Collapse Dolines and Passages of Postojnska Jama Cave System

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Abstract

The surface above the longest Slovene karst cave Postojnska Jama Cave System (20 km) is characterized by numerous dolines and collapse dolines. We have 17 collapse dolines in the area of 2,55 km^2. They vary in depth, shape and size. Some have steep slopes where collapse blocks look fresh others are relics of former collapse dolines with gentle slopes. The deepest collapse doline is basically the entrance shaft to Pivka Jama Cave (77 m), the biggest collapse doline is Vodni dol (600x240x60 m). Most of collapse dolines is situated near the crest of Postojna anticline, on it's northern flank. Development and especially deepening of collapse dolines like Velika and Mala Jeršanova doline, Vodni dol and Kozja Jama has a genetic connection with the lowering of Postojnska Jama Cave System active water passage into SW and NW passages due to the regional tectonic uplifting.

Introduction

The surface above the longest Slovene karst cave Postojnska Jama Cave System (20 km) is characterized by typical karst features as dolines and collapse dolines (CAVE REGISTER IZRK ZRC SAZU). Between numerous dolines we determined 17 to be significant collapse dolines. GOSPODARIČ (1976) related their position to the cave passages ground plan, and to the contact between limestone and flysch. Thereby he tried to find a connection between the defined geological structural element directions such as fault zones, anticline and syncline axes, with the collapse doline locations.

With detailed tectonic-lithological mapping of the area around Planina polje, Pivka and Črna Jama ČAR (1982, 1983) included the position of collapse dolines to geological structure. In 1996 (ŠEBELA) the situation of some dolines above Postojnska Jama Cave System was connected with collapse chambers in the cave. In 2000 (ŠEBELA & ČAR) detailed geological studies of Velika Jeršanova doline have been performed. This is one of less expressed collapse dolines above the Postojnska Jama Cave System. The actual shape of it represents a relic of a former well expressed collapse doline.

Based on CRAMER's (1944) work the collapse doline should be a direct result of a cave roof collapse, appearing on the karst surface. An additional condition is very usual, viz. »the diameter exceeds the depth« (GAMS et al., 1973). HABIČ (1963) stated that collapse dolines enlarge with underground water flow taking the collapse material away. Collapse dolines result simple falling-in of cave roofs. Calculations show that the primary cave chambers reduce, when moving towards the earth surface, owing to the loosening of the collapsed mass (ŠUŠTERŠIČ, 1968). According to LOWE & WALTHAM (1995) the collapse sinkholes represent a variety of closed depressions that form by collapse of the rock above an existing cave passage or chamber. Collapse dolines are funnel-shaped or deep shafts formed by the collapse of a cave roof. They may contain a lake if the water-table is sufficiently high (FARRIS-LAPIDUS, 1990).

Collapse Dolines and Geological Structure

Postojnska Jama Cave System is developed in Upper Cretaceous limestones. Cave passages are developed inside bedding planes which are deformed into Postojna anticline, which axis direction is NW-SE. This is also the most common direction of fault zones in the area and is called Dinaric direction. Tectonic deformations of the area belong to tectonic activities after the Eocene flysch deposition. In 1998 a detailed tectonic geological map of the cave passages was published (ŠEBELA, 1998). Beside geological structure of the area, the surface and underground karst features were studied.

We selected 17 collapse dolines. They vary in depth, shape and size. In Table 1 we showed the altitude of the bottom of collapse doline in meters, the length of long and short axis in meters, depth of the collapse doline, prevailing direction of long axis, surface area determined by upper edges and directions of prevailing geological structures.

NUMBER and NAME	ALTITUDE OF THE BOTTOM in m	ENTRANCE TO THE CAVE	LONG AXIS in m	SHORT AXIS in m	DEPTH in m	PREVAILING DIRECTION OF LONG AXIS	SURFACE in m^2	PREVAILING GEOLOGICAL STRUCTURES
1.Pivka Jama	473	Pivka Jama of Postojnska Jama Cave System	75	45	77	46^0	3.152,00	fault zones 30/75, 160/90
2.Drča dolina	529	/	120	95	31	347^0	9.403,00	fissured zone 160/90
3.Kozja Jama	502	/	210	120	73	6^0	22.043,00	fault zone 130/70, 150/70
4.Ruglovica	506	Ruglovica	30	20	52	90^0	615,00	fissured zone 150/80
5.SE from Ruglovica	559	/	20	20	10	0^0	285,00	fissured zone 0/90, 20/80
6.Vodni dol	497	/	600	240	60	56^0	123.713,00	fault zones 70/90, 130/80, 150/70
7.S from Drča dolina	523	Matevž passage of Postojnska Jama Cave System	350	140	32	125^0	35.421,00	fissured zones 160/90, 20/80
8.Črna Jama	531	Črna Jama of Postojnska Jama Cave System	80	75	39	0^0	4.775,00	fault zone 0/90
9.Magdalena Jama	549	Magdalena Jama of Postojnska Jama Cave System	10	10	20	0^0	149,00	fissured zone 150/80
10.near Magdalena Jama	530	/	205	185	30	25^0	28.441,00	fault zone 140/90
11.near M. and V. Jeršanova dolina	549	/	225	155	21	120^0	23.698,00	fissured zones 160/90, 170/90
12.Mala Jeršanova dolina	539	Zguba Jama	245	235	21	25^0	41.944,00	fissured zones 0/80, 30/90
13.Velika Jeršanova dolina	535	/	300	280	40	310^0	69.717,00	anticline 140/75, fault zone 140/90
14.N from Jama Koliševka	536	/	90	75	29	90^0	5.415,00	fault zones 30/90, 130/90
15.Jama Koliševka	553	Jama Koliševka	60	50	17	0^0	2.303,00	fault zones 130/90, 30/90
16.Stara Apnenica	554	/	130	125	41	103^0	12.250,00	fault zones 130/80, 150/80, 70/90, 80/90
17.Kafrna dolina	573	/	40	25	20	90^0	926,00	fault zones 70/90, 80/90

Table 1. Morphological and geological characteristics of collapse dolines above the Postojnska Jama Cave System.

Some collapse dolines have steep slopes others are relics of former collapse dolines. Vodni dol (bottom at 497 m) is the most extensive collapse doline (600x240 m and 60 m deep). The second is collapse doline south from Drča dolina (350x140 m and 32 m deep) and the third is Velika Jeršanova doline (300x280 m and 40 m deep). The deepest collapse doline is the entrance shaft to Pivka Jama Cave (77 m). Kozja Jama is the second deepest collapse doline with the depth of 73 m, and Vodni dol is the third deepest collapse doline with 60 m. Between 17 collapse dolines 4 (Pivka Jama, Kozja Jama, Ruglovica and Vodni dol) have lower bottom than is the entrance sink of river Pivka into the cave (511 m), but they are anyway higher than the downstream sump in Pivka jama. We have the possibility to reach underlying cave passages from 7 collapse dolines (Table 1). From collapse dolines Pivka jama, the one south from Drča dolina, Črna Jama and

Magdalena Jama we have the access to the passages of Postojnska Jama Cave System. The smaller caves Ruglovica, Zguba Jama and Jama Koliševka, which are also accessible from collapse dolines, are situated at higher levels than passages of Postojnska Jama Cave System.

The Velika Jeršanova doline (a.s.l.=535 m) is situated on the surface above the Postojnska Jama Cave System. Its deepening undoubtedly interrupted the continuation of Pisani rov (a.s.l.=535,5 m) towards N. Through the Velika Jeršanova doline the Postojna anticline crest runs in the direction of NW-SE. The same direction has the Jeršan fault. The Velika Jeršanova doline today does not have the typical shape of a collapse doline. The main cause for the untypical collapse shape of Velika Jeršanova doline is its formation in the Postojna anticline crest, its shaping in thin bedded clay - rich limestones and intensive erosional lowering of the area. Regarding the actual shape of the slopes and outer edges, the Velika Jeršanova doline is a relic of a former well shaped collapse doline (ŠEBELA & ČAR, 2000).

Longer axes of collapse dolines were determined according to the longest distance between upper edge and across the collapse doline bottom. Shorter axis is perpendicular to the longer axis and runs through the collapse doline bottom (Figure 1). Tectonic structural elements which were used for rose diagram (Figure 3) were taken from detailed geological maps in the scale 1:5.000 (ČAR, 1983; ČAR & ŠEBELA, 1997; ŠEBELA, 1994; ŠEBELA & ČAR, 2000).

On 2 rose diagrams (Figures 2 and 3) we presented the comparison among principal orientation of collapse dolines and principal directions of tectonic structures which can be observed inside the collapse dolines. The most common direction of longer axis of collapse dolines (Figure 2) is N0-10^{0}E (29,4%), the second most common direction is N90-100^{0}E (17%). Regarding geological structural elements which can be detected in collapse dolines fault and fissured zones prevail. Velika Jeršanova doline is developed inside the Postojna anticline axis. Two most prevailing orientations of tectonic structures (Figure 3) inside collapse dolines are N40-50^{0}W (15,2%) and N20-30^{0}W (15,2%). Three directions, which are N10-20^{0}W, N0-10^{0}E and N30-40^{0}E, represent 12% each.

We can conclude that the most common direction (29,4%) of collapse dolines longer axis fits to the tectonic zones orientation in the same direction with just 12%. The prevailing longer axis direction of collapse dolines is not the same as is the prevailing direction of tectonic zones. Collapse dolines longer axis orientation is more consistent than are directions of tectonic zones.

Conclusions

Most of the collapse dolines is situated on the northern flank of Postojna anticline. The Postojna anticline runs through Velika Jeršanova doline (number 13 on Figure 1) and continues south from the collapse doline near Magdalena Jama (number 10 on Figure 1). Just four collapse dolines are situated on the SW flank of the anticline. The surface area of collapse dolines marked with numbers 1-13 (Figure 1) is developed at lower altitudes than is the southern area. Development and especially deepening of collapse dolines like Velika and Mala Jeršanova doline, Vodni dol and Kozja Jama has a genetic connection with the lowering of Postojnska Jama Cave System active water passage into SW and NW passages. Regional tectonic and hydrologic processes which caused the uplifting of area SE and E of Postojnska Jama Cave System influenced the lowering of the active waters into the lower passages in the direction towards SW and W. By studying the evolution of early karst aquifers, GABROVŠEK (2000) pointed out that after the breakthrough the water-table will decline. This can be one of important periods for intense deepening of collapse dolines.

With statistical evaluation of most frequent directions of the collapse doline longer axes orientation and most frequent directions of the fissured zones we realized that there is not a good statistical correlation. The direction of most longer axes doesn't correspond well with the most common direction of tectonic zones. Some collapse dolines as the one S from Drča dolina (number 7 on Figure 1) have Dinaric orientation (NW-SE), others like Vodni dol (number 6 on Figure 1) have cross-Dinaric orientation of the longer axis. In just five collapse dolines (Drča dolina, Črna Jama, Magdalena Jama, Ruglovica and collapse doline near Magdalena Jama) there is just one prevailing tectonic zone, all others are situated at the crossing of two or more important tectonic zones. According to Čar (1982) the crossing of fissured zones is especially favorable for development of collapse dolines.

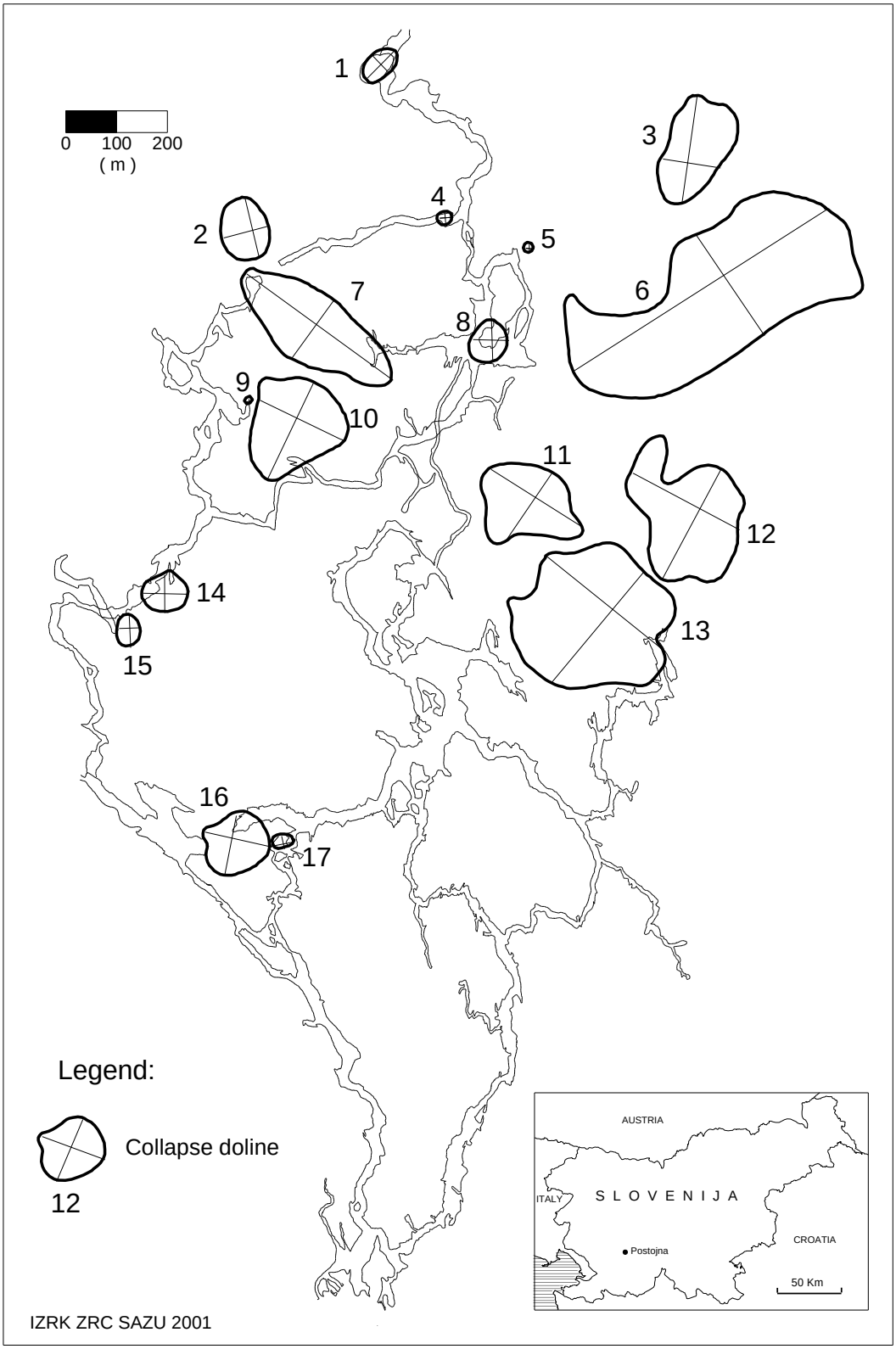

Figure 1. Position of collapse dolines above the passages of Postojnska Jama Cave System. The crossing between longer and shorter axis represents the collapse doline bottom. Numbers of collapse dolines are explained in Table 1.

Processes of surface corrosion and erosion and development of collapse dolines morphologically lowered the area with the highest density of collapse dolines. Collapse blocks and cave sediments which have not been carried away by active waters plug some passages of Postojnska Jama Cave System on the NE edge. The fact is that most of principal tectonic zones which control the development of collapse dolines are younger than Eocene flysch. The oldest cave sediments found in Postojnska Jama Cave System are 0,73-

0,90 Ma years old (ŠEBELA & SASOWSKY, 1999) and regarding their position in the cave we conclude that in the time of their deposition the collapse dolines have not been developed at the stage which can be observed today. They might have existed but their collapse blocks have not plugged the passages yet. The final lowering of Velika Jeršanova doline to the level of cave passages can be related to the period younger than 0,73 Ma (ŠEBELA & SASOWSKY, 1999) what is the age of cave sediments with collapse blocks which plug the NE edge of cave system.

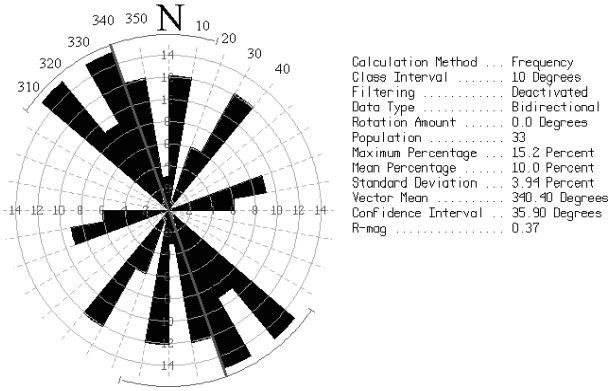

Figure 2

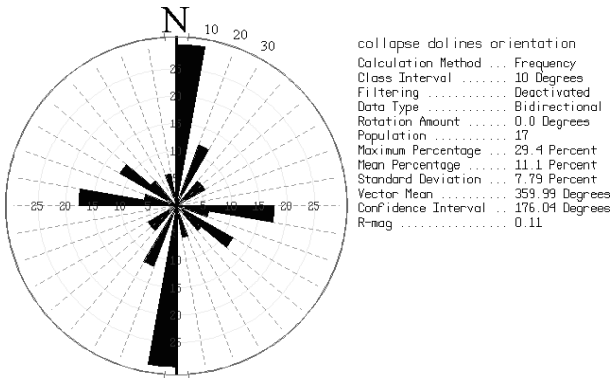

Figure3

Figure 2. Rose diagram of the most common direction of collapse dolines longer axes. Longer axes are calculated regarding their direction, the longer length of axis is not calculated with stronger values.

Figure 3. Rose diagram of directions of tectonic zones measured inside collapsed dolines. Data for tectonic zones were taken from ČAR, 1983; ČAR & ŠEBELA, 1997; ŠEBELA, 1994; ŠEBELA & ČAR, 2000.

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