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CLIMATIC AND LITHOLOGICAL INFLUENCE ON THE CAVE DEPTH DEVELOPMENT

LITOLOŠKI IN KLIMATSKI VPLIV NA GLOBINSKI RAZVOJ JAM

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Ivan Gams: Litološki in klimatski vpliv na globinski razvoj jam

Pod golim površjem visokega Alpskega krasa (primer Triglav) agresivna padavinska voda votli globoka brezna do piezometrične vodne globine. Na nižjem Dinarskem krasu (primer Postojnska jama), ki ga je v hladnih dobah Pleistocena zajela tundra, v globjih jamah in votlinah, razkritih v kamnolomih, in globljih cestnih usekih, v toplejši holocenski klimi prevladuje fosilizacija votlin zaradi zvišane korozijske fronte, in nadaljuje korozijsko poglabljanje v podaljšku subkutanih jaškov in plitvih votlin, zapolnjenih z vodoprepustno ilovico.

Ključne besede: speleologija, speleomorfologija, odlaganje sige, epikarst, brezno, Slovenija, alpski kras, dinarski kras.

Abstract UDC 551.584:551.44
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Below the bare surface of the high Alpine karst (example Mt. Triglav), the aggressive precipitation water generates deep potholes to the piezometric water level. In the lower, covered Dinaric Karst (example the Postojna Cave), invaded by tundra in the cold periods of the Pleistocene, and in the deep caves and voids revealed in quarries and deep cuttings for roads, in the warmer Holocene climate flowstone accumulation prevails due to the higher solution/accumulation front, and continues the deepening of the shallow subsoil pockets and shallow pits filled with the permeable loam.

Key words: speleology, speleomorfology, flowstone accumulation, epikarst, shaft, Slovenia, Alpine karst, Dinaric karst.

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The longest and deepest caves are in the forefront of popular interest. They are generated mostly along the underground flow of so-called sinking rivers (called also allogenic rivers), which drain the surface built of impermeable sediments and sink in the contact karst (in Slovenia: Gams 1959). Their number is limited.

In this paper, smaller voids disclosed below the karst surface are of particular interest. According to the new karst monographs (Ford & Williams 1989, p. 342) a karst cave is defined as "a solutional opening that is greater than 5-15 mm in diameter or width". In Slovenian speleology, a cave is called "void" which is penetrable by men and is at least 5 m long and/or deep. By 1995 more than 6,600 caves have been registered in Slovenia (Brenčič 1995). In 25% of them, their depth was less than 14 m and their lenghts less than 12 (and in 50%, the depth was less than 27 m). Taking into account the lowering of the karst surface, which in Slovenia amounts annually to 40-100 microns, and considering the 2 million years' duration of the Quaternary period, about 50% of the caves in Slovenia could have developed in conditions observed at present in the walls of deeper limestone quarries. These conditions, however, are different from those in the high Alpine karst. The differences between bare and covered karst are illustrated in two examples in our sketch.

BARE ALPINE KARST

The first type is illustrated by the high Alpine karst in Slovenia on the plateaus below the highest peak in Slovenia - Triglav (alt. 2864 m). There, at the contact of the Triglav crest with the small Triglav plateau a small glacier (the Triglav glacier) there is. The melting water from this glacier flows on the limestone surface to the nearby sink in the Triglav pothole at an altitude of 2400 m. During our research in 1961 (Gams 1962), the water discharge in the upper part of the pothole was about 3 l/sec, the temperature 0,2°C, and the total water hardness 36.5 mg/l of $CaCO_3$ and $MgCO_3$. In September 1994, the total hardness of water draining the mixture of ice and rubble on the left flank of the Triglav glacier was 81 mg/l (Gams 1994, p. 108). Such hardness is often found in water draining the heaps of rubble mixed with humus on the surface of the Julian Alps. In the nearby cave Ivačičeva jama the total hardness of the water dripping from the ceiling was 66 mg of $CaCO_3$ + $MgCO_3$/l (Gams 1962). At this amount the water CO_2 pressure in solutes is in equilibrium with the PCO_2 *0,03% in the free atmosphere (Ford & Williams 1989, p. 53-63).*

In August 1964, the water in the upper end of the Triglav pothole was traced with fluorescein. The tracer was registered in the spring of the Bistrica stream at the end of the Vrata valley, 1220 m below the entrance into the Triglav pothole and 1250 m from it in horizontal distance. For the underground flow, the water needed 23 hours and 40 minutes (Gams 1966). This speed is probably greater than under the surface without ice melt water. The average total hardness of the Bistrica spring is 73 mg of $CaCO_3$ + $MgCO_3$/l (Gams 1966). This content proves that the soil CO_2 is nearly absent from the river basin. Standard limestone tablets exposed at Kredarica in a heap of rubble mixed with humus which is frozen 8 months per year resulted in 13,9 microns of the limestone dissolved annually. The tablets exposed on the stony surface on Mt. Kanin with double the amount of precipitation was 6,14 mm annually, representing nearly 15% of the total denudation (94 $m^3/km^2/yr$), calculated on the basis of the runoff and total water hardness for Mt. Kanin (Kunaver 1976). It is evident that the bulk of solution in the rocky Alpine karst occurs in the deep endokarst.

The transitional zone between the flowstone forming and aggressive percolation water lies in the caves in the Slovene Alps at altitudes ranging from 1000 to 1500 m. In the cave Babji zob near Bled at an altitude of 1000 m the dripping water from the ceiling does not deposit flowstone nor is it erosionally active in the colder entrance channel (6,7°C), but it does deposit flowstone in the final, warmer separate part (7,2°C) under the forested surface (Gams 1975). The 400 m long horizontal cave is namely open to the cold winter air penetrating from the outside. The boundary zone between the soil cover and the rocky surface lies between 1000 and 1600 m on the carbonate surface of the Julian Alps. Depending on special lithology, special solutes in water and special cave air circulation, this zone can be higher or lower.

COVERED DINARIC KARST

The second type presented in our sketch is the most known Slovenian karst, the karst at Postojna. The difference in annual temperature between the two environments is 10°C (in the first case -1,6°C, and at the station of Postojna +8,4°C (1960-1990). A different role of highland and lowland environment derives mostly from the effect of soil cover in covered karst. This role resulted in the difference of the solution process of carbonate rocks, in our case limestone and dolomite, and different the depth of solution front. Under the bare karst, the solution front is up to one thousand metres (locally even more) below the stony surface. There, the corroding water is in contact only with the air and with its CO_2 concentration of 0,03%, as it is in the free atmosphere. By equilibration of its CO_2 and the CO_2 in the air the water is able to dissolve up to 70-80 mg of $CaCO_3$/l (or $MgCO_3$/l). Due to the absence of soil cover the precipitation water immediately sinks into the underground (endokarst). The cave air is there connected with the free atmosphere as the fissures are not blocked on the surface by soil, loam or silt or impermeable sediments. So the CO_2 needed for the solution of carbonates is available during the penetration of the precipitation water down to the deep piezometric water level. Due to the fact that at least two days are needed to establish the final equilibrium when the maximum saturation with CO_2 is obtained, not all waters can get the full content of 70-8O mg of $CaCO_3$/l, so solution occurs nearly within the whole aerated zone.

The surface above the Postojnska jama cave is at an altitude of 540-620 m. The mean annual precipitation amounts to 1579 mm (compare Kredarica at the Triglav glacier - 1994 mm). The total hardness of the flowstone-forming water which penetrates through the nearly 100 m thick ceiling is about 187-205 mg of $CaCO_3$ + $MgCO_3$/l. The mean hardness mentioned above demands about 0,4% of the CO_2 in the soil atmosphere. Regular measurements of CO_2 began on 18th March, 1997, where the first measurements (done with the assistance of A. Mihevc) have taken place on the southern border of the levelled surface about 80 m above the cave channels north of the Biospeleological Station. In this area, the land is an abandoned pasture partially overgrown by bushes and pine trees. In the reddish-brown loamy soil below the O horizon, the following concentrations of CO_2 were found before the vegetational period: at a depth of 20 cm below the surface 3400 ppm of CO_2, at 30 cm 4000 ppm, and at 50 cm 4100 ppm of CO_2. Its texture of mixed A and B horizont is: 2.9 % of coarse and 27.1 % of fine sand, 31.3% of silt and 48.6 % of clay. The 50 cm soil depth is hard to find there and it is traced only in the soil pockets. In the Postojna Cave the air has between 0,03 and 0,1 % of CO_2 (Gams 1970).

The precise depth of the solution front under the soil and vegetation cover in the low and middle high karst is still a matter of discussion in Slovenia. The following facts speak in favour of the assumption of the solution front near the karst surface:

1. In the shallower caves around Postojna, the ceilings of which are around 10 m thick (in some cases even less), the dripping water normally deposits flowstone (for example the cave at Groblje, Skednena jama, Gams 1966).
2. The CO_2 pressure at 0,4% concentration in the free air is more than 10 times higher than in the cave air. The penetrating water in equilibrium with the 0,4% CO_2 pressure in the soil begins the flowstone deposition in the first void of endokarst connected with the free air. For this reason, we must assume a quick solution immediately below the soil cover, pocket or shallow voids filled with loam. Also the subsoil rocky forms (Gams 1971) prove the intensive solution by means of soil moisture.

Very few dripping waters in the Postojna cave are agressive. The aggressive water in the Pisani rov of the Postojna Cave was examined more closely as an example (Gams 1966, Kogovšek 1983, trickle point No.7) and different reasons were found. Its total hardness (between 105 and 130 mg of $CaCO_3$/l) indicates the mixing of waters penetrating through the surface with the soil cover and without it. The trickling water has a higher hardness and it is flowstone-forming at the low water stage. At high discharge, the hardness is reduced and the water is aggressive. In this cave the dripping water after a longer stagnation in limestone pools has been losing solids to about 80 mg of $CaCO_3$/l. (Gams 1967). Their mean hardness (175-220 mg of $CaCO_3$/l) of 80 measurements of the penetrated water demands about 0,4% of the CO_2 in the soil atmosphere (see Ford & Williams 1989, p. 57).

CONSEQUENCES OF CHANGED CLIMATE FOR THE CAVE DEPTH DEVELOPMENT

In the coldest Pleistocene periods which were more numerous than previously presumed, tundra vegetation spread over the lower Notranjsko karst and invaded the Slovene Littoral as well (Šercelj 1996). The altitude of the grass-growing line, where the roots only partially prevented eroded soil from being transported into the fissured bedrock, is not known exactly even for the last final cold Wurmian period (W3). At least the steeper slopes were liable to erosion of the loam and soil, not only along the surface but also into opened fissures below roots. It is the general opinion that the colder periods of the Pleistocene coincide with the phase of accumulation of loam, sand and pebble in caves and poljes (Gospodarič 1976). During the period 32.000 - 125.000 BP, flowstone datings show a reduced growth of stalagmites and stalactites (Zupan 1991). These phenomena indicate a deeper solution/flowstone deposition front and a deeper zone of cave and pit forming than it is at present. In this sense, the Holocene period has brought a blockage of water conduits leading to deeper voids as the snow cover was renewed. This and the forest caused relatively faster subsoil solution, the faster lowering of the surface and thus faster disclosing of the voids filled with loam and soil.

However, in some cold spots in the high Dinaric karst plateaus between the Trnovski gozd plateau and Mt. Snežnik the deep solution front, where the winter snow cover is locally thick, still exists. On Mt. Nanos (meteorological station at 915 m), 394 mm of precipitation form about 2,3 m thick snow cover in three winter months. The cover is thicker in the bottoms of deep colapse dolines where the accumulated snow persists nearly all the year round. A century ago, firn and ice in the potholes below them were still excavated from these "glacières" and used. The participants of the Karstological School in 1996, whose main aim was to visit some of the ice shafts on Nanos, could observe the circular cross-section of their upper parts. Such profiles can be generated only if the pothole is filled with fine sediments or ice, both in contact with limestone.

In order to prove the thesis of climatic influence on the shifting of the solution/accumulation front, many quarries in Central Slovenia have been analysed. The karst with the quarries referred to belongs to the hydrological type with radial underground drainage. So allochtonous sediments in caverns disclosed there are exceptions. Sediments in the dolines (Habič 1987) and caves in the Kras region with allochtonous rivers and sediments (Mihevc &

Zupan Hajna 1996, Slabe 1996) are different and controlled also by the sinking rivers from the nearby Eocene flysch which remained in patches on the top of Gradišče hill (714 m), N of Lokve and in the near western Brkini hills (see geological map 1:100.000 of the sheets Triest and Gorica).

In quarry walls and cuttings for roads the revealed rock under dolines is usually more cracked and fissured. Between blocks in the upper part the soil prevails, and in the lower part rubble mixed with soil and loam (Fig. 1 taken at Verd). There, the lowering of the doline bottom is due to faster solution of fractured rock (compare Šušteršič 1994).

If the filling in the pit gets less permeable, the precipitation water sinks through the lateral fissures and voids. The funnel-like doline is thus enlarged and transformed into bowl-like doline. The large doline in the Fig. 2 taken in 1973 is at this stage. The colour picture of the same doline has already been published in Acta carsologica 23, 1994, Fig. 13, pp. 156-157. Its author is standing in a side pit seen in our photograph on the right side. In Fig. 3 this pit and the neighbouring side pit are shown on a larger scale.

Fig. 1: Below the dolines in quarries and cuttings for roads more fragmented rock mixed with soil and loam is usually revealed. Since the solution is faster in the cracked rock, the doline formation and the beginning of the pit formation are genetically linked. Photograph taken at Verd.

Sl. 1: Pod vrtačami je v kamnolomih in usekih za ceste običajno razkrit bolj razlomljen apnenec. Ker je korozija hitrejša v zdrobljeni kamnini, sta nastanka vrtače in začetka izvotljenja jaška genetsko povezana. Fotografirano na Verdu.

Fig. 2: The doline above the wall of the quarry at Verd where the soil was stripped off in 1993. At this stage of the doline development, karren and projecting out blocks below hinder the subsoil flow of the precipitation water toward the central pit seen on the bottom. F. Šušteršič is standing on the right side in a lateral pit (the right slope).

Sl. 2: Vrtače nad odkopno steno kamnoloma Verd, kjer so l. 1963 postrgali prst. V tej razvojni stopnji vrtače razčlenjena skalna podlaga preprečuje podtalno odtekanja padavinske vode proti osrednjemu jašku na dnu. V stranski odprtini na desnem pobočju stoji F. Šušteršič.

There the initial soil pocket has grown down in a filled pit often found as subsoil form.

As previously noticed in some cases in the quarry of Verd, the lateral infilled pits continue at the flank of the central pit. The Fig. 4 (taken in the 1960s) shows as an example the central pit in Palaeocene limestone in an abandoned quarry in Izola. In the picture the pit is filled with reddish loam. The lateral voids are destroying the rock as the penetrating aggressive water dissolves it. At the right side of the picture, there is the neighbouring filled central pit. After the intermediate rock is dissolved, the central pits will join

Fig. 3: Revealed side pits of the doline pictured in the photo No. 2, in closer view. Bedding planes and karren are making the rock permeable even between the pits. Photograph taken in the 1960s.

Sl. 3: Podrobnejši pogled na stranske jaške ob vrtači s slike 2. Kamnina je prepustna zaradi lezik in škrapelj celo med temi jaški. Fotografirano v 60-tih letih.

into one larger void. Many open potholes are a system of combined pits connected with steps.

After the infiltration water is transformed into soil/loam moisture, the precipitation waters remain aggressive regardless of their depths in the pockets, fissures or pits if the filling is permeable for water. The filling found in pits during the construction of the Vrhnika - Postojna motorway consists mostly of sand (the yellow sand contains up to 15% of quartz) and silt. There is only 1% of clay particles in them. The volume of the fillings which were observed there in the pockets and pits, distributed on the surface, is equal to 1 m thick soil cover (Šušteršič 1978). On the bottom of these permeable fillings at Verd and other quarries, signs of active solution deepening and widening of the rocky cavities were registered and many forms, similar to those on the cave rocky surface, appear there. T. Slabe (1995) classified them as solution bevel, channel, niche, roof pendants, solution cup, corrosion notches and box-work. In my opinion, one of these forms is also the so called recess, known as the subsoil form (Gams 1971). It is similar to an open large scallop having a smooth surface. This form is often found also in the revealed voids in the escarpments of quarries.

The upper zone of a quarry escarpment with its filled fissures and loam pockets is obviously the zone of the recent intensive void forming. The voids follow the bedding planes or cracks in the rock and are at their first stage strongly lithologically controlled. In this zone, filled caves are more numerous than empty ones (Šušteršič 1977). They can all be generated out of the soil pockets, subsoil pits and larger voids in shallow endokarst.

The zone of the present cave formation is shallower where voids in endokarst have no connection with the free atmosphere or where narrow fissures are filled only with the percolating water after heavy rain. If the percolating water in endokarst cannot absorb fresh CO_2 from the air and can not emit the CO_2 in the void air, it is solutionally inactive regardless of the depth below the surface. The flowstone sedimentation then begins in the first lower cavity connected with the surface air. The air permeability and its circulation within cavities is forced by the changing air pressure due to predominance of anticyclonic and cyclonic weather. This connection can use also the tiny, longer fissures running in all directions. Gravitational flowing water uses only the downward ways.

Solution below the soil pockets and on their flanks depends on the pH of the soil, and mostly on the humus and organic matter in general. The permeability of the infilling clay, loam soil, or sand controls the relation between the lateral or downward growth of the void/cave. Sands from the Eocene flysch enhance the genesis of deep potholes.

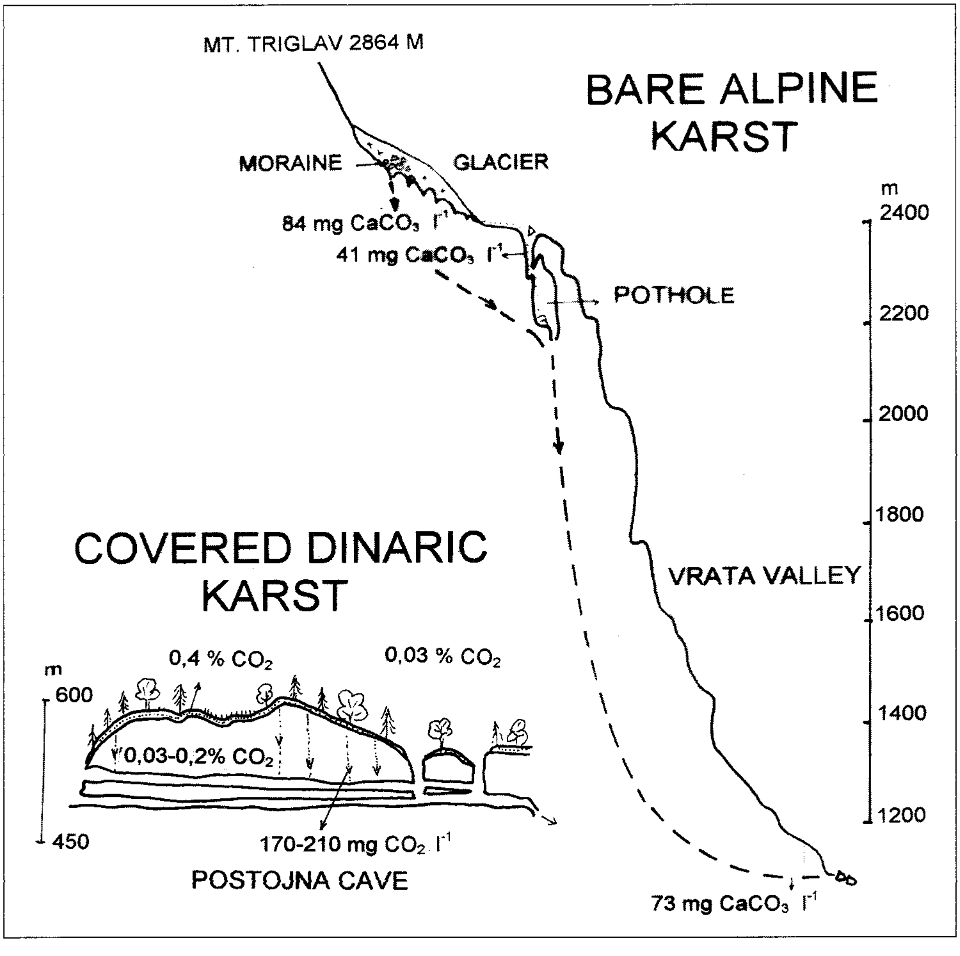
The lithological strength which controls the width of the voids has great influence on the form and situation of cavities. Nearly no voids occur in the cracked Triassic dolomite (for example in the quarry above the village Dešno in the valley of the Sava River, parts of the quarry above the village Povodje in the hills of Rašica near Ljubljana, the quarry Pirešica north of Žalec and two in the valley Paka north of Velenje). If along the faults the carbonate rock is cracked into small rubble mixed with silt and the whole mass is under pressure of blocks, the water percolation is often hindered and caves are absent. If rock is fragmented and mixed with permeable loam, the voids occur mostly inside the blocks. The deep filled potholes and voids occur mostly in the stratified solid limestone cracked in larger blocks (see also Čar & Gospodarič 1984). Not all open voids are used for penetrating water there. Some fissures are blocked with flowstone and the void get no more moisture.

The average altitude of the surface in Slovenia is 551 m and the average altitude of the entrance into the cave is 785 m (Verša 1995). Higher altitudes and colder climate are obviously favourable for the development of voids. The predominance of potholes above the horizontal caves in Slovenia can be partially explained as the consequence of the pits forming in the Pleistocene.

Due to fast changes in filling and evacuation of the pits, due the changed permeability for precipitation water and changes of the local depth of solution front, the effects of the transition from the Pleistocene to Holocene climate are less evident. They are more clear in cases where more development stages can be recognized in sequence from the bottom to the upper end of one larger cave.

The Fig. 5 and 6 taken in 1996 from two nearby disclosed filled pits.
In the first pit the following development stages were evident:

1. Solution of the rock and forming of the void. No signs of the running water can be found. Solution by stagnant water is possible, but no proof for that exists. In the last stage of the pit widening, the contact solution loam/rock resulted in the smooth surface of the limestone face and slower solution of the calcite veins (Fig. 5) which project from the wall. The only possible explanation for this formation is: aggressive water gliding in the



overhanging position. Some parts of the filling are coloured differently, but the contacts were not sharp and the climatic influence on its formation is not clear (compare Urushibara 1976). The lower infilling is in general more red and with more clay particles.

2. End of loam accumulation.
3. Formation of the flowstone sheet which covers the loam infilling, thus fossilizing the pit about 25-30 m below the (present) surface. Stalactite formation on the ceiling.
4. Blocking of the pipe above the pit which previously served for the inflow of water, enriched with CO_2 in the soil on the surface.

In the neighbouring pit, the first process of widening the void was solution by stagnant water (phase no. 1). The proof is a rough rocky face (Fig. 6). Phase no. 2 followed, during which the filling of the void with reddish loam occurred and it has remained in the lower part of the pit, while in phase no. 3 the process of erosion of loam occurred in the upper part. It has remained where the crust was hardened with flowstone (phase no. 4). Stalactites are a sign of the general accumulation of flowstone (phase no. 5).

The stated solution phase followed by flowstone accumulation and thus fossilisation and accumulation phase occurred in both pits. The last phase can be regarded as an indicator of the higher Holocene solution/flowstone accumulation phase, although the bedrock was at the time getting thinner thus open the pits on the surface by roof collapse (comp. Maucci 1975).

A. Mihevc from the Karst Research Institute ZRC SAZU in Postojna began to date with U/Th methods a piece of the flowstone sheet from the pit shown in the Fig. 5 in the Uranium Series Dating Laboratory of the University of Bergen (Norway). According to the written report sent to the author, the analyses failed, probably due to mixed material.

In the light of the cited climatic speleogenesis, the phase of pit solution and accumulation of loam can be placed in the cold Pleistocene period with deep solution/sedimentation front and aggressive penetrating water. The phase of loam erosion probably occurred in the course of transition from the Pleistocene glacial period to the warm interglacial period, whereas the phase of flowstone accumulation can be attributed to the warmer Holocene period with forest and thicker soil on the surface.

The traces of the older loam accumulation phase was found in many caves (Slabe 1995, Gospodarič 1988). Pits of this type are often below the steep slope (Gams 1955). The ancient loam filling remains in many fissures and notches in the cave ceiling and walls.

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LITOLOŠKI IN KLIMATSKI VPLIV NA GLOBINSKI RAZVOJ JAM

Povzetek

V članku je navedena vrsta objav in pojavov, ki dokazujejo, da poteka na Dolenjskem in nizkem Notranjskem krasu v sedanjosti prehod iz vrhnjega pasu s prevlado korozije v nižji pas odlagajanja sige v modelu t.im. čistega krasa v glavnem nekaj metrov pod tlemi. Globlji je pod ilovico v žepih, podtalnih jaških in votlinah, zapolnjenih z prepustnimi klastičnimi sedimenti. To ne velja za brezna, ki jih dolbejo ponornice in povsod tam, kjer skozi karbonatno kamnino penikajoča voda ne more priti v stik z okoliškim zrakom, in tam, kjer parcialni pritisk CO_2 ni nižji kot v zraku v prsti. V Sloveniji je 25 % vseh registriranih jam manj globokih od 14 m in krajših od 12 m, 50 % pa jih je manj globokih od 27 m. Torej je vrhnjih 20 m prepustnih karbonatov glavno območje recentnega nastajanja votlin, nižje pa prevladuje zapolnjevanje jam, povezanih z zunanjim zrakom. Take razmere so razkrite v globljih kamnolomih in cestnih usekih.

Razmere med votljenjem jam in njihovim zapolnjevanjem v alpskem krasu pod skalnato površino brez prsti in vegetacije so na skici prikazane za primera visokega alpskega in nižjega dinarskega krasa. V primeru Triglavskih podov je prikazan primer, ko agresivna voda ponira v n.v. 2400 m v Triglavsko brezno. V enem dnevu se je obarvana voda pojavila v 1220 m nižjem izviru Bistrice s povprečno trdoto 73 mg $CaCO_3$/l. Taka trdota je plod dinamičnega ravnovesja s tlakom 0,03 % v prosti atmosferi, torej brez obogatenja CO_2 v prsti. Taka voda ne odlaga sige in korodira tamkajšnji endokarst do 1200 m pod površjem.

Ker je z našega nižjega dinarskega krasa v hladnih obdobjih pleistocena obdobno izginila gozdna zarast in prevladala tundra ter je prst zapadla eroziji oz. spiranju v špranje, so korozijsko - sigotvorne razmere postale podobne sedajim v visokogorstvu. Zato je v tem času logično pričakovati tudi na dinarskem krasu nastajanje globljih brezen v pogojih t.im. čistega krasa (korozija ponornic v podzemlju ne zapade klimatskim vplivom), v sedanjem času pa njihovo zapolnjevanje s sigo spričo višje korozijske fronte.

To tezo je avor preverjal z analizo korozijsko - akumulacijskih razmer v stenah kamnolomov, kjer je število zapolnjenih votlin znanto večje kot odprtih. Ob odsotnosti absolutnih datacij sedimentov se je avtor oprl na skalne oblike, ki jih korozija izdela na stiku vlažne prsti oz. ilovice s karbonatno skalo. Te potrjujejo zastavljeno tezo. Oblike, nastale s korozijo tekoče, po previsu polzeče ali stoječe vode ali s kontaktno korozijo, ostanejo na skalnem obodu po odstranitvi klastičnih sedimentov. Po avtorjevih opažanjih potrjujejo starejšo fazo izvotljevanja votlin in recentnega zasigavanja. Odkriteljem jam je namenjen zato nasvet, da naj zabeležijo te oblike in ostanke klastičnih sedimentov v razpokah jamskih sten.

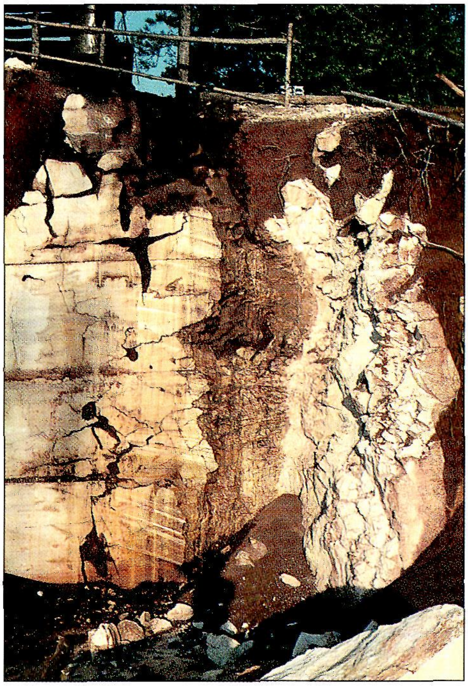

Fig. 4: The analysis of the disclosed pit in the quarry at Izola (1963) reveal that the filled pits are growing not only with the contact loam/rock solution of the central pit, but also with the solution of the intermediate rocky mass where lateral pits with aggressive waters begin to grow.

Sl. 4: Analiza razkritega brezna v kamnolomu pri Izoli (1963) razkrije, da se zapolnjeni jaški ne večajo samo s kontaktno korozijo na stiku ilovice in stene osrednjega jaška, ampak tudi s korozijo vmesne skalne gmote, kjer nastajajo bočni jaški z agresivno vodo.

Fig. 5 - Sl. 5

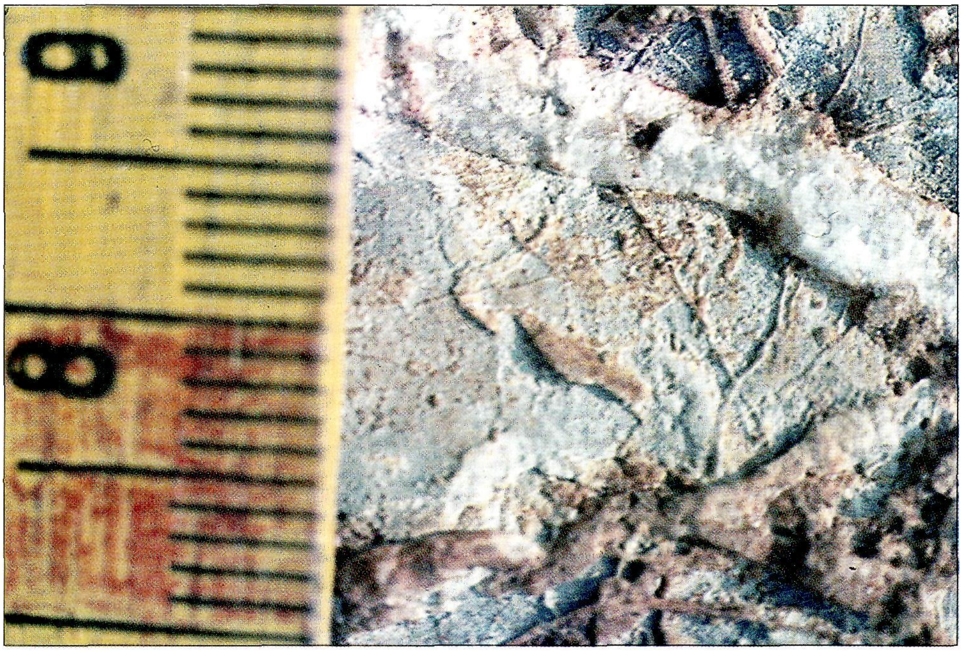

Fig. 5: The smooth wall face disclosed 30 m below the surface in the upper part of the pit in the quarry of Verd proves the action of contact loam/limestone solution. The calcitic veins protruding on the surface exclude the possibility of stagnant water solution or the contact loam/rock solution. The only possible explanation is the solution of water gliding on the overhanging position.

Sl. 5: Gladka stena zapolnjenega in zdaj razkritega brezna 30 m pod površjem dokazuje kontaktno korozijo ilovica/apnenec. Vložki iz kalcitnih kristalov, ki molijo iz stene, izključujejo možnost korozije stoječe vode ali kontaktne korozije ilovica/skala. Edina možna razlaga je korozija vode, drseče po previsu.

Fig. 6: The rough rocky face in the disclosed neighbouring pit proves stagnant water solution as the process of void enlargement. Then follows the phase of filling with loam, its erosion and its remains where the flowstone accumulation stuck them on the wall. The dripstone formation is the last development phase, attributed to the Holocene period.

Sl. 6: Robata skalna površja v sosednjem razkritem jašku dokazujejo korozijo stoječe vode kot proces razširjanja votline. Sledi faza zapolnitve votline z ilovico, njene erozije, kar pričajo ostanki, ki jih je na skalo prilepila siga. Tvorba stalagmitov je poslednja razvojna faza, pripisana holocenu.
All photographs taken by I. Gams.