State Of Show Cave Management In The World

Arrigo A. Cigna

Union Internationale de Spéléologie

Email: arrigocigna@tiscali.it

Abstract

The interest of humans into caves started since the prehistory for very practical reasons. Only much later such an interest derived from other reasons. For instance in Roman times, people were attracted by the description of the "Dog's Cave" near Naples, Italy, because of the peculiar release of carbon dioxide close to the floor which killed small animals (hence its name) while standing people were not affected. Later, in the Middle Age, the cave of Postojna, Slovenia, visitors left their signatures in a passage, which is presently known as the "Passage of the Ancient Names".

If a show cave is defined as a cave where a fee is paid in order to have access and visit it, then the oldest one is the Vilenica Cave in Slovenia. Now much attention is paid to avoid damages to the cave environment. A show cave can have a great influence on the local economy and some data concerning such influences all over the world are reported here.

In order to protect the cave environment some guidelines aiming to supply a recommendation to be endorsed for the development of show caves were drafted in the last years and received strong recommendations from the UIS Department of Protection and Management. Such guidelines are reported here.

A Short History of Show Caves

Caves have always attracted the attention of humans since the prehistory, but at that time the interest was mainly quite practical, i.e. to have a shelter, a sanctuary or a burial place. Later, until the Middle Age, caves were associated with the devil or hell in general and people avoided getting into them for fear. For this reason bandits could use caves as hiding-places without problems due to undesired visitors.

Some historical show caves were known already in ancient times. About 2000 years ago Plinius, a Roman writer, described the "Dog's Cave" near Naples, Italy, being visited by people because of the peculiar release of carbon dioxide close to the floor which killed small animals (hence its name) while standing people were not affected. Other caves were visited not purely for tourism but mainly for religious purposes: such shrines may be found everywhere.

In Postojna Cave (Slovenia), on the walls of the so called "Passage of the Ancient Names" on account of the old signatures left by occasional visitors, the most ancient ones date back to 1213, 1323 and 1393 according some authors of the 19th Century. Around 1920 such signatures were scarcely visible on account of the seepage; presently the oldest signature which can be read easily dates 1412 and from the 16th Century onward they became rather abundant. This means that from the 16th Century the cave was visited more frequently by many persons attracted by the underground world. Therefore this period may be considered the start of cave tourism.

In a more recent time the Cave of Antiparos in Cyclades, Greece, became a great attraction in the 17th Century as a result of the many prints reproduced in the cave. The Kungur Cave, 100 km SE of Perm, near Kungur (Urals), Russia, is an ice show cave visited already in the 18th Century. Probably it is the largest show cave in gypsum. On 13th August 1772 the scientist Joseph Banks landed on Staffa Island and in November he wrote in the "Scots Magazine":

> *…there is a cave in this island which the natives call the Cave of Fingal.*

Since that time this cave became one of the best known caves of the world, inspiring poets and musicians. Its fame was so great that it became the natural cave most represented in paintings and engravings all over the world.

The Cango Cave (Oudtshoorn, South Africa) was discovered around 1780 and the first recorded visit was made in 1806. A few years later a farmer bought the land around the cave with the exclusion of the entrance. The

Governor included into the deeds the condition that the farmer was obliged to leave perfectly free and undisturbed the entrance of the cave, to be considered as public property, with a road in his land to reach the cave. This document has a historical importance because it is probably the first attempt in the world to legislate for cave protection.

In the U.S., the Mammoth Cave, Kentucky, was defined "the stellar attraction of the Mammoth Cave National Park" by R. and J. Gurnee (1990). Already known in prehistory, in the late 18th Century the cave was mined for saltpeter to make gunpowder. Only at the beginning of the following century did Mammoth Cave beccome a tourist attraction.

If a show cave is defined as a cave where a fee is paid in order to have access and visit it, then the oldest one is the Vilenica Cave in Slovenia. The cave is close to the village of Sezana, just a few kilometres from the Italian border. At the beginning of the 17th Century the Count of Petac began to invite the people of Trieste and some noble friends to visit the cave. On certain holidays, a hundred metres from the entrance, an area for the orchestra and a dance floor were set up and the entire dripstone passage was illuminated with torches and candles. Probably already in 1633 the Count Benvenut Petac charged an admission to visit the cave. Part of the money was donated to the local church of Lokev where masses were dedicated to "greater safety" of the people in the cave.

The Environmental Protection of Show Caves

A cave is an environment with little contact with the outside. For this reason its equilibrium may be easily changed when additional energy is introduced (Cigna, 1993). Obviously such changes may occur more frequently when the whole energy budget of the cave is small, but in the case of show caves the energy budget is often not very small, because of their size which is generally large. A river or a subterranean lake plays an important role in keeping the natural equilibrium because they may absorb more easily than rock, any further input of energy.

In a show cave both the visitors and the electric lighting system release energy into the environment. A person who is walking releases nearly as much energy as a 200 watt bulb at a temperature of about 37°C. Therefore the total energy released by hundreds or thousands of visitors in a day is not negligible as an absolute amount. The heat released by the electric lighting system has the same order of magnitude.

There are different ways to keep the additional energy input into the cave as low as possible. A limit of the number of visitors is given by the so called "visitors' capacity" which is defined as the maximum number of visitors acceptable in a time unit under defined conditions which does not imply a permanent modification of a relevant parameter. Otherwise, instead of reducing the number of persons, the time they spend in the cave may be reduced. This result may be easily achieved when people enter the cave through one entrance and exit along another passage, instead of returning along the same pathway they entered by.

Using high efficiency lamps can reduce the contribution by the electric lighting system. A further reduction can be obtained if the lamps are switched on only when visitors are in the vicinity.

Another perturbation of the cave environment is also due to the lint (hair, dry-flaking skin, dust from shoes and lint from clothing) left by visitors. In caves visited by a large number of people the accumulation of lint becomes a real problem to be solved by an accurate removal. In fact it would cause deterioration of formations and reduce their pristine white beauty to a blackened mess.

Lint released into a cave might be reduced by means of air curtains at the entrance. Such a solution would "wash people" entering the cave and, at the same time, isolate the cave environment from outside, since an air curtain acts as an invisible door and avoids airflow through it.

The protection of the environment of a show cave is fundamental both from the point of view of avoiding any damage to a not-renewable patrimony and the conservation of the source of income for the cave management. Therefore such a common interest may have an important role in the implementation of any action aiming to safeguard the cave environment.

Visitors also release carbon dioxide as a result of their breathing. Until few years ago such carbon dioxide was considered as a threat to the cave formations since it could have increased the water acidity and, consequently, the corrosion instead of the deposition of new formations. Further accurate studies (Bourges et al., 1998) have shown that in many instances the carbon dioxide produced by natural processes (oxidisation of organic matter in the soil above a cave) may introduce through the water percolating into the cave, amounts very much larger than the carbon dioxide released by visitors.

When the water, with a relatively high concentration of carbon dioxide, reaches the cave environment it releases immediately part of such carbon dioxide, which is not in equilibrium with the carbon dioxide in the air. Therefore the chemical reaction moves towards the deposition of calcium carbonate and the formations continue to grow. In general, rather small caves with a high visitor flux and without any input of natural carbon dioxide might have formations corroded because the chemical reactions would be reversed when the carbon dioxide of air dissolves into water, particularly when water vapor condenses on the cave walls.

Another form of environmental pollution may occur through a joint contribution by visitors and light. Persons release into the cave spores or seeds of plants and they may grow in the vicinity of lamps if the light flux is high enough. The result is the so-called "lampenflora" i.e. green plants (generally algae, fern, moss) developing on cave walls or formations close to a light source. Such plants cover the surfaces with a greenish layer, which can become included into the calcite deposition and no longer removable. In fact the lampenflora may be washed away by bleach or hydrogen peroxide if it is not covered by any calcite. Special care must be paid to avoid any impact on the cave fauna.

The growth of lampenflora can be avoided by the employment of light sources with a very low emission of light useful for the chlorophyllian process and low light flux at the rock surface.

The Development of a Show Cave

A correct development of a show cave must take into account both the protection of the environment and the safety of the visitors. As it has been already pointed out in the previous paragraph the physical and chemical equilibria of the environment should be modified outside the range of the natural variations.

At the same time, any undue source of harm to the visitors must be avoided. This means that the pathways must be strong enough to withstand the very high humidity and, sometimes, also floods. In the past wooden structures were often used, but they had to be replaced frequently; presently some "green" people would still use wood because this material is natural. Nevertheless the rather short life of a wooden structure in the cave environment implies an additional cost which is not justified by any advantage. On the contrary the rotten wood supplies large amounts of food modifying the equilibrium of the cave life.

In particular at present, the criterion to use only structures, which can be easily decommissioned, is substantially wrong because, once it is no longer convenient to manage a show cave, no one will spend any money to take out any structure inside the cave. Only when show cave managers will be obliged to deposit a given amount of money to assure the future decommissioning of any structure, it is possible to use structures to be easily disassembled.

In the meantime, it is preferable to use a material which is compatible with the cave environment and will not release pollutants in the long run. A material with these characteristics and not expensive is concrete. It may be conveniently used for pathways in general.

The handrails in stainless steel are also a convenient solution, particularly when they are also used as pipes to provide water in different parts of the cave to wash out the pathways. In fact, a higher cost of stainless steel is justified by a lack of any maintenance after many years of operation. Sometimes plastic may be used under the condition that it does not contain any contaminant (e.g., heavy metals or organic compounds which may be released).

When an artificial entrance is needed in order to give an easy access to the cave or to establish a circuit by avoiding the return of visitors on the same pathway, it is absolutely necessary to install a system of doors to stop any additional airflow

in the cave. Up to now, doors operated mechanically or manually are normally used, but it would be most preferable to install air curtains. This solution (suggested already many years ago by Russell and Jeanne Gurnee) is less expensive, quite safe and has the great advantage of avoiding any sense of claustrophobia to visitors. In addition it also decreases the release of lint by people as reported previously.

The surveillance of the main parameters (temperature, humidity, carbon dioxide, radon, etc.) can be achieved by a monitoring network, which should always be installed in any show cave. Presently it is possible to install networks at a very reasonable cost, which are reliable and require little care, as for instance data loggers, which can be discharged every month, and the data transferred into a computer for any further evaluation. Automatic networks directly connected to a computer are operated more easily but, of course, their cost is higher. In any case it must be stressed that any kind of monitoring network always requires some attention to avoid malfunctioning and calibration, possibly once a year.

Such monitoring networks also have another important advantage because they contribute very interesting data, which has greatly enlarged the knowledge of the behavior of the cave environment. A rather widespread feeling among speleologists, and people in general, that a cave is "lost" to science when it is developed as a tourist attraction, is not at all supported by the important scientific results obtained from within many show caves. Sometimes the borderline between use and abuse may be difficult to define; nevertheless a careful development continuously monitored may be the most efficient way to protect a cave.

It is evident that the economy of a region around a show-cave-to-be can be radically modified by the cave development. Therefore strenuous opposition to any tourist visitation appears to be rather unfair towards the local people particularly when a suitable compromise between strict conservation and a sound development can be found. But in any case, as it was previously reported, a cave development cannot be accepted if it is not supported by appropriate preliminary research.

An evaluation of the number of show cave visitors all around the world (Cigna & Burri, 2000), based on data obtained for about 20% of all show caves, a global number of more than 150 million visitors per year may be estimated. By assuming a budget per person as reported in Table 1 the total amount of money spent to visit the show caves is around 2.3 billion US$. The number of local people directly involved in the show cave business (management and local services) can be estimated to be several hundred per cave, i.e. some hundreds of thousands of individuals in the world.

By taking into account that there are several hundred other people working indirectly to each person directly connected with a show cave (Forti & Cigna, 1989), a gross global figure of about 200 million people receive salaries from the show cave business. Therefore, it can be roughly assumed that behind ten tourists in a show cave there is about one employee directly or indirectly connected (Table 2).

Direct income		6.5
Other local income:		
	Souvenirs & snacks	2.0
	Meals	6.5
	Transportation	2.5
	Travel agency	2.5
TOTAL		**20.0**

Table 1 - Rough estimation of the annual direct and local budget of a show cave per visitor (US $, 2008).

In addition to show caves, consideration must be given to the existence of karst parks, which include a cave within their boundaries. As reported by Halliday (1981) the number of visitors of three top karst national parks in USA (Mammoth Cave, Carlsbad Caverns and Wind Cave) amounted to about 2,500,000 tourists each year. Therefore karst parks give a further increase to the number of people involved in the whole "karst" business.

There are many other human activities, which involve a larger number of people; nevertheless the figure reported above is not negligible and gives an indication of the role that show caves play in the global economy.

Number of show caves in the world	> 5000
Most important show caves	> 800
Total visitors per year	≈ 170,000,000
Money spent yearly to visit show caves	≈ 1.5 billion
People directly employed in show caves	≈200,000
People whose salary comes indirectly from show caves	≈100,000,000

(These figures could probably be doubled if the Natural Parks with karst interest are considered)

Table 2 - Economical importance of show caves (US $, 2008)

The protection of the cave environment

Some guidelines aiming to supply a recommendation to be endorsed for the development of show caves were drafted in the last few years and received strong recommendations from the UIS Department of Protection and Management at both the 14th International Congress of Speleology held in Kalamos, Greece, in August 2005 and the 15th International Congress of Speleology held in Kerrville, Texas, in July 2009. Such guidelines are reported here.

Development Of A Wild Cave Into A Show Cave

The development of a show cave can be seen as a positive financial benefit to not only itself, but also the area surrounding the cave. The pursuit of these anticipated benefits can sometimes cause pressure to be applied to hasten the development of the cave.

Before a proposal to develop a wild cave into a show cave becomes a physical project, it is necessary to carry out a careful and detailed study to evaluate the benefits and risks, by taking into account all pertinent factors such as the access, the synergy and possible conflict with other tourism related activities in the surrounding area, the availability of funds and many other related factors. The conversion should only take place if the results of the studies are positive. A wild cave that is developed into a show cave, and is subsequently abandoned, will inevitably become unprotected and be subject to vandalism in a very short time. A well managed show cave assures the protection of the cave itself, is a source of income for the local economy and also may contribute to a number of scientific researches.

A careful study of the suitability of the cave for development, taking into account all factors influencing it, must be carried out, and must be carefully evaluated, before physical development work commences.

Access And Pathways Within The Cave

In many caves it has been found to be desirable to provide an easier access into the cave for visitors through a tunnel, or a new entrance, excavated into the cave. Such an artificial entrance could change the air circulation in the cave causing a disruption of the ecosystem. To avoid this, an air lock should be installed in any new entrance into a cave. On the other hand it must be mentioned that in some very exceptional cases a change in the air circulation could revitalize the growth of formations. A decision not to install an air lock must be only taken after a special study.

2-1 Any new access into a cave must be fitted with an efficient air lock system, such as a double set of doors, to avoid creating changes in the air circulation within the cave.

Caves are natural databases, wherein an incredible amount of information about the characteristics of the environment, and the climate of the cave, are stored. Therefore any intervention in the cave must be carried out with great care to avoid the destruction of these natural databases.

2-2 Any development work carried out inside the cave should avoid disturbing the structure, the deposits and the formations of the cave, as much as possible.

When a wild cave is developed into a show cave, pathways and other features must be installed. This invariably requires materials to be brought into the cave. These materials should have the least possible impact on both the aesthetics of the cave and its underground environment. Concrete is generally the closest substance to the rock that the cave is formed in, but once concrete is cast it is extremely expensive and difficult to modify or decommission. Stainless steel has the distinct advantage that it lasts for a long time and requires little, to no, maintenance but it is expensive and requires special techniques to assemble and install. Some recently developed plastic materials have the advantage of a very long life, are easy to install and are relatively easy to modify.

2-3 Only materials that are compatible with the cave, and have the least impact on

the cave, should be used in a cave. Cement, concrete, stainless steel and environmentally friendly plastics are examples of such materials.

The environment of a cave is usually isolated from the outside and therefore the introduction of energy from the outside will change the equilibrium balance of the cave. Such changes can be caused by the release of heat from the lighting system and the visitors and also by the decay of organic material brought into the cave, which introduces other substances into the food chain of the cave ecosystem. In ice caves, the environmental characteristics are compatible with wood, which is frequently used for the construction of pathways, as it is not slippery.

2-4 Organic material, such as wood, should never be used in a cave unless it is an ice cave where, if necessary, it can be used for pathways.

LIGHTING

The energy balance of a cave should not be modified beyond its natural variations. Electric lighting releases both light and heat inside the cave. Therefore high efficiency lamps are preferred. Discharge lamps are efficient, as most of the energy is transformed into light, but only cold cathode lamps can be frequently switched on and off without inconvenience. Light-emitting diode (LED) lighting is also very promising. As far as possible, the electric network of a cave should be divided into zones to enable only the parts that visitors are in to be lit. Where possible a non-interruptible power supply should be provided to avoid problems for the visitors in the event of a failure of an external power supply. Local code requirements may be applicable and these may permit battery lamps or a network of LEDs or similar devices.

3-1 Electric lighting should be provided in safe, well-balanced networks. The power supply should preferably be non-interruptible. Adequate emergency lighting should be available in the event of a power outage.

Lampenflora is a fairly common consequence of the introduction of an artificial light supply into a cave. Many kinds of algae, and other superior plants, may develop as a result of the introduction of artificial light. An important method to avoid the growth of green plant life is to use lamps that do not release a light spectrum that can be absorbed by chlorophyll.

3-2 Lighting should have an emission spectrum with the lowest contribution to the absorption spectrum of chlorophyll (around 440 nm and around 650 nm) to minimize lampenflora.

Another way to prevent the growth of lampenflora is the reduction of the energy reaching any surface where the plants may live. The safe distance between the lamp and the cave surface depends on the intensity of the lamp. As a rough indication, a distance of one meter should be safe. Special care should also be paid to avoid heating the formations and any rock paintings that may exist.

3-3 Lighting sources should be installed at a distance from any component of the cave to prevent the growth of lampenflora and damaging the formations and any rock paintings.

The lighting system should be installed in such a way that only the portions of the cave occupied by visitors are switched on, leaving the lighting in the portions of the cave that are not occupied switched off. This is important from the aspects of reducing the heating of the cave environment and preventing the growth of lampenflora, as well as decreasing the amount of energy required and its financial cost.

3-4 Lighting should be installed to illuminate only the portions of the cave that are occupied by visitors.

Frequency Of Visits And Number Of Visitors

The energy balance of a cave environment can be modified by the release of heat by visitors. A human being, moving in a cave, releases about 150 watts – approximately the same as a good incandescent lamp. Consequently, there is also a limit on the number of visitors that can be brought into a cave without causing an irreversible effect on the climate of the cave.

4-1 A cave visitor capacity, per a defined time period, should be determined and this capacity should not be exceeded. Visitor capacity is defined as the number of visitors to a given cave over a given time period, which does not permanently change the environmental parameters beyond their

natural fluctuation range. A continuous tour, utilizing an entrance and another exit, can reduce the time that visitors spend in a cave, compared to the use of a single entrance/exit.

In addition to the normal tours for visitors, many show caves have special activities, sometimes called "adventure tours", where visitors are provided with speleological equipment for use in wild sections of the cave. If such a practice is not properly planned, it may cause serious damage to the cave.

4-2 When visits to wild parts of a cave are arranged, they must be carefully planned. In addition to providing the participants with the necessary speleological safety equipment, the visitors must always be guided by a guide with good experience in wild caves. The pathway, where visitors are to travel along, must be clearly defined, for example with red and white tape, and the visitors should not be allowed to walk beyond this pathway. Special care must be taken to avoid any damage to the cave environment, and the parts beyond the pathway must be maintained in a clean condition.

Preservation Of The Surface Ecosystem When Developing Buildings, Parking, Removal Of Surface Vegetation And Waste Recovery

It is important that the sighting of the above ground facilities, such as the buildings, parking and waste recovery, be well planned. There is a natural tendency to try and place these development features as close as possible to the cave entrance. Sometimes these features are built over the cave itself, or relevant parts of it. The hydrogeology above the cave must not be modified by any intervention such as the watertight surface of a parking area. Any change in the rainwater seepage into a cave can have a negative influence on the cave and the growth of its formations. Care should be exercised also when making any change to the land above the cave, including the removal of the vegetation and disturbance of the soils above the bedrock.

5-1 Any sighting of buildings, parking areas, and any other intervention directly above the cave, must be avoided in order to keep the natural seepage of rainwater from the surface in its original condition.

Monitoring

After the environmental impact evaluation of the development, including any other study of the cave environment, it is necessary to monitor the relevant parameters to ensure that there is no deviation outside acceptable limits. Show caves should maintain a monitoring network of the cave environment to ensure that it remains within acceptable limits.

6-1 Monitoring of the cave climate should be undertaken. The air temperature, carbon dioxide, humidity, radon (if its concentration is close to or above the level prescribed by the law) and water temperature (if applicable) should be monitored. Airflow in and out of the cave could also be monitored.

When selecting scientists to undertake studies in a cave, it is very important that only scientists who have good experience with cave environments be engaged for cave related matters. Many, otherwise competent scientists, may not be fully aware of cave environments. If incorrect advice is given to the cave management, then this could result in endangerment of the cave environment. Cave science is a highly specialized field.

6-2 Specialized cave scientists should be consulted when there is a situation that warrants research in a cave.

Cave Managers

The managers of a show cave must never forget that the cave itself is "the golden goose" and that it must be preserved with great care. It is necessary that persons involved in the management of a show cave receive a suitable education, not only in the economic management of a show cave, but also about the environmental issues concerning the protection of the environment at large.

Cave managers should be competent in both the management of the economics of the show cave and its environmental protection.

Training Of The Guides

The guides in a show cave have a very important role, as they are the "connection" between the cave and the visitor. Unfortunately, in many instances the guides have not been trained properly and, not withstanding that they are doing their best, the overall result will not be very good. It is very important that the guides receive proper instructions about the environmental aspects of the cave as well as dealing with the public. It is important that guides are skilled in tactfully avoiding entering into discussions, which can have a detrimental effect on the overall tour.

The guides are the guardians of the cave and they must be ready to stop any misbehaviour by the visitors, which could endanger the cave environment.

Cave guides should be trained to correctly inform the visitors about the cave and its environment.

Information On Show Caves In The World

There are many books published in different countries providing guides to the local caves. On one hand they report a rather large amount of information but, on the other hand, they are fully reliable for a short time only after their publication. In fact show caves have a certain turnover with changes of the visit details, etc. or, sometimes, on the very existence of the show cave itself.

Recently a rather useful way to obtain up-to-date information became available. "Showcaves of the World" is a website, which can be found at http://www.showcaves.com/. This site changes and grows continually, so on the web the latest version may always be seen.

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