JAPAGE: THE COLLAPSE DOLINES ON KUPRES POLJE, BOSNIA AND HERZEGOVINA

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Abstract
Kupres polje is situated within the Dinaric karst of western Bosnia and Herzegovina. In close proximity to the north-eastern edge of the polje is a group of collapse dolines which are locally referred to as *Japage*. The study revealed that the position of collapse dolines has been strongly influenced by the lithology governing the formation of a cave system which is undermining material in the subsurface below the dolines. The presence of the undermining process, as well as surface alluvial accumulation, strongly influenced the morphology of the doline floors.

Key words: karst, collapse doline, Kupres polje, Bosnia and Herzegovina

JAPAGE: UDORNICE NA KUPREŠKEM POLJU, BOSNA IN HERCEGOVINA

Izvleček
Kupreško polje se nahaja na dinarskem krasu v zahodni Bosni in Hercegovini. V bližini severovzhodnega roba polja leži skupina udornic, ki se imenujejo *japage*. Rezultati raziskave so pokazali, da je razporeditev te skupine udornic pogojena s kamninsko sestavo, ki je vplivala na razvoj jamskega sistema, ki spodkopava material pod udornicami. Prisotnost spodkopavanja in prav tako površinske rečne akumulacije sta bistveno vplivala na oblikovanost dnov udornic.

Ključne besede: kras, udornice, Kupreško polje, Bosna in Hercegovina

1. INTRODUCTION

The Dinaric Alps are positioned between the Pannonian Basin to the northeast and the Adriatic Sea to the southwest. They stretch in a northwest-southeast direction, with a total length of 645 km and a width of about 150 km. The Dinaric Alps are divided into three main natural belts in which morphology has been strongly influenced by differences in lithology. Non-carbonate rocks hosting fluvial relief prevail inland, while karst landscape dominates in the central and outer belts which are built predominantly of carbonate rocks. The karstified area of the Dinaric Alps is referred as Dinaric karst which is alleged to be the most developed and typical karst region in the world (e.g. Cvijić, 1923; Mihevc, 2010). Characteristic forms associated with the karst area of the Dinaric Alps are small karst features such as uvalas, dolines, canyons, dry valleys and collapse dolines, as well as extensive mountains, large levelled corrosion plains and intramontane basins which host poljes (Mihevc, 2010).

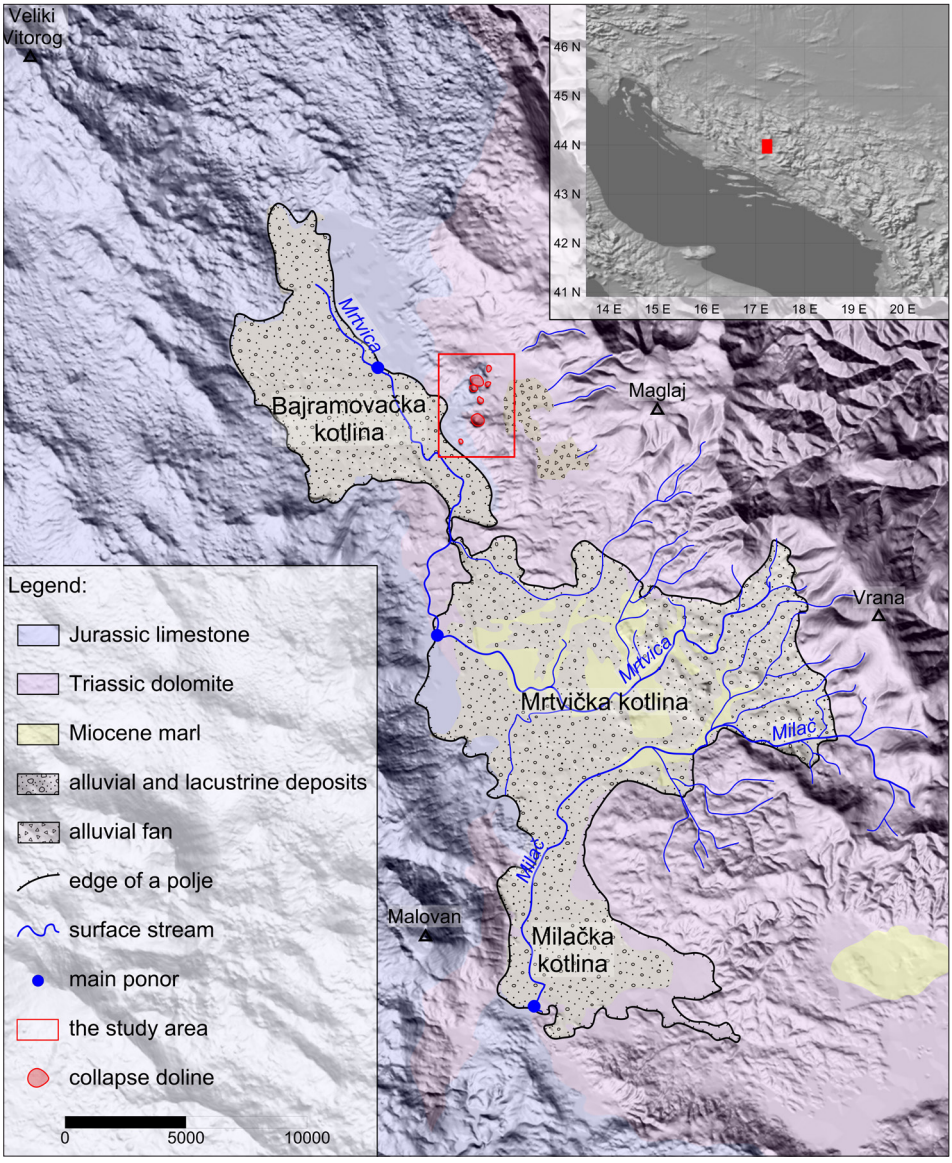
The Kupres polje is one of the biggest poljes within the central part of the Dinaric karst. It is situated in the western part of Bosnia and Herzegovina. This article discusses Kupres polje and a group of collapse dolines positioned close to its northeastern edge. The research is focused on the geomorphological analysis of the collapse dolines through detailed morphographic, morphostructural and morphometric study. Morphogenesis and recent functioning of the collapse doline group is discussed on the basis of data obtained through geomorphological analysis.

2. GENERAL OVERVIEW OF THE RESEARCH AREA

Kupres polje is positioned in western Bosnia and Herzegovina north of Duvno polje and east of Glamoč and Livno poljes, stretching in a northwest-southeast direction. It is 24 km long, 10 km wide and covers an area of 93 km^2. The flattened areas of the polje are on an elevation of about 1130 m. The whole polje is surrounded by higher relief in which the most dominant peaks are Veliki Vitorog (1906 m a.s.l.) to the northwest, Malovan (1826 m a.s.l.) to the west, Maglaj (1703 m a.s.l.) to the northeast and Vrana (1758 m a.s.l.) to the east. The flat floor of the polje is not uniform, but dissected into three basins: Bajramovci basin (Bajramovačka kotlina) to the north, Mrtvica basin (Mrtvička kotlina) in the central section and Milač basin (Milačka kotlina) to the south (Mijoč, 2011).

Kupres polje is filled with Quaternary deposits of mostly alluvial and lacustrine sediments. Mrtvica basin is positioned in the central part of the polje and consists of alluvial and lacustrine sediments as well as of Miocene marl. The elevated area around the Kupres polje is built mainly of Triassic dolomite and Jurassic limestone. Triassic dolomite in the area is generally bedded including thin strips of limestone, while Jurassic limestone is mostly massive and in some areas also well-bedded. In general, dolomite lithology prevails on the eastern side of the polje, while the western side is mostly composed of limestone (Vujnović, 1975).

Figure 1: Geological map of Kupres polje with the study area
Slika 1: Geološka karta Kupreškega polja z območjem preučevanja



Numerous intermittent surface streams exist in the eastern part of the Mrtvica basin, which is built of Triassic dolomite and Miocene marl. Most of the streams flow towards the polje from elevated relief on the east. Among others, these include the sources of Mrtvica and Milač, the two major streams on the polje. Both streams join with their

tributaries in the Mrtvica basin, however they flow further in different directions. Milač flows towards south into the Milač basin, where it gradually sinks on the contact with the limestone on the southern side. Part of its waters reemerge in the springs of the Sušica River which runs towards Duvno polje, and another part towards the spring Duman on Livno polje. The stream Mrtvica flows towards the western part of the Mrtvica basin, where series of ponors are positioned at the contact with limestone. The waters from those ponors reemerge in the Duman spring. At higher discharges, Mrtvica flows on the polje further in a northwest direction to the Bajramovci basin. Since the majority of the Bajramovci basin is bounded by limestone lithology, the stream gradually sinks in numerous ponors along the riverbed. Subsurface flow direction from this part of the polje is oriented towards the northwest, towards the springs of Pliva River (Petrović, Prelević, 1965).

3. METHODOLOGY

3.1. Concepts

Collapse dolines are one of the most impressive surface karst forms. The formation of smaller collapse dolines is usually related to a cave chamber collapse. Volumes of larger collapse dolines exceed the volumes of the largest known cave chambers, so their formation cannot be related solely to a series of collapse processes (e.g. Habič, 1963; Šušteršič, 1973; Stepišnik, 2004, Waltham, Bell, Culshaw, 2005; Stepišnik, 2010). Development of larger collapse dolines involves a gradual removal of material above the hydrologically active cave passages (e.g. Habič, 1963; Mihevc, 2001; Stepišnik, 2004).

The duration of the undermining process defines the volume of the collapse dolines, and the dynamics of the process defines the inclination and morphology of the slopes (Gabrovšek, Stepišnik, 2011; Stepišnik, Kosec, 2011). The dominance of material removal over the bedrock weathering on the doline slopes results in the formation of steep slopes and walls (Stepišnik, 2010; Stepišnik, Kosec, 2011).

Collapse doline floors are subjected to several processes that result in the development of a variety of floor morphologies. Collapse dolines undergoing continuous removal of material above active cave passages display floors with conical shaped depressions in accumulated talus. Where the process of material removal is negligible or absent, concave floors occur which are filled with the finer fractions of weathered bedrock and are commonly covered by soil or sod. Flat floors of collapse dolines built of loamy material are the result of the occasional flooding of the doline floor with suspended load rich waters. Deposition of the load during high piezometric levels results in formation of a flat loamy floor (Stepišnik, 2003; Stepišnik, 2010).

Many morphological classifications of collapse dolines have appeared in literature. The most common is a simple subdivision of collapse dolines into ‘immature’ and ‘mature’ or ‘degraded’ (e.g. Habič, 1963; Šušteršič, 1973; Waltham, Bell, Culshaw, 2005). However, collapse doline morphology is much more complex, being a result of dynam-

ics, extent and duration of their formation processes (Stepišnik, 2010; Stepišnik, Kosec, 2011). Therefore, the classical view of collapse doline classification, which estimates their age on the basis of their general morphology, is not applicable.

3.2. Research methods

Detailed field morphographic and morphometric surveys were taken throughout whole area of the Japage collapse dolines. The geomorphological mapping consisted of morphographic and morphometric analysis of collapse dolines with special regard to their slopes and floors. The slopes were classified into active and balanced (Stepišnik, 2010; Stepišnik, Kosec, 2011) while the floors were classified into active, balanced and alluvial as suggested by Stepišnik (2010). Morphographic analysis was based on a detailed examination of the study area along with morphographic mapping using 1 : 25,000 topographic maps.

Morphometric data of the collapse dolines was obtained in the field using barometric altimeter, clinometer and GPS. Furthermore, the morphometric analysis was supported by analysis of orthophoto images and a 1 : 25,000 topographic maps. Geomorphological interpretation of collapse dolines was based solely on morphographic and morphometric data obtained through fieldwork or from maps; geologic data was obtained from geologic maps (Vujnović, 1975) and hydrologic data obtained by various sources in literature (Petrović, Prelević, 1965; Mijoč, 2011).

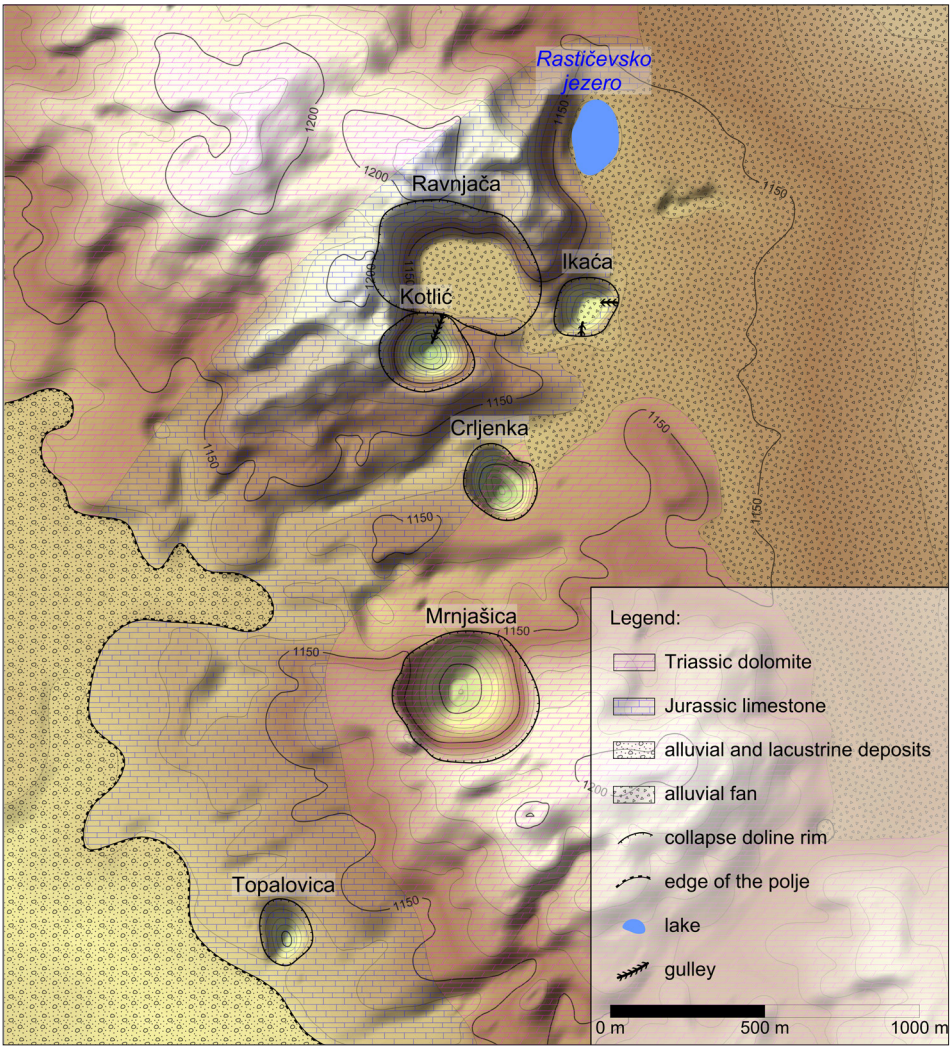
4. THE JAPAGE COLLAPSE DOLINES

Northeast of the Kupres polje, a group of seven collapse dolines locally termed Japage is positioned. According to claims of local people, the term *japaga* means a type of abyss (Marić, 2014). The dolines are organised in a scattered line in a north-south direction. They are positioned from about 200 up to 1500 m away from the floor of the polje. Their rims are from 5 to 65 m above the flat surface of the polje, which is on an elevation of 1120 m near the area of the collapse dolines.

All of the collapse dolines are positioned at the contact between Jurassic light grey massive limestone and Upper Triassic well-bedded grey dolomite, or in close proximity of this contact. These strata of different ages are separated by erosional unconformity. On the eastern side of the study area is an extensive alluvial fan influencing or completely covering some collapse dolines. The alluvial fan was formed by several intermittent streams flowing from the dolomite area on the east. Ponors of those streams were at the edge of the fan and also in collapse dolines.

There is not much data about hydrological properties in the area of the collapse dolines. We know that the waters of river Mrtvica from the Bajramovci basin drain towards the north in the watershed of the Pliva River (Petrović, Prelević, 1965). A detailed pattern of subsurface drainage is not known.

Figure 2: Map of the Japage area
Slika 2: Karta območja japag



5.1. Topalovica

The southernmost collapse doline, named Topalovica, lies some 200 m away from the flattened floor of the Kupres polje. The lowest part of its rim on the southern side is on an elevation of 1125 m, while the highest part of the rim on the north is positioned about 10 m higher. The rim of the collapse doline is almost circular, with average width of 106 m. The lowest part of the floor is on an elevation of 1095 m, while the estimated volume of the collapse doline is 0.2 Mm^3.

The collapse doline is positioned entirely in massive limestone of Jurassic age. All slopes of the collapse doline are active. The upper sections of the southern, western and northern slopes are rocky walls, other parts of the slopes are covered by scree. Scree slopes reach the lowest part of the doline which is of conical shape. The floor is covered by a couple of bigger limestone collapse blocks. One of the blocks has been carved into the shape of medieval tombstone termed *stećak*. Apparently the collapse doline was once a quarry for tombstones for a nearby medieval graveyard, dating from 10th to 11th century (Figure 3; Mijoč, 2011).

Figure 3: Medieval cemetery of stećaks in the vicinity of the Topalovica collapse doline (photo: U. Stepišnik)
Slika 3: Srednjeveško pokopališče s stečki v bližini udornice Topalovica (foto: U. Stepišnik)

5.2. Mrnjašica

The collapse doline, with the toponym Mrnjašica, is situated 500 m to the northeast of the Topalovica collapse doline. The highest part of the rim is positioned at 1195 m and the lowest at 1140 m. The lowest part of the doline floor is on an elevation of 1085 m, with an average depth of 82 m. The width of the doline which is almost a circle in ground plan is about 310 m. With these dimensions, it is the biggest collapse doline in the area, with a volume of about 4.1 Mm^3.

The lithology of the doline is solely well-bedded dolomite of Upper Triassic age. Almost all slopes of the collapse doline are balanced and covered with sod. There are some smaller areas of scree on the northern slopes. The floor of the doline is slightly flattened by regolith. Some locals claim that the floor of the doline used to be occasionally inundated during longer rainy periods. They claim that the depth of the floods in this collapse doline reached up to 5 m (Marić, 2014; Šebes, 2014).

Figure 4: The Mrnjašica collapse doline from the northwest (photo: U. Stepišnik)
Slika 4: Udornica Mrnjašica od severozahoda (foto: U. Stepišnik)

5.3. Crljenka

The Crljenka collapse doline is situated about 250 m north of Mrnjašica. It has its lowest rim on an elevation of 1135 m and its highest 10 m higher. The lowest part of the doline floor is on an elevation of 1065 m, with an average depth of about 75 m. In ground plan, the doline is elongated in a northwest-southeast direction. Its length is 195 m and width 145 m. The volume of the collapse doline is about 1.1 Mm^3.

The doline is, according to the geological map (Vujnović, 1975), positioned on the contact between different lithology. The northwestern side of the doline is positioned in massive limestone of Jurassic age, and the southeastern side in bedded dolomite of Upper Triassic age. Most of the upper sections of the slopes are extensive steep rocky walls. The colour of walls on the western slope is reddish, so the name of the collapse doline is possibly derived from it (red in Bosnian language is *crven*). Lower sections of the slopes are entirely covered by scree. The doline floor is of scree and it is conical in shape. Locals claim that this doline is also inundated on the same occasions as the nearby collapse dolines Mrnjašica and Kotlić. The depth of water in the doline can be, according to the locals, between 20 and 30 m (Marić, 2014).

5.4. Kotlić

The most impressive looking collapse doline in the area due to its extensive steep rocky slopes is the Kotlić collapse doline. It is located approximately 180 m northwest from the Crljenka collapse doline. It is situated on a gentle slope, so while the lowest rim of the collapse doline is on an elevation of 1140 m, the highest part of the rim is 50 m higher. The floor of the doline is on an elevation of 1085 m, and the average depth of the doline is 82 m. In ground plan, it is slightly elongated in a northwest-southeast direction

with a longer diameter of 215 m and shorter of 175 m. The volume of the collapse doline is about 1.7 Mm^3.

The whole area of the doline is positioned within massive limestone of Jurassic age. All upper sections of the doline slopes are vertical rocky walls, while the lower sections of slopes are covered by scree. Scree also covers the doline floor, which is conical in shape. Locals claim that the Kotlić collapse doline floor is also occasionally inundated to a depth of 10 to 20 m.

The Kotlić collapse doline is situated in close proximity to the Ravnjača collapse doline. Part of the northern slope nearest to the Ravnjača collapse doline is breached by a gap. On basis of the morphology of the gap and features on the slope below, it is evident that the gap is an erosion gulley. Therefore we have geomorphological evidence of surface streams flowing from Ravnjača into the Kotlić collapse doline.

Figure 5: The Kotlić collapse doline from east (photo: U. Stepišnik)
Slika 5: Udornica Kotlić iz vzhoda (foto: U. Stepišnik)

5.5. Ravnjača

Just north of Kotlić lies the Ravnjača collapse doline. Its floor is actually the lowest section of the alluvial fan on the east. It is completely levelled, and looks like huge amphitheatre. An extensive gap in the rim of the doline can be seen to the east nearer the alluvial fans, on an elevation of 1137 m. The highest section of the rim on the slope is on an elevation of 1195 m. The collapse doline is elongated in a northwest-southeast direction, with a length of 350 m and width of 270 m. The flattened floor is 250 m long and 160 m wide. The lowest part of the floor is at the gap where the apex of the erosion gulley at the northern slope of the Kotlić collapse doline is positioned.

The whole doline is positioned within Jurassic massive limestone and its floor is levelled and filled by an alluvium derived from a dolomite hinterland to the east. In the upper sections of the western and eastern slopes are some steep rocky walls and some limited areas of scree below them. Other sections of the slopes are less inclined, balanced and covered with sod. The levelled alluvial floor is also completely covered by sod. Some depressions on the southern side of the floor just below the slope are not natural, but rather are artillery trenches from the last war. The whole floor is filled by alluvium derived from alluvial fans. Streams were flowing through the Ravnjača collapse doline towards the gap into Kotlić collapse doline.

Figure 6: The Ravnjača collapse doline from northwest (photo: U. Stepišnik)
Slika 6: Udornica Ravnjača iz severozahoda (foto: U. Stepišnik)

5.6. Ikaća

Ikaća collapse doline is positioned about 50 m east of Ravnjača. The rim of the doline is in the level of the lowest sections of the alluvial fans on the east, at an elevation of 1335 m. In ground plan, the doline is slightly elongated in a southwest-northeast direction, with a longer diameter of 160 m and shorter diameter of 115 m. The floor is levelled with alluvial material on an elevation of 1105 m. The estimated volume of the collapse doline is about 0.3 Mm^3.

The doline is completely situated within Triassic well-bedded dolomites. All slopes of the doline are active. Only some limited areas of the lower sections of western slopes are covered by scree. On the southern and eastern side are two gullies incised into a slope. They were formed by intermittent flows from the fans onto the collapse doline floor. The alluvium levelling the floor is derived from dolomite hinterland.

5.7. Rastičevo lake

Rastičevo lake, also known as Blagaj lake, is a lake situated about 250 m north of the Ikaća collapse doline. Since this lake has the same dimensions as surrounding depressions

of the collapse dolines, it is, in a morphogenetic sense, simply a completely inundated collapse doline. Its morphology was described in detail by Spahić (2001). The rim of the collapse doline is on an elevation of about 1142 m with a longer diameter of 129 m and shorter diameter of 101 m. The depth of the lake is 16.5 m, with an estimated volume of about 0.1 Mm^3.

The lake is positioned in the lowest section of the eastern alluvial fan, so fine grained alluvial material prevails. Western and northern slopes are of Jurassic massive limestone. The morphology of the collapse doline is not typical. West and north of the lake depression is a slope of semicircular shape. On the eastern and southern side is an alluvial fan which gradually ascends towards the east. Limited areas of upper sections of the western slopes are steep rocky walls with some scree below. Other slopes are balanced and are overgrown by sod. Below the slopes, on the approximate elevation of the lake, is a terrace about 15 m wide. The terrace consists of fine grained loamy sediment and is covered by rare collapse blocks. Eastern and southern banks of the lake consist of dolomite pebbles and sand. According to the literature (Spahić, 2001), the lake depression gradually deepens towards the centre to a depth of 16.5 m.

The morphogenesis of the collapse doline was interpreted by Spahić (2001). He attributed the formation of the depression to karst dissolution followed by fluvial accumulation and inundation. The area of the collapse doline was presumably a ponor zone for small streams flowing from the eastern alluvial fans. Later, the ponors became choked by alluvium, and consequentially the lake was formed. According to pollen analysis of the sediment from the bottom of the lake, the age of the collapse doline can be connected to the Holocene climatic optimum (Spahić, 2001).

Figure 7: The Rastičevo lake from northwest with an alluvial fan in back (photo: U. Stepišnik)
Slika 7: Rastičevsko jezero iz severozahoda z vršajem za njim (foto: U. Stepišnik)

6. DISCUSSION

Kupres polje is situated in the western part of Bosnia and Herzegovina on an elevation of around 1130 m. The polje is dissected into three interconnected basins. The width of the polje is 10 km, while the length is about 24 km covering an area of about 93 km^2. The tectonically engendered basin of the polje is positioned lower than the surrounding relief. The lithological structure resulted in sedimentation of dolomite and marl derived fragments into the lowest areas of the polje as fluvial and lacustrine sediments (Vujnović, 1975).

The hydrology of the polje has been strongly influenced by its geologic settings. Therefore, streams flow from nearby elevated dolomite relief as well as from the eastern side of the polje, which is composed of dolomite and marl, towards the western side of the polje which is composed of limestone. The stream Milač flows towards ponors on the southwestern side of the polje. From there it flows partially towards Sušica River and partially towards Livno polje. Both of them drain towards the Adriatic Sea. The stream Mrtvica flows towards ponors in the western and northwestern side of the polje where it sinks into the subsurface. It flows partially towards Livno polje and partially towards the Pliva River which is in the Black Sea drainage basin. Therefore, through the Kupres polje stands a drainage divide between the Adriatic and Black Sea watersheds. The Milač and Mrtvica basins are positioned within the Adriatic Sea watershed, while Bajramovci basin is positioned in the Black Sea watershed.

Close to the northeastern edge of the Bajramovci basin, a group of collapse dolines is situated, locally called Japage (singular: Japaga). Most probably the toponym Japaga is derived from the word *japad* which is of old Slavic origin and means 'place which is not warmed up by the sun' (Skok, 1971).

The collapse doline group is scattered along erosional unconformity which divides bedded Triassic dolomite and massive Jurassic limestone. We do not have data about subsurface drainage in the area, but the collapse doline group appears to be associated with a cave system along the contact. In general, inception of caves and further development of cave systems is more frequent at the contact point between dolomite and limestone (Šušteršič, 1994; Lowe, Gunn, 1997).

Dimensions of the collapse dolines vary due to intensity and dynamics of the undermining processes (Stepišnik, 2010). However, in the study area, some collapse dolines were filled by alluvium after their formation, so no significant conclusions about morphogenesis can be derived solely from the dimensions of the dolines.

The morphology of the slopes of the collapse dolines were and are influenced by lithological properties. Slopes which are built of massive Jurassic limestone are, in general, active with a range of steep rocky walls and scree. On the other hand, slopes in bedded Triassic dolomite are steep and covered with sod; slope processes seem to be halted so therefore those slopes may be defined as balanced (Stepišnik, Kosec, 2011).

This group of collapse dolines displays a variety of floor morphologies. Most common is a conical floor that suggests an ongoing process of undermining in the cave system below. Such floors appear in Topalovica, Crljenka and Kotlić collapse dolines. In Mrnjašica

collapse doline, the floor is concave and covered by regolith. Floors of Ravnjača and Ikaća collapse dolines have been levelled by alluvium which was transported to the floors by intermittent surface flows from alluvial fans on the east. The flooded collapse doline Rastičevo lake is probably filled with impermeable alluvium which prevents the subsurface runoff.

We have not collected data concerning heights of flood waters inside the Mrnjašica, Crljenka and Kotlić collapse dolines, but approximate values were gathered from locals (Marić, 2014; Šebes, 2014). All three collapse dolines reportedly flood to an approximate elevation of 1090 m. According to the flood elevations, and the fact that there is no possibility that surface streams would reach those collapse dolines, we can conclude that the floors of collapse dolines are being inundated by waters from karst.

6.1. GENERAL CONCLUSIONS

On the basis of synthesis of morphographic and morphometric field data and comparison with the records from the literature, we established:

- Even though Kupres polje is divided into three separate basins which are morphologically interconnected, it fulfils all theoretical morphographic, morphometric and functional criteria for being classified as a polje according to literature (Cvijić, 1900; Grund, 1903; Gams, 1978). Due to surface streams from the elevated relief on the east, we can classify the polje as being of border type according to the hydrological function classification system (Gams, 1978).
- Since the floor of the polje is built of marls and dolomites, which are impermeable sediments, and because streams are diverted into different directions towards various ponors in limestone, we can also classify the polje as peripheral type according to the same classification (Gams, 1978).
- Kupres polje is positioned on a drainage divide between the Adriatic and the Black Sea watersheds.
- Collapse dolines next to northeastern edge of the polje are referred as Japage. The name Japaga originates from old Slavic word *japad* which denotes ‘place which is not warmed up by the sun’ (Skok, 1971).
- All collapse dolines are distributed along the line of contact between limestone and dolomite. Since bigger collapse dolines are formed due to undermining of the ceiling of active cave systems, we can assume that the cave system below the collapse dolines is oriented along this contact.
- Slope processes are directly connected to the lithological features. Due to higher mechanical strength, limestone slopes support higher inclinations. As a result, those slopes are active and have a high ratio of steep rocky walls and scree below them. Dolomites are mechanically weaker, so steep rocky walls and scree are of limited extent. Slopes are mostly balanced and covered by regolith which is covered with sod.
- The conical shapes of Topalovica, Crljenka and Kotlić collapse doline floors is evidence of ongoing undermining process in a hydrologically active cave passages below them.

- The floors of Ravnjača and Ikaća collapse dolines have been filled and levelled by alluvium which was introduced to the floors by surface streams. Even though literature suggests that the alluvium is of Pleistocene age (Spahić, 2001), the process of sedimentation is still operating in Ikaća collapse doline. Surface streams flow into Ikaća collapse doline from two directions, leading to the formation of erosion gullies. Locals claim that streams flow into the doline floor occasionally when intermittent streams from the slopes have higher discharge.
- Since the Mrnjašica, Crljenka and Kotlić collapse dolines are reportedly occasionally flooded during the same events, we can conclude that their floors are positioned in the epiphreatic zone. The upper limit of the epiphreatic zone is on an elevation of 1090 m.
- The level of the Rastičevo lake is on an elevation of 1142 m, which is about 50 m above the highest local water table level. The floor of the lake is choked by alluvium as suggested by Spahić (2001). Water in the lake is being fed only by sporadic surface stream inflows and meteoric waters.

(Translated by the author)

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JAPAGE: UDORNICE NA KUPREŠKEM POLJU, BOSNA IN HERCEGOVINA

Povzetek

Kupreško polje leži v zahodnem delu Bosne in Hercegovine in je eno od večjih kraških polj v osrednjem delu Dinarskega krasa. Članek obravnava skupino udornic na severovzhodnem obrobju polja, ki se imenujejo Japage. Predstavljene so osnovne značilnosti Kupreškega polja ter podrobna geomorfološka analiza udornic. Podrobneje smo analizirali njihove morfografske, morfometrične in morfostrukturne značilnosti. Na podlagi pridobljenih geomorfoloških podatkov smo razložili vrsto in dinamiko procesov v udornicah ter procese njihovega nastanka.

Kupreško polje je široko okoli 10 km in dolgo 24 km ter ima skupno površino okoli 93 km^2. Leži na nadmorski višini okoli 1130 m. Polje je tektonska kotanja, katere dno je nižje od okoliškega površja. Razčlenjeno je na tri kotanje, ki so med seboj povezane. Na severu se nahaja Bajramovačka, v osrednjem delu Mrtvička in na jugu Milačka kotlina.

Geološka zgradba polja ima močan vpliv na hidrološke značilnosti polja. Potoki tečejo iz višjega dolomitnega površja vzhodno od polja in iz vzhodnega dela polja, ki ga gradijo laporji in dolomiti, v smeri zahoda, kjer prevladujejo apnenci. Potok Milač teče od vzhodnega dela Mrtvičke kotline proti ponikvam v Milački kotlini na jugozahodni

strani polja. Podzemno odteka v potok Sušico, ki napaja Duvanjsko polje, ter v smeri izvira Duman na Livanjskem polju. Potok Mrtvica ima povirni del prav tako v vzhodnem delu Milačke kotline, nato odteka proti njenemu zahodnemu robu v skupino ponikev in nato podzemno proti izviru Duman. Ob visokih vodostajih Mrtvica nadaljuje površinski tok v smeri severozahoda v Bajramovačko kotlino. Tam ponikne v mnogih požiralnikih v rečnem koritu in podzemsko odteka proti severozahodu v izvire reke Plive. Ker sta Livanjsko in Duvanjsko polje v jadranskem povodju, reka Pliva pa v črnomorskem, leži Kupreško polje na razvodnici; Bajramovačka kotlina pripada črnomorskemu povodju, Milačka in Mrtvička kotlina pa sta v jadranskem povodju.

V bližini severovzhodnega roba Bajramovačke kotline se nahaja skupina udornic, ki se imenujejo Japage. Najverjetneje ima toponim *Japaga* izvor v staroslovanski besedi *japad*, ki pomeni 'mesto, ki ga sonce ne ogreje' (Skok, 1971).

Skupina udornic je razporejena v bližini erozijske diskordance (nezveznosti), ki razdvaja plastovite triasne dolomite ter masivne jurske apnence. O podzemnih tokovih v območju udornic ni podatkov, a je očitno, da je skupina udornic vezana na jamski sistem, ki se nahaja ob tej diskordanci. Jamski sistemi se namreč pogosteje oblikujejo na kontaktu med apnenci in dolomiti (Šušteršič, 1994; Lowe, Gunn, 1997).

Različne dimenzije udornic nakazujejo razlike v času in dinamiki procesov spodkopavanja pod njimi. Ker so nekatere udornice zapolnjene z rečnimi nanosi, ne moremo podati morfogenetskih zaključkov na podlagi njihovih dimenzij.

Litološke značilnosti udornic imajo močan vpliv na oblikovanost pobočij. Pobočja udornic v masivnih jurskih apnencih so povečini aktivna s strmimi prepadnimi stenami v vrhnjih delih in melišči pod njimi. Pobočja v triasnem dolomitu pa so porasla z rušo, sledovi pobočnih procesov pa v površinski oblikovanosti niso opazni. Ta pobočja smo opredelili kot uravnotežena (Stepišnik, Kosec, 2011). Udornice imajo različno oblikovana dna. Najpogosteje so dna stožčaste oblike, kar kaže na aktiven proces spodkopavanja v jamskem sistemu pod njimi. Takšno obliko dna imajo Topalovica, Crljenka in Kotlić. Dno Mrnjašice je konkavno, zapolnjeno s pobočnim materialom. Dna Ravnjače in Ikaće so uravnana z rečnim nanosom občasnih tokov iz vzhoda. Poplavljena udornica z Rastičevskim jezerom ima najverjetneje dno zapolnjeno z neprepustnimi naplavinami, ki preprečujejo odtekanje vode v podzemlje.

Podrobne meritve višin poplavnih vod v udornicah Mrnjašica, Crljenka in Kotlić nismo izvedli. Približne višine teh vod so nam podali domačini (Marić, 2014; Šebes, 2014). Vse tri udornice poplavi približno do nadmorske višine 1090 metrov. Na podlagi višin poplavnih vod in dejstva, da jih površinski tokovi ne morejo doseči, sklepamo, da udornice zapolni kraška voda in da je nadmorska višina 1090 m globina epifreatične cone na tem območju.