IMPACTS OF VISITORS ON CAVE'S PHYSICAL ENVIRONMENT

IMPACTOS DA VISITAÇÃO NO AMBIENTE FÍSICO DAS CAVERNAS

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Abstract

Studies of impacts on caves usually cover the topics of water pollution, microclimate, lampenflora and cave biota. On the other hand there is a much more important influence on the morphology of the cave directly from visitors, such as footprints, soiled and broken formations, graffiti, etc. They accumulate in caves and reduce their scientific (i.e. they "erase" important information on the development of caves and the surface above) and aesthetic values. The impacts of visitors were studied in 22 caves of the Classical Karst in Slovenia and in 2 caves of the Classical Karst in Italy (Carso Triestino). The caves were divided in the following groups: show caves (7), well-known caves (9), less-known caves (4) and easily accessible caves (4). The most significant impacts are off-trail footprints – trodden fine sediments, destroyed gours and cave pearls; graffiti and broken formations. In show caves, infrastructure causes the most significant and visible impacts, followed by the impacts of cave maintenance (off-trail footprints, broken formations, etc.). Infrastructure for mass visits of caves must comply with regulations on the safety of visitors, but these regulations often require interventions in caves that cause harm on their inventory.

Key-Words: Classical Karst, Slovenia, deterioration, visitors, cave physical environment.

Resumo

Os estudos sobre impactos em cavernas normalmente cobrem os tópicos relacionados a poluição da água, lampenflora *e fauna cavernícola. Por outro lado, há uma influência muito mais importante sobre a morfologia da caverna diretamente relacionada a ação dos visitantes, tais como pegadas, sujeira e quebra de espeleotemas, grafites, pichações, etc. Tais impactos acumulam-se nas cavernas e reduzem seus aspectos científicos (e.g.: "apagam" informações importantes relacionadas ao desenvolvimento das cavernas e da superfície) e seus valores estéticos. Foram estudados os impactos causados por visitantes em 22 cavernas da região do "Carste Clássico", na Eslovênia, e em 02 cavernas do "Carste Clássico" na Itália (*Carso Triestino*). As cavernas foram divididas nos seguintes grupos:* show caves *ou cavernas turísticas (7), cavernas bem conhecidas (9), cavernas menos conhecidas (4) e cavernas de fácil acesso (4). Os impactos mais significativos são as pegadas fora das trilhas - sedimentos finos pisoteados, destruição de pérolas de caverna, grafites e pichações e espeleotemas quebrados. Nas* show caves, *a infraestrutura causa os impactos mais significativos e visíveis, seguidos pelos impactos das atividades de manutenção da caverna (pegadas fora das trilhas, espeleotemas quebrados, etc.). A infraestrutura para visitas em massa em cavernas turísticas deve cumprir com os regulamentos sobre a segurança dos visitantes, embora tais regulamentos muitas vezes exigem intervenções nas cavernas e que causam danos do seu patrimônio.*

Palavras-chave: *Carste clássico, Eslovênia, deterioração, visitantes, ambiente físico cavernícola.*

1. INTRODUCTION

People have been using the caves in the Classical Karst for different purposes since prehistoric times. They served as shelters, hiding places; they were used for cult purposes, for storage (weapons, explosives, refuse dumps and waste water) and the exploitation of natural resources (karst springs, ice, etc.). Since the 17th century, the caves have predominantly been used for tourist and speleological purposes. The region and its natural phenomena have gained international importance as a result of speleological explorations, and the developments of tourism, and karstology as a science. However, the long and intense use of caves, particularly in the previous two centuries, has also had significant impacts on the physical environment of caves.

2. IMPACTS ON CAVES

The impacts on caves and their environment can be divided in several ways. Here they are

divided in two groups. In one group are the impacts with a pollution source outside the cave. In the other group are impacts with a pollution source in the cave and they are usually due to the visitors. Those impacts contribute to the main pollution of caves and are usually connected with the pollution of the underground or percolating water. The sources of the polluted water can be treatment plants, sewage systems, military activities, intensive agriculture, waste dumps, or polluted rivers themselves. The other most important pollutant of caves is waste that has been deposited in them or on the surface above them. These impacts influence mainly the quality of the water and affect cave biota. The other groups of impacts on cave environment are produced directly in the cave by the visitors of the cave and are mainly connected with caving, tourism and scientific research.

3. THE IMPACTS OF CAVING

Some of the impacts of recreational cavers on caves are: i) different traces, such as footprints of each visit; ii) carbide dumping and marking of walls; iii) compaction of sediments and its effects on hydrology and fauna; iv) erosion of rock surfaces (ladder and rope grooves, direct lowering by foot traffic); v) introduction of energy sources from mud on clothes and food residues; vi) introduction of faeces and urine leading to water pollution; vii) entrance and passage enlargement by traffic or digging; viii) cave vandalism and graffiti (Gillieson 1996).

There are many caves that have a free access and suffer vandalism, such as waste material, graffiti, and breakage of speleothems and mechanical enlargement of passages.

It is not to be missed that the damage done in caves is not necessarily done by cavers; especially in the open caves with easy access and wide passages the damage is done mainly by "non–cavers", such as occasional visitors, young people, junkies, etc.

4. THE IMPACTS OF SCIENTIFIC RESEARCH

Significant impacts to the cave environment are caused by scientists it the course of their research. Those impacts include: i) excessive breakage of formations; ii) excessive disturbance of cave biota; iii) excavation of shafts subsequently left unfilled; iv) permanent marking of study sites or survey stations with inappropriate media (paint, permanent tags, flagging tape); v) leaving monitoring infrastructure in the cave; (Gillieson 1996).

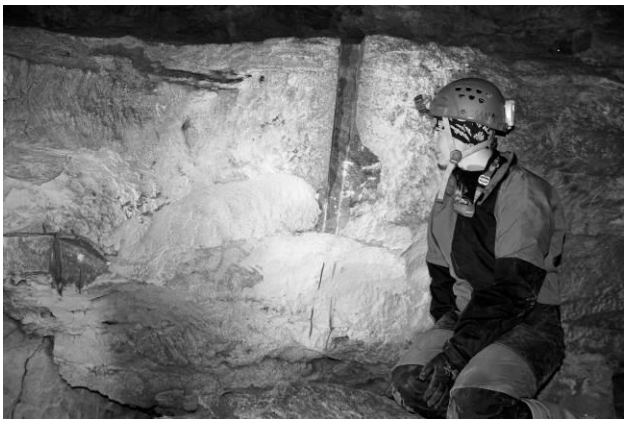

Fig.1: Impacts of scientific research, Trhlovca cave. Photo by: Emil Karič

5. THE IMPACTS OF TOURISM IN SHOW CAVES

In show caves the impacts can be divided in three groups: i) impacts caused by making the infrastructure in the cave; this group is the most evident and causes the greatest impacts; ii) impacts caused directly by the visitors; iii) impacts caused by the managers of the caves (by maintaining the infrastructure in the cave).

Impacts, caused by creating the infrastructure

In all show caves there is the infrastructure that serves for safety and the easier visit of visitors. The tracks (pathways, stairs and hand railings) and electricity are the main infrastructure there. In several caves there are also built objects that serve to maintain or keep the infrastructure gear, tools and equipment. Making the infrastructure has the greatest and the most direct impact on cave physical environment.

Some of the impacts of the infrastructure are: i) deepened or enlarged passages, ii) destroyed flowstone formations, fluvial or alluvial sediments for pathways; iii) materials for pathways or railway, including concrete surface, hand rails, wires, etc.; iv) destroyed flowstone formations or flood sediments due to electric installations; v) the growth of lampenflora due to electric illumination;

Impacts caused directly by the visitors

Probably the most intractable of impacts, resulting directly from the presence of visitors is accumulation of lint, consisting of fibres from clothing, dust carried in by visitors and flakes of human skin. Visitors may also leave behind less

visible evidence of their presence in the cave, including invasive species, some of which may be microbiota (Hamilton–Smith 2004). The effects of anthropogenic dust on caves may be subtle, but threaten many cave values. In all show caves, the colour of decorations is degraded as they become covered with dust. In many caves this effect has not been noticed but there is awareness of the accumulation of textile fibres (only a minor component of dust) which are picked out by hand (Michie 2004).

Impacts, caused by cave maintaining

One of the implementation issues in conservation management is the common practice of many work crews leaving behind minor debris resulting from their work. Metal fragments from fabrication of guardrails, or cuttings of electric wiring, often introduce materials toxic to cave fauna. Small clippings of copper will generate compounds toxic to invertebrates, while the cadmium impurities in galvanizing are toxic to microbiota and so will inevitably damage the integrity of cave soils (Hamilton–Smith 2004).

Fig. 2: Broken speleothem, Dimnice cave.
Photo by: Rosana Cerkvenik

6. CASE STUDIES AND METHOD USED FOR EVALUATION OF DETERIORATION

The impacts of visitors were studied in 23 caves of the Classical Karst in Slovenia and in 2 caves of the Classical Karst in Italy. The caves were divided in the following groups: show caves (7), well-known caves (8), less-known caves (4) and easily accessible caves (4). The selected caves are not homogenous, which is most obvious in the group of show caves, where the number of visitors varies from a few hundred to half a million a year. This is the source of important disparities in cave management and differences in infrastructure that is provided for visitors. Besides, some caves are morphologically heterogeneous. Some of the caves were studied in detail, but for an even more in-depth analysis (a detailed evaluation of deterioration) it would be necessary to divide them into several parts because of their large dimensions.

7. THE SELECTION OF THE METHOD AND PROBLEMS ENCOUNTERED

The selection of the method to describe the deterioration was rather difficult. The main problem was to define the "original value" or a "primary value" in the cave, meaning the conditions of physical environment before deterioration. There are some exceptions where data about deterioration is available. In several caves it is also difficult to define if for example the speleothems were broken by people or by natural processes. In some cases, the value of a certain category of negative influences is high and has a significant influence on cave physical environment; nevertheless, the influence is slightly diminished when compared with the sum of all influences. This could be illustrated by a cave with mostly damaged flowstone formations and no other forms of deterioration. Another problem is the aesthetic value of the caves; in some caves the deterioration is statistically, scientifically, etc. not so important, but their aesthetic value can be reduced. And vice versa: most of the visitors take care of the flowstone formations and forget (or are not aware) about importance of the fine sediments and cause great damage with footprints.

Caves have different degrees of vulnerability. But it seem that we "see" that caves which have been explored only recently are more vulnerable than the same types of caves that have been explored in the past and are already damaged. This derives from the fact that in a non – damaged cave, recently explored, every trace is very visible, such as footprint, soiled formation, etc., while in a cave which is already damaged, those (even minor) traces are far not so visible and thus – in the mind of visitors – less important.

The use of a quantitative method to define the impacts of visitors in the caves would be perfect. But due to above mentioned problems the use of a complete quantitative method for all types of human impacts would be almost impossible. For these reasons a semi – quantitative (descriptive) method was used, based on field observations and collection of semi – quantitative data.

The evaluated parameters were: contemporary graffiti, carbide dumps, contemporary litter and/or human waste, infrastructure, artificially enlarged areas, off trail footprints, broken formations, soiled

formations, destroyed gours and cave pearls and destroyed rock surface. To facilitate comparisons and get a systematic review, we draw up a table (Tab.1) where numerical values (points) 1, 3 or 5 were set. Numerical values are inevitably subjective; they are based on the difference between "least", "medium" and "most". Value 1 signifies "least" (influences from visitors and deterioration are minimal, as well as the pollution of the cave from the surface); value 3 signifies "medium", while value 5 means "most" (the impacts of visitors, risks for pollution from the surface and deterioration are very significant).

Table 1: Description of evaluated deterioration

	0	**1**	**3**	**5**
Contemporary graffiti	No graffiti	Historical signatures made by pencil in the 19th century and/or before; very seldom; graffiti in (active) clay layers; cleaned graffiti	Graffiti appear in few areas and are deteriorating the aesthetical value of the cave; they are made by carbide lamp soot or with black colours; are pale	Graffiti appear in several areas and are deteriorating the aesthetical value of the cave very much; they are made by colours or cut in the formations and are very remarkable; they appear on significant formations; graffiti all over the cave
Carbide dumps	No carbide dumps; carbide dumps cleaned	Carbide dumps in active water caves; up to 5 carbide dumps	Carbide appear in formations that are classified as *3*	Several carbide dumps of few m2; appear on significant formations, e.g. those that are classified as *5*
Contemporary litter and/or human waste	No litter and waste	Litter and waste cleaned; few pieces of litter; old litter	Frequent appearance; litter in caves classified as *5*; old equipment from cavers	Cave used as dump; waste water; recent litter
(Decayed) infrastructure	No infrastructure	Wood pieces; Tracks made of broken flowstone formations	Built tracks - concrete tracks, railings	Built objects in greater quantities
Artificially enlarged area (enlarged passages and enlarged and levelled surface for visitors)	No artificially enlarged areas	Passages or entrance for human pass	Dimensions greater than only human pass; entrances closed not to change the air circulation in the cave; artificially enlarged areas in solid rock	Several artificially enlarged areas; Dimensions greater than only human pass; enlargements in flowstone formations
Off trail footprints and mud tracks	No off trail footprints and mud tracks	Seldom; from the first cave explorers	Up to 50% of floor is covered with off trail footprints	Appear in most of the cave
Broken formations	No broken formations	Almost no or only those in artificially enlarged areas due to cave exploration	Up to 50%; broken formations classified as 3	More than 50 % or significant formations in the cave
Soiled formations	No soiled formations	Almost no soiled formations; only on the track that is marked	Up to 50%; broken formations classified as *3*	More than 50 % or significant formations in the cave
Destroyed gours and cave pearls	No destroyed gours and cave pearls	Almost no destroyed gours and cave pearls; only those on the track that is marked	Up to 50%; destroyed gours and cave pearls classified as *3*	More than 50 % or significant formations in the cave
Destroyed rock surface	No destroyed rock surface	Almost no destroyed rock surface; only those on the track that is marked	Up to 50%; destroyed rock surface classified as *3*	More than 50 % or significant rock surface
Lampenflora – in show caves	None	Almost invisible	Significant, covering the formations, classified as *3*	Very significant, covering the formations, classified as 5; appears around most of the lights

Table 2: The most representative characteristics of the classes

Class number	*Range of points*	*Description of the class*
1	0 - 18	Deterioration of the cave physical environment is minimal.
2	19 - 35	Deterioration of the cave physical environment is significant.
3	36 - 55	Deterioration of the cave physical environment is very significant.

After we had set a numerical value we got max 50 points. Then we established the number of classes with the Sturges formula ($K = 1 + 3.322 \log_{10} N$), where K is the number of classes and N is the number of data, in this case 10 in open caves and 11 in show caves. This process was used to establish classes; we categorised the caves into individual classes according to the total number of points awarded. According to the data and Sturges formula the group would be of 4 classes. In order to have better comparison with some other evaluated parameters, three classes were used. It is important to use the text description and the tables to get the optimal impression about each cave.

8. RESULTS – SHOW CAVES

Seven caves were selected as case studies: Dimnice, Divaška jama, Postojnska jama, Sveta jama, Škocjanske jame, Vilenica and Grotta Gigante (Velika jama v Briščikih). The case studies can be divided in two groups:

- Show caves with a high number of visitors and significant interventions, mainly linked with infrastructure. These are Škocjanske jame and Postojnska jama in Slovenia and Grotta Gigante (Velika jama v Briščikih) in Italy. Both caves in Slovenia have, in comparison to other caves, a particular management regime and they are the only two caves with a clearly defined management regime, i.e. *The Cave Protection Act*.
- Show caves, managed by cave societies – Sveta jama, Vilenica, Divaška jama and Dimnice.

One of the main issues concerning show caves in Slovenia is that a management required by *The Cave Protection Act* is not established. One of the consequences is that caves do not have management plan describing future investments and interventions. There are no common guidelines for investments and interventions in caves.

The visitors of these caves are of different types: tourists, cave administration staff, cavers and casual visitors (in the past). Tourists are the most frequent visitors of these caves. In Sveta jama and Divaška jama the number of tourists is less than 1.000; in Vilenica and Dimnice up to 6.000; in Škocjanske jame and Grotta Gigante (Velika jama v Briščikih) up to 100.000; and in Postojnska jama around 500.000 per year.

The deterioration in caves is closely connected with the intensity of cave use. The most significant impacts in these caves are the result of infrastructure that was built for visitors, such as paths, handrails, illumination, and electricity, built objects and in Postojnska jama also by the cave railway. As regards infrastructure, all caves got 5 points, with the exception of Divaška jama, Postojnska jama, and the non-tourist part of Vilenica, where this element got 3 points. There are various types of paths. In Postojnska jama and Grotta Gigante (Velika jama v Briščikih) they are cement, while in the other caves they are partly concrete and partly cut in fine sediments, set on broken formations (this is obvious in Vilenica or Divaška jama) or covered with gravel. The stairs are concrete or cut in flowstone or solid rock. Hand rails are in some cases fixed in flowstone formations and are made of different materials – iron, steinless steel or rope. The cave railway in Postojnska jama requires several enlarged passages and cuts, it causes dust and vibrations.

Electric installation is laid in Škocjanske jame, Postojnska jama, Vilenica, Grotta Gigante (Velika jama v Briščikih) and in Divaška jama (partly). Some electric cables are covered with pieces of flowstone, some are dug into fine sediments and some are hidden behind flowstone formations. In Škocjanske jame, Postojnska jama and Grotta Gigante (Velika jama v Briščikih) lampenflora appears around the majority of lights. In Vilenica there is no lampenflora. The presence of lampenflora was particularly manifest in the tourist part of Postojnska jama, in Tiha jama (a part of Škocjanske jame), and in Grotta Gigante (Velika jama v Briščikih), where it got 5 points. In the water part of Škocjanske jame it was awarded 3 points, and in the non-tourist part of Postojnska jama it got 1 point. Electric installations usually caused considerable damage on clay sediments and flowstone depositions, one of their negative impacts is also lampenflora. Another adverse influence is the waste material accumulated over years, mostly because little attention was paid to environmental protection when illumination was introduced. That is

why it is imperative that the protection of cave physical environment is taken into account when renovations take place; one should not disregard the fact that illumination should be "visitor friendly", i.e. it should be concealed and not disturbing.

Fig. 3: Hidden electric installations, Postojnska jama cave. Photo by: Rosana Cerkvenik

Artificially enlarged areas are of two types. On one hand there are enlarged passages for visitors or for railway in Postojnska jama and on the other hand there are levelled surfaces where guides can provide their explanations. The artificially enlarged areas are in solid rock and in some cases in flowstone. The largest artificially enlarged areas are found in the best-known caves – Škocjanske jame, Postojnska jama and Grotta Gigante (Velika jama v Briščikih) where this element was awarded 5 points; on the other hand, this influence got 1 point in Divaška jama, Sveta jama, and Vilenica. In some of these caves, one may also find several built objects, such as an altar in Sveta jama; a monitoring station in Grotta Gigante (Velika jama v Briščikih); different objects in Škocjanske jame; and a post office and a pool in Postojnska jama.

Waste predominantly consists of decayed infrastructure, lights, pieces of wood, etc. Litter from visitors is mainly cleaned by the staff, but usually this is not the case for lint. The majority of caves got 1 or 3 points, with the exception of Divaška jama where this element got 5 points because of scoria. Carbide dumps are not frequent but they do appear in all the caves. All caves were awarded 3 points, with the exception of Dimnice and Grotta Gigante (Velika jama v Briščikih) that got 1 point.

The most significant and visible forms of deterioration are broken formations and destroyed fine sediments. Some broken formations have remained in caves while others were taken out. The caves got 3 or 5 points, with the exception of the water part of Škocjanske jame that was awarded 1 point. Divaška jama, Postojnska jama and Sveta jama suffered the most extensive damage (5 points). Fine sediments are destroyed in all the caves where they can be found. This deterioration is due to past and present uncontrolled visits and works. Damage was perceived also in the caves where fine sediments are present or significantly important, which is why they got 5 points. Such are Škocjanske jame, Postojnska jama and Divaška jama. Present deterioration is mainly connected with off-trail footprints, caused by staff, and with works in caves. New breaking of flowstone formations was not detected.

Graffiti are present but are not very significant, even though they appear in all caves. There are historical signatures and graffiti in all the caves. Graffiti are more frequent in Vilenica (5 points), Divaška jama (5 points), Dimnice (3 points) and Sveta jama (3 points).

Cave rock surface is mainly not deteriorated, except in some cases in Postojnska jama where damage was done because of enlarged passages. Only in Postojnska jama, the damage on cave rock surfaces got 3 points, in other caves it was awarded 1 point.

According to deterioration, Postojnska jama and the tourist part of Škocjanske jame were classified into the third class, which means that physical environment is highly deteriorated. Postojnska jama got a total of 43 points (from 55), its non-tourist part got 37 points. Tiha jama in Škocjanske jame got 37 points; its water part got 17 points. All the other caves were classified in the second class (significant deterioration). The following caves got from 28 to 34 points: Dimnice 28, Vilenica 30, Grotta Gigante (Velika jama v Briščikih) 31, and Divaška jama 34.

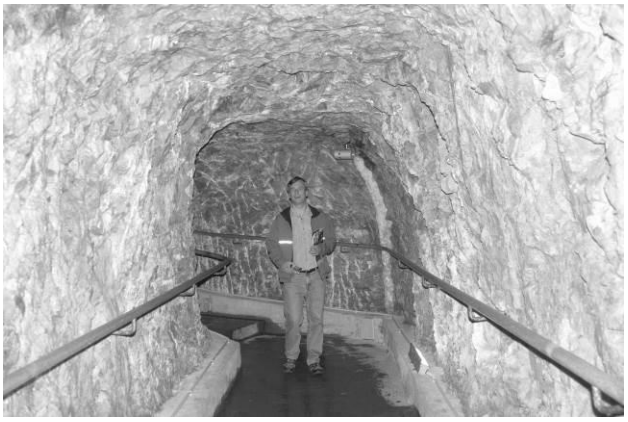

Fig. 4: Artificially enlarged tunnel, Grotta Gigante (Velika jama v Briščikih) cave.
Photo by: Rosana Cerkvenik

Postojnska jama shows a significant importance of its physical environment on one hand and intense cave use, impacts on the surface above the cave and significant deterioration in the cave on the other hand. The situation in Škocjanske jame is similar. Our evaluation showed that threats for caves from the surface remain minor, with the exception of Škocjanske jame and Postojnska jama. This is predominantly due to polluted waterways and a military building on the surface (above Postojnska jama).

9. RESULTS – WELL KNOWN CAVES

Nine caves have been selected as case studies: Bestažovca, Gustinčičeva jama v Blažčevi dolini, Jama 1 v Kanjaducah, Jama v Partu pri Ogradi, Kačna jama, Abisso di Trebiciano (Labodnica), LP 2, Lipiška jama and Škamprlova jama.

The characteristics of these caves require the use of caving techniques and they are mostly visited by cavers. We can estimate that the average number of visitors to these caves is from 15 to 40 per year. In Lipiška jama and Kačna jama, the average number is 200 visitors per year and in Abisso di Trebiciano (Labodnica) about 400 visitors per year. The exception is Gustinčičeva jama which was only visited during cave explorations and the total number of visitors has remained 48 since 2000. The majority of visitors are cavers, not only local but also from abroad. The use of all these caves has been long and intense, with the exception of Gustinčičeva jama, LP 2 and Jama 1 v Kanjaducah which were explored in the last decade.

Graffiti are common in three caves which are among the most well-known caves on the Kras – Lipiška jama, Škamprlova jama and Jama v Partu pri Ogradi. These caves have been known since the 19th century and have similar graffiti patterns, which suggest that they were visited by the same people. In these caves, graffiti were awarded the highest mark (5 points) and could be used as a case study for explanation. In the caves which were explored only later, for example Gustinčičeva jama, Jama 1 v Kanjaducah and LP 2, graffiti do not appear.

Off-trail footprints are the most significant in Lipiška jama and Bestažovca where the whole floor, which is covered with fine sediments, is trodden. These are case studies for the evaluation of 5 points. Similar to off-trail footprints are destroyed gours on the floor. An example of destroyed gours evaluated with 5 points is found Škamprlova jama, where in a meander passage the gours cover the area of 250 m^2 and are trodden all over. Where fine sediments prevail, soiled formations are noticed as well.

Broken formations also appear in caves which have been known for long, namely Lipiška jama, and Jama v Partu pri Ogradi (5 points). In the caves that were explored only recently there are no broken formations.

Artificially enlarged passages appear in all caves but the most significant impact is in Abisso di Trebiciano (Labodnica) where the shafts were enlarged all the way to the river. This is the only cave in the group of well- known caves that got 5 points as regards artificially enlarged areas. In all other caves artificially enlarged passages are also present and were made during cave explorations. The only exception is Gustinčičeva jama where these impacts appear but are minor.

Škamprlova jama, Lipiška jama and Bestažovca were also used as waste dumps, although not to a great extent. All the waste was cleaned by cavers. At the bottom of Kačna jama there are the remains of the first paths – iron and wooden pieces – and the remains of bodies of 25 German soldiers. In some caves there are some carbide dumps, mostly already hardened. In Lipiška jama and Jama v Partu pri Ogradi the carbide dumps were cleaned.

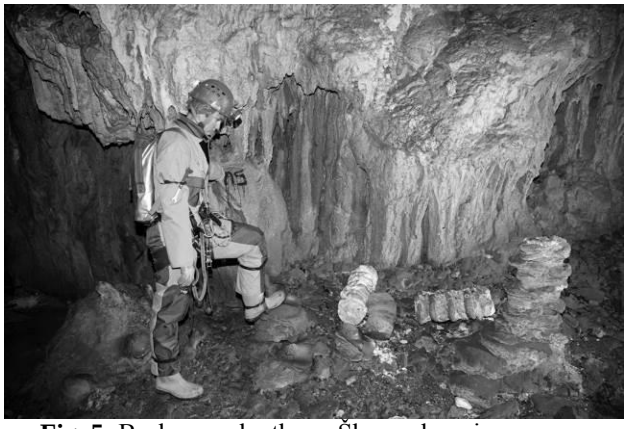

Fig. 5: Broken speleothem, Škamprlova jama cave.
Photo by: Emil Kariž

In some of the caves – Lipiška jama, Jama v Partu pri Ogradi, Škamprlova jama, LP 2, Gustinčičeva jama and Jama 1 v Kanjaducah – the trail markers were placed by cavers from Sežana which is an example of good practice in cave conservation, particularly if done just after or during the first explorations.

According to deterioration, most of the caves are classified in the first class, which means that the deterioration of cave physical environment is minimal. The most well-preserved caves are Gustinčičeva jama, LP 2 and a flowstone passage in Jama 1 v Kanjaducah. Lipiška jama and Škamprlova jama were classified in the second class, which means significant deterioration of cave physical

environment. This was expected as they are among the most well-known and popular caves. The damage in these caves has been accumulating through history. Only the artificially enlarged passages are a one-time phenomenon. In the caves which were explored only recently, the good practice can be recognized as they were immediately gated and trail markers were placed in them.

The impacts on the surface above the cave pose a risk for all caves with an underground water flow – Kačna jama, Jama 1 v Kanjaducah and Abisso di Trebiciano (Labodnica). In these caves, a significant risk is water pollution. There are no other significant impacts above these caves because of recent land use.

Fig. 6: Speleothem, cemented in the path. Škocjanske jame caves. Photo by: Rosana Cerkvenik

10. RESULTS – LESS KNOWN CAVES

Four caves were selected as case studies: Belinca Nikotova jama, Rebčeva jama and Ukmarjeva jama. They are rarely visited and we estimate that there should not be more than 5 to 10 visitors per year. The most frequent visitors are cavers. The signatures in Belinca jama show that it has also been visited by local people who are not cavers.

The environmental components are mainly well-preserved because of low frequency of visits and cave formations which are not very notable.

The main form of deterioration in these caves is graffiti, speleothems in Belinca jama and off-trail footprints in Nikotova jama. Graffiti appear in Ukmarjeva jama, Belinca jama and Rebčeva jama. In Ukmarjeva and Rebčeva jama, graffiti are not frequent but they appear in significant places and have a strong visible effect. The most significant impacts are broken speleothems in Belinca jama. In Nikotova jama that was explored only recently, the impacts are some off-trail footprints.

According to the classification of deterioration, all four caves are in the first (lowest) class, but Ukmarjeva jama, Rebčeva jama and Belinca jama are in its upper half. Ukmarjeva and Rebčeva jama are not significantly damaged; despite this they got more points because of some graffiti in significant places and their visible effect, as well as the presence waste. Belinca jama got many points because of a considerable damage on speleothems.

Fig. 7: Graffiti, Škamprlova jama cave. Photo by: Emil Karič

11. CONCLUSION – EASILY ACCESSIBLE CAVES

This group of caves consists of four horizontal caves - Malanca, Petnjak, Spodmol Rupa and Trhlovca. Horizontal caves have always been suitable for human use and also the selected caves were used already in prehistoric times. The archaeological finds prove the use of Trhlovca and Malanca. Not many people visit these caves. We can estimate that there are up to five visitors per year. Trhlovca may be visited more frequently but there should not be more than 20 visitors per year. Mostly, they are local hikers or casual visitors, or collectors of archaeological finds and old weapons.

Fig. 8: Trail markers, Lp 2 cave. Photo by: Emil Karič

At present, these caves are not interesting for cave exploration, although some exploration was carried out there in the past. The most intense was the use of Trhlovca which was also used as a storehouse for military supplies (magazine). This is also the reason that it was significantly reshaped. Spodmol Rupa was also reshaped because it was used during World War II as a shelter.

The most significant impacts in Trhlovca and Spodmol Rupa are an artificially levelled surface and – in Trhlovca –, built walls and artificially enlarged passages. In Trhlovca, significant damage was done also by sampling the flowstone and fine sediments.

Major damage might have been done in the entrance part of these caves. If the polygonal floor ever existed – and there is evidence of it – it is destroyed. The floor was damaged by walking and levelling the surfaces. In all the caves fine sediments – if they are present – are trodden. In Trhlovca, for example, this is the case in the whole passage measuring 150 m^2.

There are also some broken formations and graffiti in all the caves but these impacts are not very significant.

As regards deterioration, these caves were classified in the first class, which means that the deterioration is minimal. Only the upper part of Trhlovca was classified in the second class because of interventions necessary for the construction of a magazine.

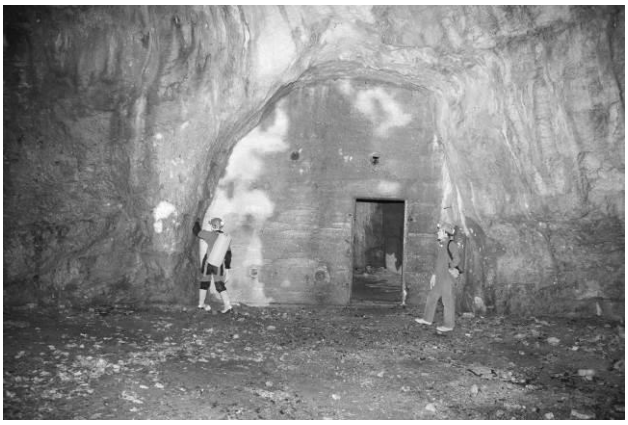

Fig. 9: Entrance into the Trhlovca cave.
Photo by: Emil Kariž

12. CONCLUSION

Open caves are far less deteriorated than show caves. The most visible and significant elements of deterioration are trodden fine sediments, gours and cave pearls, off-trail footprints, broken formation and graffiti. The majority of fine sediments and gours are trodden, except in the caves that have been explored only recently and have been equipped with trail markers. Graffiti made with colours date back to the beginning of the 20th century. Graffiti were very frequent until the end of the 20th century. In general, the process of breaking of speleothems stopped after 1990. Cave rock surface is mainly well-preserved, with the exception of some surfaces covered with graffiti. Most of the caves that are filled with human waste are or were used as waste dumps, while waste from visitors is usually limited to carbide dumps and decayed equipment. The process of depositing waste in caves was considerably reduced after the introduction of municipal utility services in the 1990s, after the entry into force of new regulations in industry and the decline of some industrial branches, and after the withdrawal of armed forces. Carbide dumps can still be found in caves (only a few caves were cleaned); in the last 10 years, there are hardly any carbide dumps since the electric (led) lamps have been in wide use.

An evaluation has shown that visitors are mainly aware of protecting flowstone formations and far less of other cave components, such as clay sediments, rock surface or floor features. The awareness of visitors about the significance of cave formations largely depends on the explanations of cave guides.

In most of the caves it is difficult or impossible to divide the deterioration according to the type of visitors because the deterioration accumulates and usually there is no detailed information about cave use and/or several caves have been used by several types of visitors.

To estimate the deterioration precisely and also classify it, it would be necessary to know the "original value" of a cave, e.g. the conditions in it before it was used. It would be necessary to get detailed information from measurements, for example the rate of damage on dams due to visitors walking on them. The process required to get relevant information would be quite lengthy. It is also difficult to define the criteria as the "visibility" of the same type of deterioration may differ between individual caves. For example, in a cave with abundant flowstone formations an amount of broken formations is scarcely noticeable, while in a cave that is not so abundant with flowstone formations an equal amount of broken formations is very noticeable. So it is more appropriate to use percentage values to estimate the level of deterioration. Nevertheless, personal impression remains one of the most important criteria. It also seems – in human perception of caves – that the

caves which are already deteriorated are less valuable and less vulnerable. On the other hand, there are some caves – namely Gustinčičeva jama, Jama 1 v Kanjaducah and LP 2 – that were explored relatively lately and are conserved to a degree that allows for an establishment of an "original value". This assumption is possible because the morphology of these caves is rather similar to the morphology of other caves on the Kras which are most frequently visited and present "case studies" of caves.

Our attitude towards cave conservation has started to change but the process is slow. The question when cave conservation will become an integral part of our attitude to caves thus still remains to be answered. On the other hand, damage in caves can be "utilized" for interpretation – what was going on in caves, which activities are not acceptable form the aspect of nature conservation. They can be a valuable lesson in what is not to be done in caves.

13. OPEN QUESTIONS

One of the issues is when will mankind be able to recognize the importance of caves, their environment and components? It is true that the process has begun, but only the first steps have been made so far.

Management in show caves should be closely involved in these processes. The main issue is how to choose proper methods for building infrastructure and its maintenance. Special attention should be devoted to works in caves in order to minimize the damage, done by them. Trained and skilled experts should closely cooperate with technical staff (such as electricians, builders, etc.). Management in show caves should be also involved in these processes through the interpretation, e.g. guiding service.

We should also become aware that caves are a unique environment, where there are no anthropological elements and where silence and darkness reign. Even though man has been present in some caves since prehistoric times, he remains an "intruder" in cave environment.

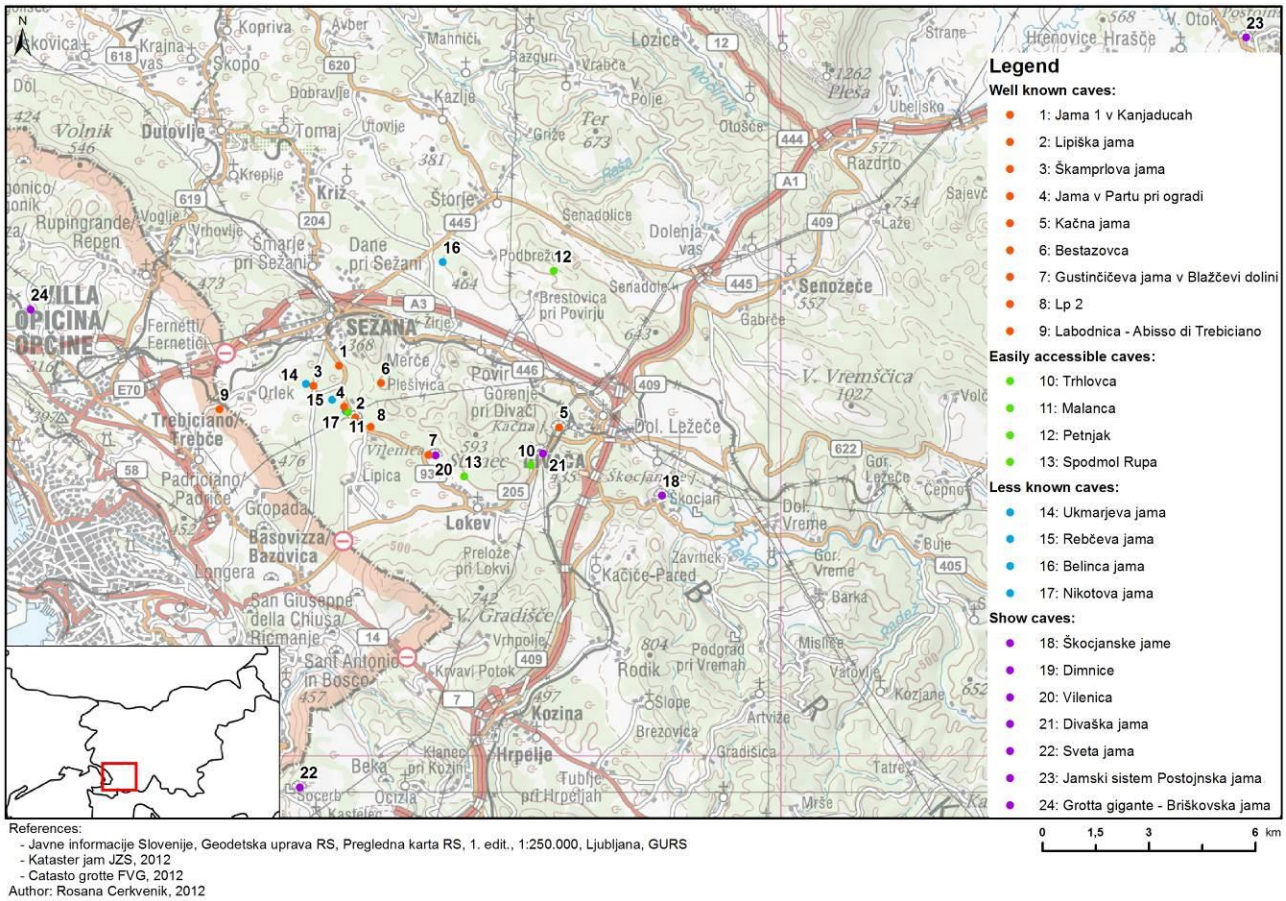

Fig. 10: Map of the locations of case studies

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