in gypsum thick up to 20 m, above are limestone, clay and loam, thick to 50 m. The cave covers 215.500 m^2 of surface. In gypsum are also Cave Ozernaja (82 km), maize cave (170.000 m^2) Zaluška (82.000 km), built in up to 30 m thick gypsum, Kristalnaja (22 km), Verteba, 7.8 km) and some smaller ones (Dubljanski et al., 1980).

The longest cave in the world Mammouth Cave in Kentucky is a special kind of contact karst. The accelerated solution of aggressive streams draining the slopes built of sand and shale is at present limited to the limestone floored “valleys” in Chester Uppland. Many of them have been essentially widened by growing closed basins together and by collapse dolines (Miotke, 1975, s.139 - 149). In the late Tertiary and early Quaternary time, after sand and shales were progressively evacuated from the older limestone in Pennyroyal Plateau, their aggressive river water

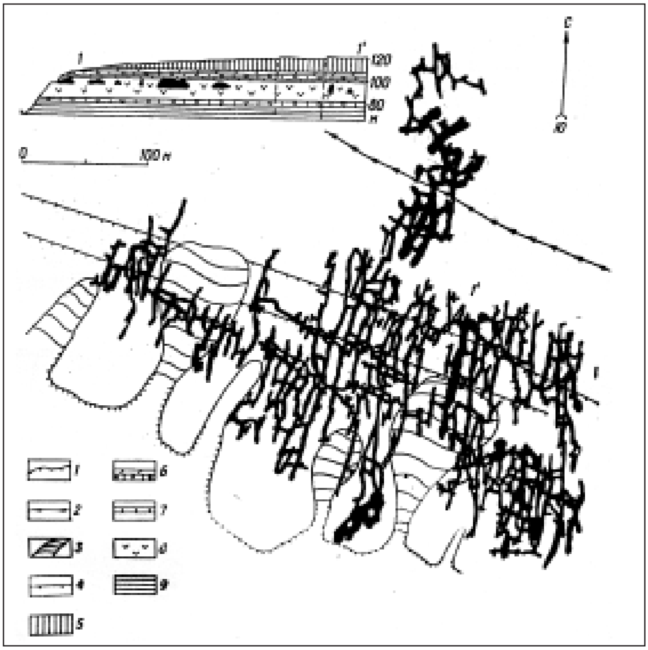

Fig. 7: Map of the maize cave Mlinki (19 km) in Podolia, and stratigraphic profil, in it are black indicated channels in thin layer of gypsum (Acc. To Dublanskij, B.,N., Lomaev, A.A. Karstovie peščeri Ukrajini, Kiev, 1980, p. 63). 1 - gentle and steep slopes in the valley of the river Mlinki, 2 - main watershed, 3 - alluvium and slided material, 4 - fissures of deepening, 5 - Quaternary deposition; upper Tortonian: 6 - marl and limestone, 7 - limestone of Ratin, 8 - gypsum, 9 - Silurian sediments.

Sl. 7: Načrt labirintne jame Mlinki (19 km) v Podoliniji, in stratigrafski profil, v njem so črno označen rovi v tanki plasti gipsa (po Dublanskij, V.N., Lomaev, A.A., Karstovie peščeri Ukrajini, Kiev, 1980, s. 63). 1 - položno in strmo pobočje doline reke Mlinki, 2 - glavno razvodje, 3 - odplavljeno in odplazelo, 4 - razpoke posedanja, 5 - kvartarne odkladnine; vrhnji torton: 6 - laporji in apnenci, 7 - apnenci Ratina, 8 - gips (sadra), 9 - silurske odkladnine.

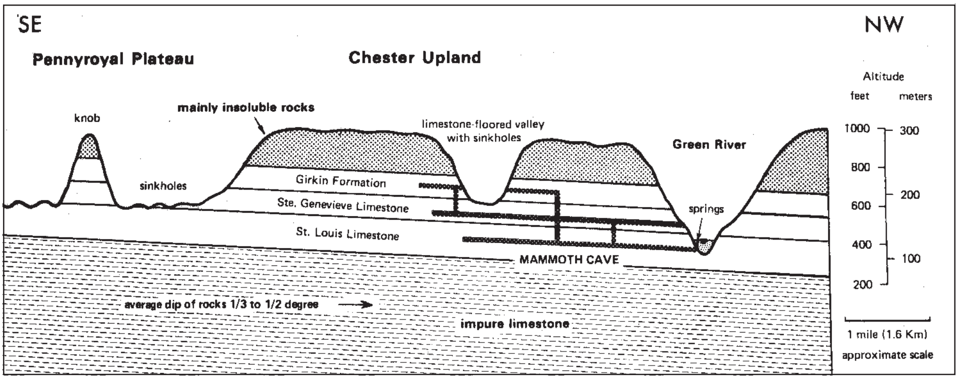

Fig. 8: Cross section through the Mammoth Cave area (Acc. to Arthur N. Palmer, A geological guide to Mammoth Cave National Park, 1981, p. 6).

Sl. 8: Profil skozi območje Mamutske jame (Po: Arthur N. Palmer, Geološki vodnik parka v območju Mamutske jame, 1981, str. 6).

contributed to the generation of higher cave passages in the whole area and also under the present ridges in Chester Upland where some knobs are still capped with impermeable rocks. In this phase the Mammoth Cave area was a type of horizontal contact of impermeable and permeable rocks. Later precipitation water dissolved the upper Girkin and higher limestone strata of Meramec series and destroy upper channels in them. All six levels of the channels controlled by Green river terraces remained under the "rising" Mammoth, Flint, Joppa and other small ridges where limestone channels have been protected by insoluble sand and shales on he top. The protective role of this cap for cave conservation recognized both authors of cave monographs (Miotke, 1975, Palmer, 1981). The insoluble and impermeable cap hold back the percolation water through cave ceiling. By this way break down and flowstone deposition in the old channels is limited to the slope area built of limestone (Miotke, 1981, Fig. 38 on page 111). Development of the cave passages (530 km) is mostly the result of the horizontal and their conservation of the vertical disposition of soluble and insoluble rocks.

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POJEM IN OBLIKE KONTAKTNEGA KRASA

Povzetek

Skica 1 z načrti in preseki kaže značilne oblike kontaktnega krasa kot posledico ugodnih kombinacij na vodoravnem in navpičnem stiku vododržnih in vodoprepustnih skladov. Te oblike so prebojna dolina, slepa dolina, kraški ravnik, jama z alogeno reko, pretočno kraško polje, jama na vododržni podlagi, podledeniški kras in jama v sendviču. Članek obravnava le nekaj od njih. Vlogo klime in naplavine za zaprte kotanje je prikazana s primerjavo semiaridnega Wombijskega krasa v Avstraliji in Velega polja v Julijskih Alpah. V zmerni alpski humidni klimi, z januarsko temperaturo ok. -6 °C in pol leta trajajočo snežno odejo, je intenzivno mehanično preperevanje na strmem in golem pobočju nad Velim poljem (1580 m), ki se dviguje do 2200 m. Po nalivih ponika občasni Velski potok na 400 m široki naplavni ravnici polja in pri tem odlaga grušč, pesek in organske delce. Kljub temu se dno ne dviguje. Občasne udorne vrtače nakazujejo živahno podnaplavinsko korozijo apnenčeve osnove. Ta proces traja od zadnjega umika ledenika pred 9 - 10.000 leti. Z merjenjem je bila tudi drugod dokazana pospešena korozija vode, ki priteče z golega na pokriti kras. Kljub starosti več milijonov let in sotočja dveh vodnih tokov iz okolice iz magmatskih kamnin na južnem koncu 3,6 km^2 obsežnega otoka iz čistega wombijskega marmorja prevladujejo soteske, jame in ozke slepe doline brez širšega naplavinskega dna in uravnav. Vse kaže, da je za razlike kriva predvsem semiaridna klima in odsotnost naplavine, ki drugod povzroča širši in dolgotrajnejši vlažni stik naplavine z apneniško podlago. Tudi ledenik na apnencu pomeni kontaktni kras, v katerem pride ledeniška voda prvič v stik s karbonati. To je ilustrirano z 270 m globokim Triglavskim breznom, ki se odpira v n.v. 2400 na spodnjem koncu Triglavskega ledenika. Merjena narast trdote dokazuje sposobnost vode za korozijo med pretakanjem skozi apnenec do 1200 m nižjega izvira v Vratih. Iz istega vzroka so brezna na visokih kraških planotah v Pirenejih, Alpah in na Kavkazu gosta in mnoga med najglobljimi na svetu. Kot klasični primer medskladovne labirintne jame je na skici prikazan načrt jame Mlinki (19 km), izvotljene v 16 m debelem hitro topnem sadrenem skladu. V isti sadri so tudi druge jame Podolinije, med njimi tudi druga najdaljša na svetu, Optimističeskaja (165 km). V začetnih fazah razvoja Mamutske jame v Kentuckyju, v

času večjega obsega neprepustnih peščenjakov in skrilavcev na platoju Pennyroyal, pozneje skrčenih na vršne lege holmov, so agresivne ponornice izvotlile zgornje hodnike v višavju Chester na vodoravnem stiku neprepustnih in prepustnih kamnin. Ko je korozija padavinske vode znižala okoliško površje iz apnenca pod Chester Upland, netopni in neprepustni pokrov slemen Mammoth, Flint in Joppa preprečuje udore jamskega stropa in nastanek sigovih kop v hodnikih pod njimi. Zato je vertikalni razpored neprepustnih in prepustnih kamnin lahko ohranil pod slemeni prehodne rove jame, ki je z dolžino 530 km najdaljša na svetu.