Unroofing of a Cave System – an Example from Classical Karst

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Abstract

Old caves are being exposed due to lowering and dissecting of a karst surface. The surface either uncovers or intersects them. In the first case the unroofed caves display the form of an oblong indentation and in the second a doline-like feature. Repeatedly intersected passage is shown as a series of described features. The most expressive are these features when the transport of sediments out of the caves is faster than the lowering of the nearby carbonate surface. A bigger cave system near Kozina indicates a diversity of exposing types. A smaller and already vacant passage was known before the earth works for motorway construction started. Other passages were filled up by fine-grained and gravel flysch deposits. Some of them have a thin roof other were roofless already. At the surface parts of a cave system are seen as a system of different indentations and doline-like features.

1. Introduction

Motorway construction reveals karstic relief and even frequently cuts deep into it, exposing a variety of interesting karstic phenomena and features of the development of the hollowed karstic aquifer and the formation of the karstic relief and composed epikarst. The construction of the last 50 km of motorway in the Karst has exposed over 300 caves; two thirds are filled with sediment and gravel and nearly one third are without ceilings (KNEZ & SLABE, 1999; KNEZ & ŠEBELA, 1994; KOGOVŠEK *et al*., 1997; MIHEVC, 1996; MIHEVC, 1999; MIHEVC & ZUPAN HAJNA, 1996; SLABE, 1996, 1997a, 1997b, 1998; ŠEBELA & MIHEVC, 1995; ŠEBELA *et al*., 1999). The latter were of special interest to us because they proved to be a more common karstic phenomena than was thought before they were exposed (Fig. 1). We also identified their characteristic forms (MIHEVC *et al*., 1998; KNEZ & SLABE, 2001, to be published).

This paper is an overview of experience gained in past years of research into this interesting karstic phenomenon. This includes current results, as motorway construction is ongoing and we are still performing karstological monitoring. We are of the opinion that more attention should be directed towards this karstic phenomenon even though it is not a new discovery. Our text focuses on cases in the Classic Karst, i.e. the Karst from which the name of all carbonate rock landscapes on which karstology has formed is derived (KRANJC *et al*., 1997, 1999).

The Classical Karst is a karstic plateau overlooking the boundaries of the north-western part of the Adriatic Sea. It is composed primarily of highly pure rudist Cretaceous and mostly foraminiferal Tertiary limestones, and in some places dolomites and clastits. The central part of the plateau is between 200 and 500 m above sea level. The 440 km^2 plateau was until recent times almost completely bare of plant cover, now is covering by forest. To the north-west it borders on the Vipava valley and to the south-east on the vast flysch area, where it rises to over 600 m above sea level. Its north-western boundaries are the Friuli lowlands and the Soča river; to the south-west lies the Adriatic Sea.

Our research did not uncover any traces of surface flows, which in the past was thought to explain the formation of the plateau surface. However, due to the karstification of carbonate rock the water level in the aquifer dropped to the present 200 m and more below the surface. Surface flows do not exist in the Karst. All karstic flows disappear underground in the area of contact between the flysch and the limestone bedrock. Of greater significance are the karstic aquifer and the sub-surface flows of water to the source of the Timavo river in Italy. The largest underground flow is the Reka river, which disappears underground in the Škocjan caves. From an environmental viewpoint the Karst is one of the most vulnerable natural systems in Slovenia.

2. Morphology of Relief Above Cave System

The relatively flat surface located between 520 and 530 m above sea level and with separate steep steps is segmented by dolinas and dolina-like landforms up to 10 m deep and 50 m in diameter, as well as oblong depressions up to 70 m long, 3 m deep (i.e. relatively shallow) and 5 m wide. Dolinas and dolina-like landforms with semicircular and oval cross-sections are separate or in pairs. We also observed the layout of dolinas in series parallel to the contour lines and 600 m in length. Cave passages appeared during motorway construction along the whole length of the series. The oblong depressions were located independently on the surface, some running from the dolinas and some connecting them. Real dolinas were filled with thick layers of soil or developed karren of a metre or more in depth. Removing the soil uncovered traces of water percolating at the perimeters of the karren and cracks through which surface water runs off on the bottom.

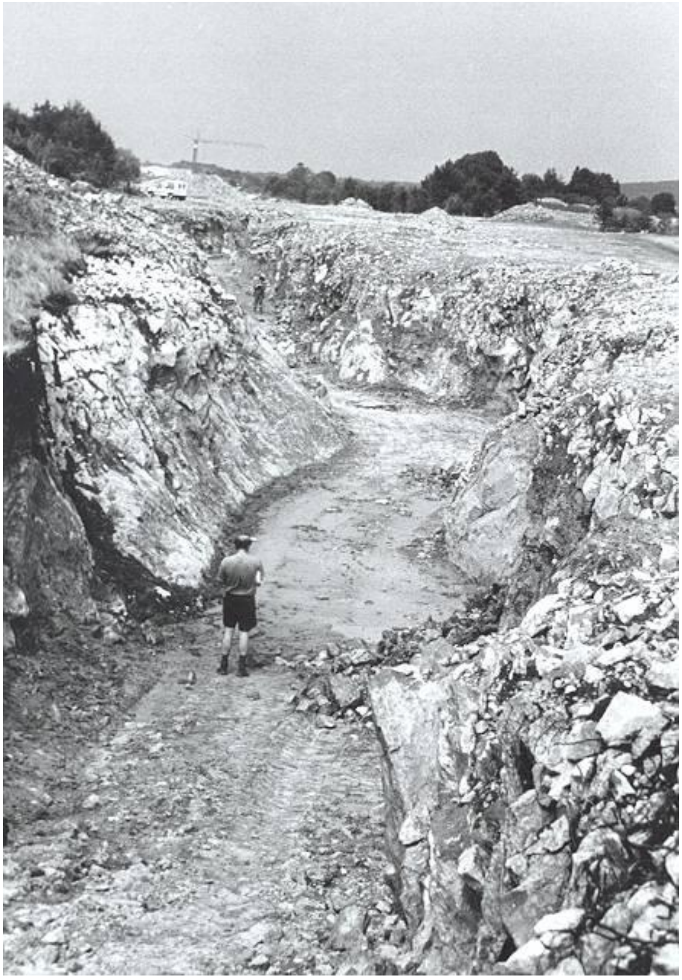

Figure 1. Unroofed cave.

3. Form of Cave System

The area under discussion contained a known, small and empty cave. Its bottom was covered with collapse rock and the lateral extension of the cave was filled with angular gravel.

We had predicted that unroofed caves would appear during the groundwork that bared the karstic surface; this was confirmed. Unroofed caves (Fig. 2) were individual dolina-like landforms that had developed in the middle of old passages, or oblong depressions as individual landforms on the karstic relief or intertwined with small dolinas. The dolinas were interrupted by preserved sections of the old ceiling. One characteristic of unroofed caves, which are in the majority and at the same time preserved as individual landforms, is the filling of the cave with sediments and flowstone. After the sediments and flowstone were removed from the caves, individual passages appeared. They were up to 5 m in diameter, while only the largest part of the cave, which on the surface gave the appearance of a landform similar to a shallow dolina, was up to 10 m in diameter. We concluded that the caves exposed by groundwork were below the 600-m-long series of dolinas and depressions of the same cave network. The enclosed drawing of part of the cave system being presented clearly shows how the dolinas cut through the network of cave passages. Individual passages opened in the cross-sectional direction during road bed construction, indicating that a thin passage ceiling was preserved.

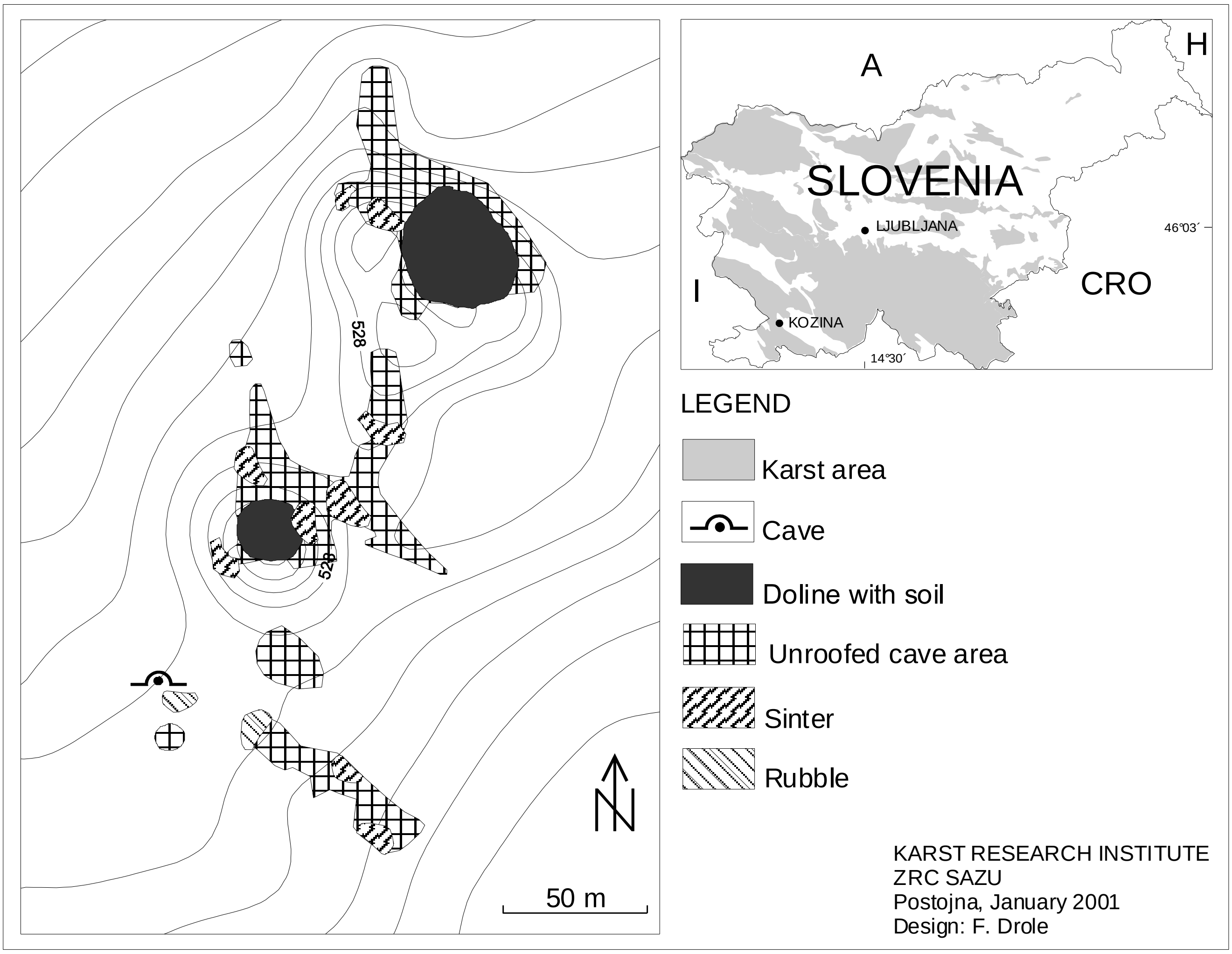

Figure 2. Part of the cave system at Kozina.

4. Sediments

The caves were filled primarily with sediments, flowstone and Pleistocene gravel. The filled space in the cave ensures better stability of the rock; this is why the ceiling in such passages can be thinner.

One third of the cave in the motorway construction area revealed a layer of yellow-brown sediment of flysch origin up to a few metres thick (Fig. 3). A fine-grainy sediment of sand size and fine gravel with separate layers of rubble were prevalent. Rubble stones with a diameter of over 10 cm were rare. The rubble and fine-grainy sediments are traces of underground water flows and floodwater in the caves. In addition to the yellow-brown sediment of flysch origin in the filled caves, we found a lateral dark red sediment which is younger and is the result of surface carbonate weathering. Both genetically different sediments are clearly delineated. They present the typical filling of underground passages. Soil was located above them in vertical fissures.

Stalagmites were rare among the flowstone whereas flowstone piles were more numerous. The flowstone was intensively white- to black-coloured, depending on the level of cations and oxides in the solution. Most of the observed flowstone was still compact; a smaller part disintegrated intensively into calcite debris on contact with atmospheric air. Paleogenetic limestone in this part of the Karst is thick-bedded and quite deformed, and is thus less resistant to weathering. During the Pleistocene Epoch it disintegrated into angular gravel; in some locations it covered areas of over 100 m^2 and in others it filled caves. We frequently found it over old flow sediments or filling space under sills. Due to Pleistocene material shifting, the angular gravel is often found mixed with loam, flysch sediments, finer sand and pieces of flowstone. The flowstone is sometimes found in its original location (stalagmites).

The filling type indirectly determines the speed at which the underground space empties and disintegrates.

Paleomagnetic research of the upper layers of yellow-brown sediment which fills the underground passages showed a normal magnetic turn, placing them in a period more recent than 0.73 Ma (ŠEBELA & SASOWSKY, 2000). The lower-lying sediments are much older. Paleomagnetic analyses performed by Šebela and Sasowsky showed a normal Gaussian curve (2.48-3.4 Ma) and Gilbert reverse period (3.8-5.9 Ma). BOSAK *et al*. (1998, 2000) also found a turn between the Brunches and Matuyama epochs. The latter data indicates the possibility that the cave formed before the Messina Age, characteristic of which is the lowering of the sea level and the development of karst in the Mediterranean area connected to it. After it was over, the cave filled with sediment.

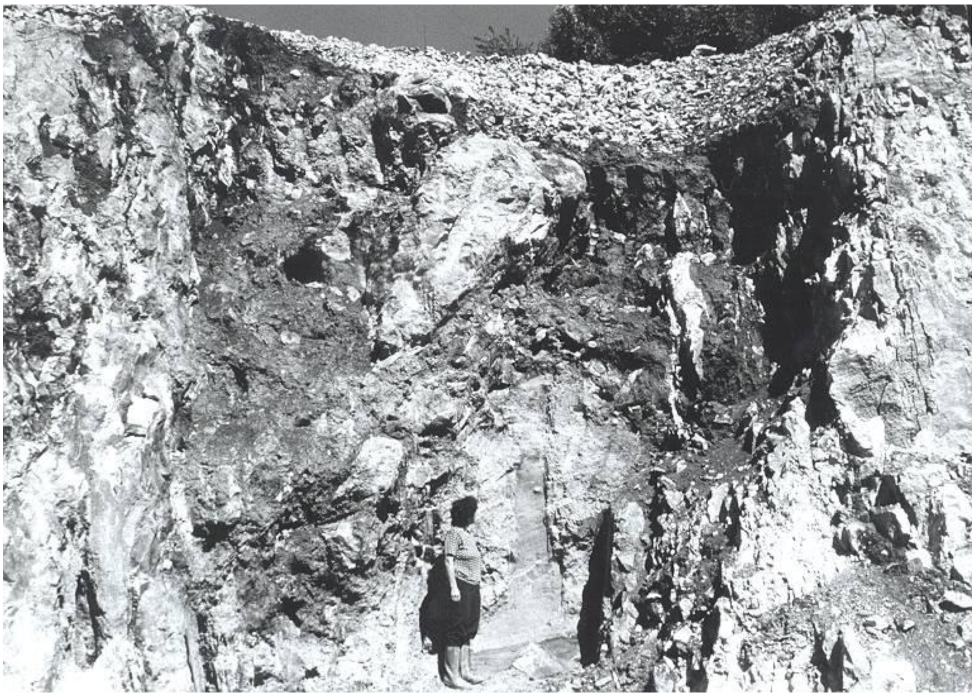

Figure 3. Sediments in unroofed cave

5. Conclusion

The lowering of the karstic relief gradually exposed a large, horizontally and vertically branched-out cave network, mostly filled with sediment and gravel. A portion of the passages still have thin ceilings; others opened to the surface as they became unroofed caves. Larger horizontal passages opened as oblong depressions, their parts and steep passages cut by surface have dolina-like shapes. Dolinas cut through the cave network in a number of locations. Unroofed caves are a more discernible landform when located in the vicinity of dolinas or where water can rapidly remove the sediment from the cave. The exposure of the cave network is thus a significant surface karstic phenomena and part of the epikarst. The proportion of this phenomenon in the observed part of the karstic relief also demonstrates its significance.

The landforms of unroofed caves, which include dolina-like landforms, series of such landforms and oblong depression (KNEZ & SLABE, 2001, to be published), are the consequence of cave forms and the development of the relief above them. The relation between the speed of sediment removal from the cave and the lowering of the surrounding relief determines how discernible these landforms are.

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