ROCKY RELIEF IN SOME CAVES OF "NOTRANJSKO PODOLJE"

SKALNI RELIEF V IZBRANIH JAMAH NOTRANJSKEGA PODOLJA

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Tadej Slabe: Skalni relief v izbranih jamah Notranjskega podolja

Skalni relief je pogosto pomembna speleogenetska sled. To nam potrdi tudi proučevanje skalnega reliefa izbranih jam Notranjskega podolja. Izsledki nam služijo pri opredeljevanju nastanka in razvoja tega morfogenetsko povezanega kraškega predela.

Ključne besede: jamski skalni relief, speleomorfogeneza, Slovenija, Notranjsko podolje

Abstract UDC 551.435.1:551.442(497.4)

Tadej Slabe: Rocky Relief in some Caves of "Notranjsko Podolje"

Rocky relief frequently serves as important speleogenetical evidence. This is also confirmed by study of rocky relief in selected caves of Notranjsko podolje. The results may be used to define the origin and development of this morphogenetically consistent karst area.

Key words: rocky cave relief, speleomorphogenesis, Slovenia, Notranjsko podolje

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INTRODUCTION

Studying the origin and formation of the cave rocky forms has shown that rocky relief frequently serves as an important speleogenetical evidence. This is confirmed by study of rocky relief in selected caves of *Notranjsko Podolje*. Podolje means the lowlend consisting of karst poljes of this area. The results may be used to define the origin and development of this morphogenetically consistent karst area (Fig. 1). I have chosen the caves at the inflow (Križna jama) and outflow (ponor caves Mala Karlovica and Zelške jame) sides of the Cerknica lake and an active effluent cave Planinska jama where the waters of Pivka and Rak flow together. At, NW, higher part of Notranjska depression, i.e. at the border of Črni vrh polje, I have studied Ciganska jama near Predgriže. Logaška jama is an old cave lying on the Logatec karst plain.

Fig. 1: Ceiling pocket in Križna jama (scale = 15 cm)
Sl. 1: Stropna kotlica v Križni jami (merilo = 15 cm)

KRIŽNA JAMA, MALA KARLOVICA AND ZELŠKE JAME ROCKY RELIEF

Progressive karstification has left several traces in the speleogenesis of the higher level Križna jama which were presented in detail in *Acta carsologica* (Slabe 1989). The cave was formed by the waters flowing to Cerkniško jezero. Slow flow in that phreatic zone left big scallops (fig.) and ceiling pockets in some parts of the entrance channels which are now dry. Water channel level lowering has resulted in water level horizons. In the passages which are no longer reached by the actual water flow above water level rocky forms developed. Today the cave is deepened by water flow of rather high velocity and seasonal high waters in smaller channels incise small scallops (Fig. 1) on leeward side of the bigger passages fine-grained sediments are deposited. The below-sediment half tubes and solution niches occur.

Relatively quick transformation of the rocky relief is reflected in the different kinds of development of Mala Karlovica and Zelške jame. Heterogeneous cave development is evidenced by sediments and flowstone, and the rocky relief is concordant with the last stage of the cave development. High waters seasonally flooding Mala Karlovica up to 550 m, up to the ceiling with the exception of the breakdown halls, have transformed the traces of the older cave development. The flow velocity through the passages is medium, in narrow parts obviously a bit quicker, and concordant with the distribution of variously sized facets. The water erodes the rocky perimeter of channel, the flowstone and deposits which cover the floor for several metres thick on some places. The actual flow did not everywhere reach the original rocky bottom of the channels. Similar is the formation of Zelške jame. The water flow in the cave already incises the rocky bottom at the level of 505 m, the while seasonal high waters reach Blatni rov at 515 m. Slow water flow which drained through Blatni rov left bigger scallops (Fig. 2) and ceiling pockets. It is a characteristic flooded channel. Today the highest waters reach the lower part of the channel only. The rocky relief is formed below the fine-grained sediment deposited by the outflowing waters. The water flowing downwards off the flooded channel through smaller pasages incised smaller scallops. It means that at the time of the last prominent transformation of the upper channels the lower-lying water channel already existed. In the final part of Vodni rov there are rather bigger scallops on the upper parts of the channel than those at the level of the actual water flow. The channel was thus entirely flooded and the discharge through it was slower.

According to the sediments in the caves Gospodarič (1970, 138) inferred that the most important speleogenetical process was the sediment fill of the caves at Cerkniško jezero in Karlovice up to 550 m and in Zelške jame up to 525 m. It caused the waters to start transforming the former channels, which were in Karlovice at 548 m and in Zelške jame at 520 m a.s.l. Such

Fig. 2: Bigger scallops in Blatni rov of Zelške jame
Sl. 2: Večje fasete v Blatnem rovu Zelških jam

development is confirmed by rocky relief too. Reverse erosion advancing from Rak valley towards Cerkniško polje enables the transport of the sediments out of the caves and this is felt, even by deepening of the channels in Zelške jame.

PLANINSKA JAMA ROCKY RELIEF

Gospodarič (1974 a, 180)) studied the gravel in the cave. He stated that the speleogenesis of the passages between the Pivka basin and Planinsko polje is closely connected with various stages of sedimentation of the deposits. He continued this study two years later (Gospodarič 1976). He defined several erosion and accumulation phases of the development though they could not be identified in the rocky relief of the Rak branch. He connects the first erosion phase with gravel of coloured cherts transported by a water velocity of 2 m/s, while in the second phase a water velocity of 3 m/s transported gravel of white cherts. In Lower Würm the passages were filled up by laminated loam. Flood loam was deposited during Upper Würm too. During Holocene the sediments were washed away, the ground subsided, the speleothems collapsed

and flowstone was deposited (Gospodarič 1976, 112). Kogovšek (1982) studied the hydrodynamics of water percolation into the cave and its corrosion efficiency.

The rocky relief of the Rak branch reveals two development phases. The first one is slow water flow through longitudinal and cross winding and flooded channels reaching in some sections 480 m above sea level. The results of such water flow are big scallops and ceiling pockets in the higher parts of the channel which are no more reached by the actual waters. The phase of erosion incision followed, probably with free water flow which levelled and deepened the channel. Nowadays we still witness the downcutting of the river which has not yet reached the rocky bottom from the period before the filling with older laminated loam (Gospodarič 1976, 68). The water washing the sediments out of the cave frequently flowed slowly and stagnated in front of the breakdowns. The walls were covered by manganese coating. The actual biggest discharges in the initial passages of smaller diameter reach velocities of 2-3 m/s. This is why the water flow forms smaller scallops.

In the Pivka branch also several development phases may be defined (Fig. 3) on the basis of the rocky relief. Slow water flow in the higher parts of the channel left ceiling pockets and big scallops (Slabe 1993, 150). In some places the gravel is stuck to them. The levelling and deepening of the channel was caused by water flow with bigger velocity and gradient. The channel deepened quickly and only the old rocky forms are preserved. Younger, progressive channel deepening and seasonally slower water discharge of higher waters in the wider parts of the conduit are evidenced by scallops of medium size on the walls above the level of medium high Pivka water. At the fifth bridge the river bed is already incised into the rocky floor. Flow at high velocity forms small scallops shapes the river bed nowadays also. The filling up the cave by fine grained sediments witness the above flood forms preserved in higher dry passages.

Gospodarič (1976, 65) considered that Pivka at first flowed through the Rak branch in Planinska jama and the former way towards Malni was later used by the Javorniki underground stream. The rocky forms really evidence similar development phases in the upper passages of Postojnska jama and in the upper parts of Pivka and Rak branches in Planinska jama. In both caves the oldest traces of the cave development are left by slow water flow. Referring to Gospodarič's (1981, 106) temporal definition of the development phases of the cave system on the base of the sediments and flowstone, one may infer that these channels were formed before the prominent erosion activity of the river and before the deposition of coloured chert gravel in Mindel. The origin of traces of faster epiphreatic water discharge through the caves may be connected. These are water level horizons on the walls evidencing the deepening of the Planinska jama channels and smaller and medium sized facets and ceiling pockets in the higher (520-530 m a.s.l.) passages of Postojnska jama.

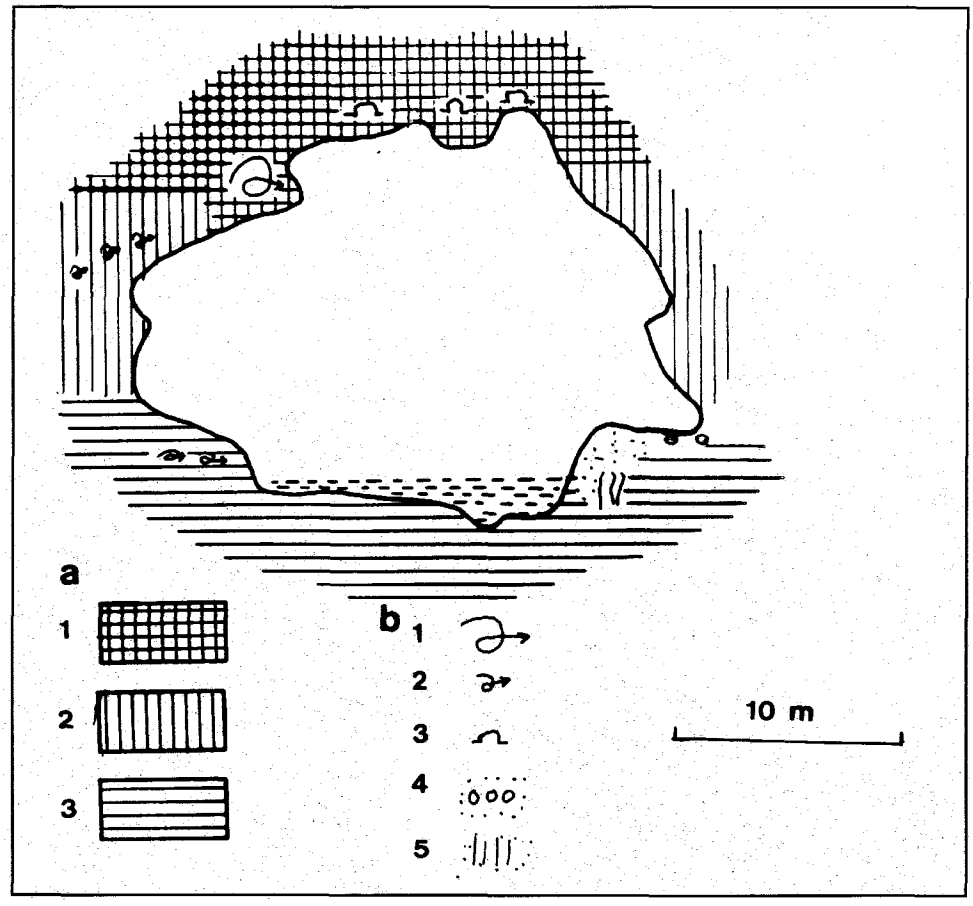

Fig. 3: Cross section of the Pivka branch in Planinska jama (Pri Golgoti) and hydrological zones of rocky relief formation

A 1. phreatic zone
2. epiphreatic zone
3. vadose zone

B 1. big scallops
2. medium or small scallops
3. ceiling pockets
4. below-sediment solution niches
5. below-sediment half tubes

Sl. 3: Prerez Pivškega rokava v Planinski jami (Pri Golgoti) in hidrološke cone oblikovanja skalnega reliefa

A 1. freatična cona
2. epifreatična cona
3. vadozna cona

B 1. velike fasete
2. srednje velike in majhne fasete
3. stropne kotlice
4. podnaplavinske vdolbinice
5. podnaplavinski žlebiči

SUHADOLICA ROCKY RELIEF

The rocky relief in the active cave below the higher outflow karst of Javorniki is accordant with the actual processes of its genesis. Due to high water pressure in the hills behind it, its discharge through relatively small periodically flooded channels is of high velocity. It therefore forms small ceiling pockets (Fig. 4). Smaller seasonal water level oscillations cause the deposition of fine-grained sediments on the rocky relief and thus corrosion typically transforms the rock.

Fig. 4: Ceiling pockets in Suhadolica
Sl. 4: Stropne kotlice v Suhadolici

ROCKY RELIEF OF CIGANSKA JAMA NEAR PREDGRIŽE

All over the cave (Fig. 5) the older traces of water flow in the phreatic zone mingle with dispersed vertical infiltration (Fig. 6), still active. The last process is less efficient as the traces of former cave development are well preserved. On the bottom of the narrow part of the passage, with rounded cross section, scallops are preserved; ceiling pockets may be found all over the

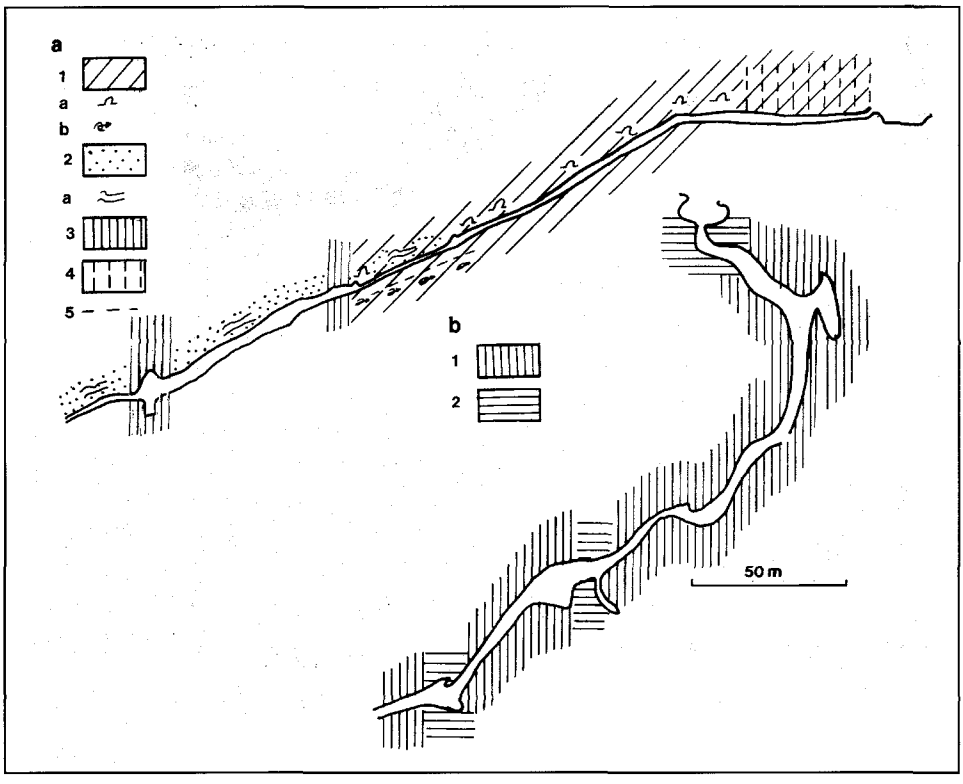

Fig. 5: Rocky relief and its hydrological zones of formation in Ciganska jama

A 1. rocky relief formed by water flow
a. ceiling pockets
b. scallops
2. rocky relief along the sediment
a. above-sediment channel
3. rocky relief formed by trickling water
4. rocky relief transformed by condensation corrosion
5. floor channel

B 1. epiphreatic zone
2. vadose zone

Sl. 5: Skalni relief in hidrološke cone njegovega oblikovanja v Ciganski jami

A 1. skalni relief, ki ga oblikuje vodni tok
a. stropne kotlice
b. fasete
2. obnaplavinski skalni relief
a. nadnaplavinski žleb
3. skalni relief, ki ga oblikuje polzeča voda
4. skalni relief, ki ga preoblikuje kondenzna korozija
5. talni žleb

B 1. epifreatična cona
2. vadozna cona

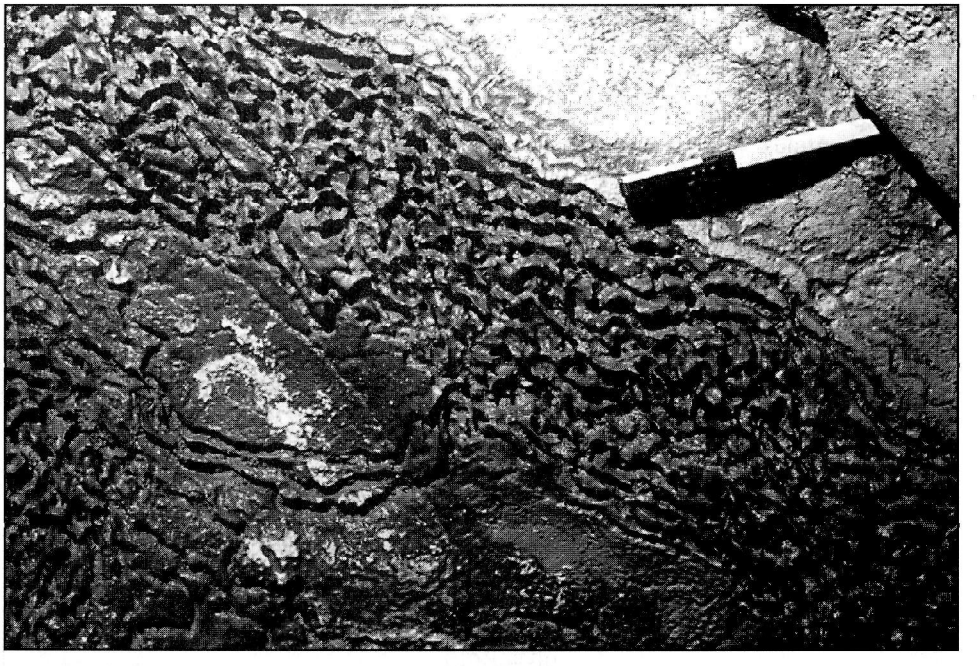

Fig. 6: Half tubes on overhanging wall due to trickling of smaller amount of water
Sl. 6: Žlebiči na previsni steni so posledica polzenja manjše količine vode

cave. The scallops developed in the phreatic zone, as an open conduit would cut smaller forms in a passage with considerable gradient. Large discharge is characteristic for the bottlenecks in the channels. In the spacious parts of cave, and in the fissures of the narrow part too, the ceiling pockets developed. Flood waters later filled the cave with fine-grained sediments and above them the smaller water quantity flowed over ceiling channels. The water flow that transported the deposits out of the cave partly transformed the ceiling channel too. Due to ground water lowering, the water only infiltrates through the old passages. It incises potholes and flutes. The transition period was progressive; in some floor pits caused by water dripping from the ceiling there is preserved the fine-grained sediment deposited by seasonal flood waters. They flooded the cave from down upwards. Today a weak condensation corrosion transforms the entrance parts of the cave.

LOGAŠKA JAMA ROCKY RELIEF

Logaška jama lies south from the old road leading from Logatec towards Vrhnika, below Veliki hrib. Below the 35 m deep entrance pothole the

passage is oriented N and S. The central part of the passage, about 5 m wide and from 5 to 10 m high, has a semicircular ceiling. Part of the southern branch is similar; the northern branch ends in a smaller chamber from which a small passage leads along the fissure. A part of the cave is transformed by breakdown and covered by flowstone, on the bottom; in particular at the end of the northern branch there are many fine-grained deposits. Large scallops and ceiling pockets (Fig. 7) show that a slow water flow drained through the main flooded passage. Smaller scallops on the lower part of the walls of the same passage are covered by traces of larger discharge. It was free water flow. If the water flow had filled the entire passage it would have transformed the upper part of the rocky surface as well. Youngest may be the period of flooding of the lower chamber where the water deposited fine-grained deposits. The below-sediment flutes developed there. Gams (1964, 15) too infers that the water from this part of the cave drained through the corrosion fissure after the period of main accumulation. The entrance pothole was widened by trickling waters. Its walls are covered by flutes. Aggressive water dissected the ceiling of the main passage into chimneys and probably transformed the ceiling pockets along the fissures.

Fig. 7: Ceiling pockets in Logaška jama
Sl. 7: Stropne kotlice v Logaški jami

Logaška jama may be attributed to the former Ljubljanica river basin and the karstification to the subsidence of Ljubljana Moor. I do not have temporal indices of the cave development. Implying the caves to be of the same river basin I may presume that a slow stream drained through the water-filled cave at the beginning of the Quaternary while larger discharge flowed through the cave in the middle Pleistocene until the floods did not only occasionally appear from lower lying channels.

CONCLUSION

The karstification is mainly the result of vertical dissection of karst landscapes in terms of related impermeable rocks which reperesent the water barrier. The vertical karst dissection is the result of tectonics and erosional lowering of the valleys and lowered surfaces. The more intensive the karstification, the better the characteristic rocky relief is preserved in the vertical section of the caves. Tectonic dissection of the lowered surface and formation of a piezometric water table by depositing sediments and incising of the water flow into the rocky bottom of the passages enabled the progressive development of Križna jama. Cave development at almost the same altitude as the related impermeable barrier does not allow the preservation of the old rocky relief. Various formation processes appear, and the more distinct younger ones cover older traces of the cave development. It is characteristic in particular for the karst areas which subside and where the waters deposit sediments. In Cerknica cave systems younger processes occurred at approximately equal altitude above the sea level. This is evidenced by the Mala Karlovica and Zelške jame rocky relief composed rocky forms which are the traces of the youngest development phases. Ciganska and Logaška jama formed by water flows in lower zone and situated today high above the piezometric water level are transformed by percolating water only. They are clearly polygenetic caves.

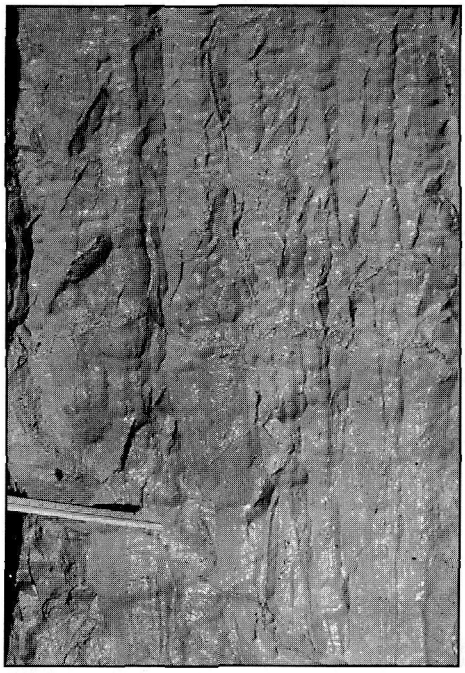

Fig. 8: The shafts wall shaped by trickling water
Sl. 8: Stena brezna, ki jo oblikuje polzeča voda

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SKALNI RELIEF V IZBRANIH JAMAH NOTRANJSKEGA PODOLJA

Povzetek

Pri proučevanju nastanka in oblikovanja jamskih skalnih oblik se je izkazalo, da so te, zlasti če jih povežemo v skalni relief, pogosto pomembna speleogenetska sled. To spoznanje nam potrdi tudi proučevanje skalnega reliefa izbranih jam Notranjskega podolja. Izsledki nam služijo pri opredeljevanju nastanka in razvoja tega morfogenetsko povezanega kraškega predela. Izbral sem jame na pritočni (Križno jamo) in odtočni (ponorno Malo Karlovico in Zelške jame) strani Cerkniškega jezera ter izvirno Planinsko jamo, v kateri se stekajo vode Pivke in Raka. Na SZ, višjem delu Notranjskega podolja, torej ob robu Črnovrškega polja (Gams 1974), pa sem proučil Cigansko jamo pri Predgrižah. Logaška jama je stara jama na Logaškem ravniku.

Zakrasevanje je predvsem rezultat navpičnega členjenja kraških predelov glede na okolne neprepustne kamnine, ki predstavljajo vodni jez. Navpično členjenje krasa pa je posledica tektonike in erozijskega nižanja okoliških dolin ter podolij. Hitrejše je zakrasevanje, lepše je v navpičnem prerezu votlin ohranjen značilni skalni relief. Tektonsko razčlenjevanje podolja in oblikovanje piezometričnega vodnega nivoja z odlaganjem naplavin in vrezovanjem vodnega toka v skalno dno rovov je omogočilo postopen razvoj Križne jame. Razvoj votlin na skorajda enaki nadmorski višini, glede na okoliški neprepustni jez, onemogoča ohranitev starega skalnega reliefa. V njih se lahko zvrstijo različni

oblikovalni procesi in izrazitejši, mlajši prekrivajo starejše sledi jamskega razvoja. To je značilno predvsem za kraške predele, ki se grezajo in v katerih vode odlagajo naplavine. Tudi v Cerkniškem jamskem sistemu so se mlajši procesi vrstili na približno enaki nadmorski višini. To nam dokazuje tudi skalni relief Male Karlovice in Zelških jam, ki ga sestavljajo skalne oblike, ki so sledi najmlajših razvojnih obdobij. Cigansko in Logaško jamo, ki sta se oblikovali z vodnimi tokovi v nižinski coni, danes pa sta visoko nad piezometričnim nivojem vode, preoblikuje prenikajoča voda. Sta torej izrazito poligenetski.