



## Some large dolines in the Dinaric karst

Andrej Kranjc

*Karst Research Institute, Postojna, Slovenia, E-mail: [kranjc@zrc-sazu.si](mailto:kranjc@zrc-sazu.si)*

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### Abstract

The main characteristics of the Dinaric karst are all kind of depressions, not only poljes and dolines, but also collapse dolines and similar forms. Some examples of such forms of large dimensions are located on the higher karst plateaus (Pokljuka, Jelovica, Snežnik in Slovenia), on the contact karst (Škocjanske Jame), on the levels above poljes (Crveno Jezero above the Imotsko Polje), and behind large karst springs (Unška Koliševka above the springs of Malni). Slovene terms for karst depressions are defined.

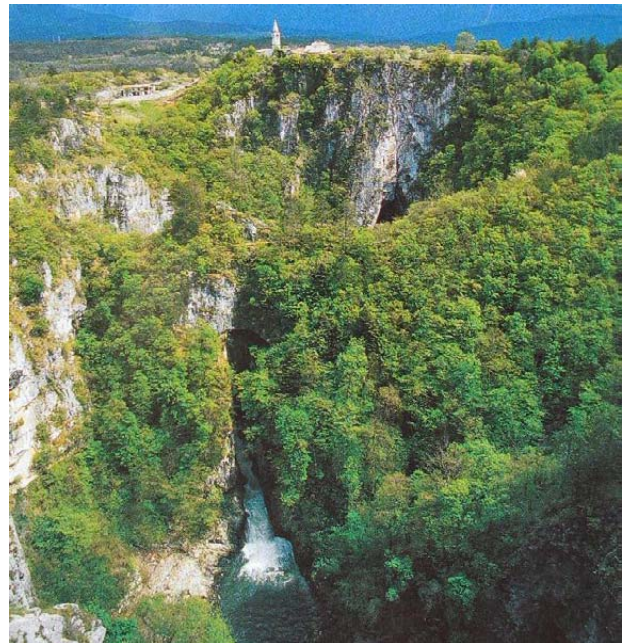
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### Introduction

Karst depressions are the most characteristic features of the Dinaric karst, which covers the region between the Friuli plain in the northwest and the Albanian mountains in the southeast. These include are not only dolines, uvalas and poljes, but also collapse dolines and other depressions that are similar to collapse dolines (Kranjc, 2004). In practice, it is often difficult to distinguish a real collapse doline from other types of karst depression. It is even more difficult in the case of the older features, which have been modified by corrosion and other surface processes, and where the primary origin is no longer clear.

On the Kras plateau (from where the term *karst* originates), a typical example of an active collapse doline that has a river across its floor is Velika Dolina (Great Doline) (Fig. 1). It is situated very close behind the ponor where the Reka River disappears into the caves of Škocjanske Jame (Kranjc, 1997, 2004). The doline mouth measures 170 x 300 m and the depth is 155 m. There are more collapse dolines on the Kras plateau, including some that are even larger than Velika Dolina, but they do not reach the underground water course.



**Fig. 1.** Škocjanske Jame - the view over the collapse dolines of Velika Dolina and Mala Dolina, towards the village of Škocjan. (Photo: Škocjanske Jame Regional Park)

## **The konta and Draga doline types**

There are many large and deep depressions on the higher Dinaric and Pre-Alpine plateaus. Some of these could have a collapse origin, or collapse process at least played an important role in their genesis. One important type of depression is known as a *konta*; this is a local name, but it does appear in the Slovene karst terminology (Gams, 1973). A *konta* is a closed karst depression, like a doline, that has been remodelled during Pleistocene glaciation. Thus it is viewed among glaciokarstic landforms, or as a polygenetic karst depression of multiple origins. It is difficult to decide if the original depression was a solution or a collapse doline. On the floor of a *konta*, thick unconsolidated sediment (normally of glacial till) has accumulated, and creates a local aquifer, so that small springs occur. The combination of good soil and reliable water is the basis for the economic use of the *konta* in farming. A good example is the *konta* of Kranjska Planina on the Pokljuka plateau, which is used as a summer mountain pasture (Fig. 2).



**Fig. 2.** Kranjska Planina *konta*, a glaciokarstic depression used for summer pasture

Similar large depressions appear also on the lower Dinaric plateaus. These are not considered as glaciokarstic landforms because there was no overall glaciation on these plateaus, with the exception of some small-scale, local ice. This type of depression is locally known as a *dol* or a *draga*. It is again not clear if the original form was a solution doline or if it is a polygenetic form as an intensively remodelled collapse doline. Although these plateaus were not glaciated during the Pleistocene, the climate then was sharp, and frost shattering was more intensive. A good example of such a depression is the Smrekova Draga (Spruce Tree Doline) on the plateau of Trnovski Gozd. Its rim stands at an altitude of 1250-1400 m (Rojsek, 1995). It is about 1500 m in diameter, reaching a depth of 150-300 m. There are no rock walls that can be evidence of a collapse origin. The southern

slopes reach the highest and are very steep, while the northern slopes are more gentle. The approximate volume is 18M m<sup>3</sup>. During the last Pleistocene glaciation, a small glacier from the nearby mountain of Golak reached the *draga*, and left till on its floor. According to Habič (1968), ice should have filled the whole depression at the peak of the glaciation, remodelling and deepening it by about 100 m, by mechanical and chemical processes. Some of these large Dinaric depressions have steep rocky slopes, and there are entrances to cave or shafts on the floors of others. Whether these are or are not collapse dolines, such forms and features are not typical of normal solution dolines.

## **Hydrology of the collapse dolines**

Velika dolina (Fig. 1) is an active collapse doline in a hydrological sense, as a river flows across its floor, within the cave system of Škocjanske Jame. Typically, the bottom of a collapse doline is filled with boulders, breakdown debris and other mechanical weathering products. Only in some cases is it possible to find a connection to the underground water course. Downstream of Škocjanske Jame there is the collapse doline of Risnik (Lynx Doline). In plan this measures 540 x 360 m, while its depth is 74 m. The cave passages carrying the Reka River lie 160 m beneath the doline floor (Mihevc, 2001). Another great collapse doline, Unška Koliševka (Doline of Unec), lies immediately behind the karst springs of Malni, not far from Postojna. The doline's maximum depth is 119 m and the stream feeding the Malni springs passes through at a level only 33 m beneath its floor.

The collapse doline of Crveno Jezero (Red Lake), near the town of Imotski, Dalmatia, Croatia, is a special case (Bahun, 2000). Its maximum depth is 528 m, and it is filled with water 287 m deep (Fig. 3). It had been thought that the water level in Crveno Jezero corresponds to the regional piezometric water level and that small fissures provided the only effective connection between the water of the collapse doline and the host aquifer (Kunaver, 1959). However, recent diving explorations have found large openings in the submerged walls of the doline and cave entrances at its floor (Garašić, 2000). These conduits allowing water to flow in and out, and through the doline.

The topographic locations of collapse dolines does relate to patterns of underground water flow. Many of them are on the karst plateaus, on reasonably levelled surfaces. Dolines on the high plateaus are high above the piezometric levels, and high above the main underground streams.



Consequently most of these great depressions do not have the characteristics (or at least do not have enough characteristics) to be classified among the collapse dolines (that form by collapse into cave passages). Their collapse origins remain open to debate.



**Fig. 3.** The Crveno Jezero collapse doline near the town of Imotski. (Photo: Tony Waltham)

Collapse dolines that lie relatively close to underground streams are situated either close behind karst springs (such as Unška Koliševka above the Malni springs) or immediately downstream of ponor caves (such as Velika Dolina at Škocjanske Jame). They are situated also on surfaces where the underground streams are relatively near the surface (such as Risnik on the Kras, and Crveno Jezero in the marginal slopes of the Imotski polje). It does appear that the larger collapse dolines only develop where there is a large underground river.

### Dimensions of some collapse dolines

Smrekova Draga, on the plateau of Trnovski Gozd, has a volume of  $18\text{M m}^3$ , and is probably the greatest such depression in Slovenia. But according to the Slovene karst terminology it is a *konta*, which is a glaciokarstic depression and is not a collapse doline.

Volumes of collapse dolines on the Dinaric karst around Logatec, north of Postojna, have been calculated (Šušteršič, 1973). The highest value was  $2.75\text{M m}^3$ , for Laška Kukava (Doline of Laze), but these results are not fully reliable, and may be underestimated by about 30%. They are therefore much smaller than the great Chinese *tiankengs*, of which Xiaozhai, Haolong and Dashiwei have volumes of 119, 110 and  $67\text{M m}^3$  respectively (Zhu & Chen, this volume).

On the Kras plateau the greatest collapse dolines are Senik (Hay Barn) near the village of Nabrežina,

(Aurisina in Italian), and Veliki Dol (Great Doline) near the village of Avber. Senik measures  $770 \times 650\text{ m}$  across its rim, and has a mean maximum depth of  $50\text{ m}$ ; it has a volume of  $9.89\text{M m}^3$  or  $11.2\text{M m}^3$ , depending upon the definition of the rim. Veliki Dol, near Avber, is an elongated depression of  $600 \times 350\text{ m}$ , with a mean maximum depth of  $70\text{ m}$ ; its volume is calculated as  $7.18\text{M m}^3$ . In the caves of Škocjanske Jame, Velika Dolina and Mala Dolina, together with the two smaller collapse dolines of Sapendol and Lisičina, have a combined volume of  $6.2\text{M m}^3$ . Further out in the Kras, the largest collapse doline is Radvanj ( $9\text{M m}^3$ ), followed by Globočak ( $4.6\text{M m}^3$ ), Bukovnik ( $1.5\text{M m}^3$ ) and Risnik ( $1.5\text{M m}^3$ ) (Mihevc 2001).

There are no published data on the volume of Crveno Jezero. A rough estimation can be calculated from the depth of  $520\text{ m}$ , the dimensions of the upper rim of  $450 \times 400\text{ m}$ , and the diameters at water level of  $210 \times 180\text{ m}$ . This gives a value of at least  $25\text{M m}^3$ , though figures of  $30\text{M m}^3$  have been quoted.

### Terminology

When using English, the Slovenes also use the international term collapse doline, irrespective of the type of a collapse doline or whether there is a special term for it that is used in the Slovene language. According to the Slovene Karst Terminology (Gams, 1973), the language has 11 synonyms for a collapse doline: *dol*, *dolina*, *draga*, *koleševka*, *koliševka*, *konta*, *koševc*, *kukava*, *udorna dolina*, *udorna vrtača*, and *udornica*.

The terms *dol* and *dolina* are very clear. In the largest sense *dol* means down, as opposed to up that is a hill or mountain. *Dolina* means a valley, covering all the types of valleys, from broad river valleys to the small close depressions on karst. The expressions *udorna dolina*, *udorna vrtača*, and *udornica* originated from *udor*; this means collapse. The origin and meaning of the other terms is not so clear. In colloquial language some of these terms do mean collapse doline in the strict sense of the word, while the others cover the large palette from doline and collapse doline to *uvala* and *polje*.

These comments on the Slovene language must also apply in the other languages of people living on karst. There are many words for the same phenomenon, and on the other hand the same term can mean a set of different phenomena. A good example is the word *jama*: in Slovene, this means a horizontal cave, while in the Croatian and Serbian languages it means a vertical shaft.

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