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PRELIMINARY CONSIDERATIONS UPON THE MAIN TYPES OF SPELEOSITES IN THE APUSENI MOUNTAINS (ROMANIA)

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ABSTRACT – Speleosite assessment is a complex process due to the specificity of caves that contain particular intrinsic values. Eight main categories of speleosites are outlined based on the main intrinsic value of the analyzed sites. Speleosites for their morphology represent the first category of speleosites, containing those sites that are important because of spatial development or cave formations. Hydro-speleosites, ice speleosites, bio-speleosites, paleontological and archaeological speleosites, speleosites of landscape importance and complex speleosites are the other categories of such sites. Regarding the functional value, one can note that caves have a high scientific value due to their intrinsic qualities, while having a significant role as scientific resources. The tourist potential of these geosites is also very high, but tourism development is not suitable for many speleosites because of the need for protection of these fragile environments. Show caves, allowing the practice of underground geotourism, and caves where recreational caving is carried out are the main speleosites of actual tourist value.

Keywords: speleosites, Apuseni Mountains, intrinsic value, scientific value, geotourism, caving

INTRODUCTION

Caves are significant elements of geoheritage and they should therefore be included in any inventory of geosites in a given region. However, their assessment using general geosite assessment methods can be a difficult process and can present many weaknesses mainly because speleosites are very different from the other types of geosites. The specific type of values that caves possess (speleothems, cave ice formations, paleontological remains, etc.) do not have a correspondent in the surface landscape, just as the presence of a water stream, a lake or a waterfall has another impact in a cave, so the appliance of the same criteria seems unfair. Cocean G. (2011) noted the difficulty of applying the same criteria for the underground geosites and proposed a specific criterion for caves (regarding the configuration of the cave development) in the method used for assessing geomorphosites in the Trascău Mountains.

There are few analyses in the scientific papers regarding geosites that target the specificity of endokarst, the approach of Piccini et al. (2005) being one of the most comprehensive papers on the subject. The authors use the term GIN (Geositi Ipogei Naturali – Natural Hypogean Geosites) and identify five categories of GIN, depending on the value that confirms them as geosites: *GIN for the intrinsic characteristics of the cave* (caves with outstanding morphological and morphogenetic features); *GIN for the interest of the hosting karst area* (caves that are representative for the area in which they are located); *GIN for the nature of the outcropping rocks* (caves containing petrographic, mineralogical, tectonic or stratigraphic valuable features); *GIN for the material contained in them* (caves containing speleothems, minerals, archaeological or paleontological remains that allow studies upon past conditions or processes, as well as caves of biological interest); *GIN for the importance in Man's history* (caves that served as a habitat of the prehistoric or modern man).

Although the particular case of speleosites is not thoroughly analysed in the geosite literature, there are however many studies regarding cave heritage (Jiménez-Sánchez et al., 2011; Cigna and

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Forti, 2013; Ballesteros et al., 2015) and cave management (Tercafs, 2003; Bocic et al., 2006; Cigna, 2011; Parise, 2011; Forti, 2015).

METHODS

We believe that geosite inventory in a given region should address speleosites separately by classifying and assessing them in accordance to their most representative values, both intrinsic and functional values.

When analysing the intrinsic value of speleosites, there are some features that we have taken into account, from the dimensions of the cave to the morphological complexity, as well as the presence of underground streams or the function that the cave might have had in the past as shelter for both the prehistoric man and some animal species (*Ursus spelaeus*). It is such features that give a speleosite its defining intrinsic value, determined by means of a comparative approach, based on sustained bibliographical research and direct observations in the field.

In terms of functional values, we have first referred to the scientific value of caves, based on their intrinsic value. Both the type of intrinsic values and its significance vary from one cave to another (Gillienson, 2011), so the scientific value of caves will also be different for different caves.

Caves are also the most important resource for geotourism in the world (Cigna and Forti, 2013) but, when addressing the tourist value of speleosites, we have only referred to those sites for which tourism development is accepted and agreed upon by all parties – local authorities, the Federation of Speleology, Commission of the Speleological Heritage etc. Of course, for some caves, exploitation for tourism purposes is ruled out. In those cases, the tourist value is in fact irrelevant because of the need to exclude any tourist activities due to particular protection needs.

SOME NOTES ON THE ENDOKARST IN THE APUSENI MOUNTAINS

The Apuseni Mountains stand out in Romania in terms of endokarst, since on 1,132 km² of limestone and dolomites there are around 4,000 caves. Thus, the endokarst development index is of 3.5 caves/km², as compared to 2.95 caves/km² at national level (Cocean, 2000).

The analyzed area holds some of the representative endokarstic features at national scale: the longest cave in Romania (Vântului Cave of over 50 km); the cave with the largest development (Humpleu Cave); ice caves, unique in the southeastern Europe (Scărişoara Ice Cave, Focul Viu Ice Cave and Borţig Pothole); major endokarstic systems on two or three levels in correlation to the three leveled surfaces of the exokarst (the best known is the Scărişoara - Ocoale system, displayed on three levels: the upper level – Scărişoara Ice Cave - Pojarul Poliţei, the medium level – Şesuri Pothole - Poliţei Spring, the lower level – the current underground course of the Ocoale Valley towards the Coteţul Dobreştilor resurgence) (Rusu and Cocean, 1992).

Among the genetic types of caves present in the Apuseni Mountains (as described by Cocean, 2000), the hydrodynamically conditioned caves are the most numerous (Vântului Cave, Vârfurașu Cave, Ungurului Cave, Devenţului Cave, Huda lui Papară Cave, Cetăţile Ponorului Cave, Câmpeneasca Cave, Osoi Cave, the Coiba Mare - Coiba Mică system, Runa Pothole, Seşuri Pothole, etc). Caves of tectonic origin come in smaller numbers (Dâmbău Pothole in the Trascău Mountains, the potholes in the Lumea Pierdută plateau, Borţig Pothole, some caves in the Runcului and Râmeţului gorges etc.).

TYPES OF SPELEOSITES ACCORDING TO THEIR INTRINSIC VALUES

The classification that we propose has some common grounds with the one previously elaborated by Piccini et al. (2005), the category of *speleosites for their morphology* overlapping the category of *GIN for their intrinsic characteristics of the cave* and the category of *archaeological speleosites* overlapping the category of *GIN for the importance in Man's history*. However, the present classification is more detailed, containing different categories of sites in accordance to the main valuable features (other than the morphological ones). Other types of values that were not included in the previous study have also been addressed (such as the presence of ice blocks).

Thus, in the study of speleosites in the Apuseni Mountains, we have identified eight categories of speleosites according to their defining intrinsic features.

1. Speleosites for their morphology stand out due to aspects regarding their development, the shape and size of their extension, the scale of the modeling processes and diversity of component microforms.

Speleosites for their dimensions represent the first subcategory of this type of speleosites. It includes caves of considerable length (Vântului Cave, Hodobana Cave, the Zăpodie-Peştera Neagră system), caves with an ample, labyrinth-like development (Meziad Cave, the Cave in Valea Firei), caves with an ample linear development (Cetăţile Ponorului Cave) and caves with an ample, vertical display (Stanu Foncii Pothole). Length has been previously used as a criterion in the preliminary selection of potential geosites in the Trascău Mountains, Cocean G. (2011) only assessing caves with a development greater than 100 m, whilst the configuration of the cave development was used in the actual assessment of geomorphosites of tourist value in the same study.

Speleosites for cave formations represent the second subcategory of speleosites defined by their morphology. This subcategory includes caves containing: large stalactites (Urşilor Cave, Vârtop Ice Cave), montmilch columns (Vârfuraşu Cave), overhanging flowstone (Osoi Cave, Moanei Cave), curtains (Vârfuraşu Cave, Pojarul Poliţei Cave), helictites and coralloid speleothems (Pojarul Poliţei Cave), cave pearls (Vântului Cave, Urşilor Cave), anthodites (Vântului Cave), flowstone (the Cave in Valea Firei, Urşilor Cave), gours (Igriţa Cave, Vadu Crişului Cave), large rimstone pools (Tău Cave, Căput Cave) (Bleahu et al, 1976; Orghidan et al, 1984; Cocean, 1995) etc.

When inventorying speleosites included in this category, three aspects ought to be considered that allow subsequent comparisons among sites: the variety of speleothems (one can note some caves containing a wide variety of speleothems – Altarului Cave, Pojarul Poliţei Cave, Urşilor Cave, Fagului Cave, Bătrânului Cave), the surface occupied by speleothems (measured as a percentage, relative to the total area of the cave) and the dimensions of speleothems (the Humpleu Cave is representative due to its emblematic calcite crystals of 50-100 kg – Cocean, 1995).

2. Hydro-speleosites are interesting mainly because of the underground streams, lakes or waterfalls (Cetăţile Ponorului Cave, Ciur-Ponor Cave, Huda lui Papară Cave, Peştera cu Apă de la Bulz). Large karstic draining systems are also included, some of which have not been entirely explored yet, such as the Coiba Mare – Tăuz Spring in the Bihor Mountains, or the drainage associated to the Izbândiş Spring, in the Pădurea Craiului Mountains. In these later examples, the flooded sectors are predominant, thus presenting a particular karstic evolution.

3. Ice speleosites (caves hosting underground ice blocks) are of major importance. Because in the Apuseni Mountains there is no perennial ice, they represent a unique feature for the climate of the area. The caves listed in this category are Scărişoara Ice Cave, Borţig Pothole and Focul Viu Pothole. One should note that the previous studies (Orghidan et al, 1984; Cocean, 1995) also refer to the Barsa Ice Cave; however, the climate warming in the last two decades has led to the melting of the ice block in the entrance sector during summer. These speleosites display a unique underground landscape and have a high aesthetic value. This has exposed the caves and the already highly vulnerable ice blocks to the effects and implications of exploitation for tourism purposes.

4. Bio-speleosites are caves of biological interest, the most eloquent example being the Huda lui Papară Cave, that hosts the most important bat population in Europe (of over 300,000 individuals). Other colonies are located in the Aştileu Cave, Meziad Cave, Peştera cu Apă din Valea Leşului (where there is a record number of cohabiting species, that is 16), Moanei Cave, Peştera cu Apă de la Bulz, Ungurului Cave and Coliboaia Cave (Farkaş Szodoray-Paradi, 2011).

5. Paleontological speleosites include the caves containing paleontological remains (*Ursus spelaeus*): Igriţa Cave, Micula Cave, Zmeilor Cave in Onceasa, Urşilor Cave etc. Of higher value, there are those speleosites containing complex, unique or rare vestiges, followed by those containing abundant relics in different stages of preservation. Many such remains and relics were extracted in the past from the caves in the Apuseni Mountains and some can be found in the museums of natural sciences in Vienna, Budapest, etc.

6. Caves containing vestiges of national or international importance (such as the footprints in Ciur-Izbuc Cave or Vârtop Ice Cave) stand out among ***archaeological speleosites***. They are followed by speleosites containing regionally important vestiges, such as Cetăţeaua Mare Cave, Ungurului Cave or Poarta Zmeilor Cave.

7. Speleosites for their impact upon the landscape decisively mark the karst landscape in which they are located, due to their imposing, large entrances: Cetăţile Ponorului Cave, Coiba Mare Cave, Meziad Cave etc. Swallets, elements of the karst landscape with a dual function, both morphological and hydrological, are also included in this category. Their impact upon the landscape is due to their steep antithetic scarps or temporary lakes that appear during periods of maximum rainfall. The Vânătara Swallet is the most representative; its continuous deepening generated the highest antithetic scarp in the Apuseni Mountains, of over 250 m; but there are other important examples: the swallet of the Tău Cave in Vlădeasa, Runcşorului Swallet, the swallet of the Câmpeneasca Cave, etc.

8. Complex speleosites are sites that can easily be comprised in two or more categories of speleosites, due to at least two high and close intrinsic values. Urşilor Cave in Chişcău, whose complex paleontological vestiges and richness in speleothems confer a high intrinsic value, is representative for this category. Huda lui Papară Cave, the only ample endokarstic landform in the Trascău Mountains, formed by the underground evolution of the Ponorului and Poienii streams, united in the Vânătara Swallet is yet another representative example. Its value as a hydro-speleosite is obvious, its main characteristics being essentially related to the presence of the underground stream, but its value as a bio-speleosite and its impact upon the landscape of the nearby area are also important. Speleosites of both archaeological and paleontological importance, such as the Ciur-Izbuc Cave are also included in this category.

Thus, for the inventory of speleosites all potential values must be recorded, followed by the identification of the main, defining value of the site and the listing in one of the categories presented above. Any comparisons between speleosites should only be relevant when made within the same category, considering the defining intrinsic value at first and other secondary valuable features secondly. The comparisons performed between sites with the same type of value and interest have also been recommended when assessing geosites in general (Wimbledon, 2010).

CONSERVATION OF SPELEOSITES

However, another issue that needs to be taken into account is the level of integrity and conservation of the analysed sites, especially due to the high fragility and vulnerability of the underground environment.

Speleosites with a high preservation degree are practically those in which access has been restricted immediately after discovery (Altarului Cave). Indeed, restricting the access is the most efficient form of protecting speleosites at the moment.

Speleosites that have been moderately impacted by human actions are caves that have had a certain protection either due to an access restriction at a certain moment and a control of visits (visits only performed based on access permits) or by means of organized tourism (the opening of a show-cave). The most illustrative example is the Urşilor Cave in Chişcău that benefited from such a protection immediately after its discovery in 1975 and was later arranged for tourism on one sector. The Meziad Cave is yet another example of a speleosite that has been arranged for tourism, thus controlling the entries.

Finally, there are some speleosites strongly impacted by human actions: the exploitation of limestone or water in the nearby area (Porţile Bihorului), waste storage (Cociului Cave and other several easily accessible caves), vandalism (Fagului Cave, in 1973), thievery (theft of paleontological remains from Zmeilor Cave in Onceasa and Igriţa Cave). Circumstantial tourism arrangements of caves can also have a major negative impact upon the underground environment, as it was the case for Huda lui Papară and Vadu Crişului caves (Cocean, 2001).

THE FUNCTIONAL VALUE OF SPELEOSITES

The scientific value of speleosites is determined firstly by the intrinsic features presented above. Other important aspects also contribute to their value, such as the role that a cave has as a testimony in reconstructing evolutionary scenarios or past phenomena manifested in the area in which it is located, or as a reliable source of information on the anthropization of the region (Tercafs, 2003; Piccini et al., 2005; Brandolini, 2007; Cigna, 2011; Jiménez-Sánchez et al., 2011; Cigna and Forti, 2013; Forti, 2015).

The Cetăţeaua Mare and Cetăţeaua Mică caves in Turda Gorge, facing each other on the two separate slopes, resulted from the development of an aquifer in the limestone bar. They indicate an intense underground activity in the limestone bar and attest the epigenetic deepening of the Hăşdate valley as it formed the gorge sector and segmented the original cave.

Speleothems also provide important information about climate change, tectonic or volcanic activity etc. (Forti, 2015). The stalagmitic domes fallen to the floor in the Dârninii Cave and Humpleu Cave are an indicator of past, intense seismic activity in the Albac and Someşul Cald basin areas (Cocean, 2012).

In the Scărişoara Ice Cave, studies performed on pollen, micro- and macrocharcoal, and macrofossil recovered from the ice block contain valuable information on the composition of regional flora and the human impact in the past 1000 years (Perşoiu and Onac, 2012).

For geosites in general, the observation made by Warowna et al. (2014), that geosites with the highest scientific value are usually the ones with the highest tourist value, is generally true. For caves, however, this is a debatable standpoint. Although many caves of high scientific value have a high *tourist potential*, one cannot speak of an actual *tourist value* given the fact that access in those caves is restricted for the public. The access in caves of exceptional scientific value, such as the "A" class caves (as classified according to the Law no. 462/2001 modified and completed by the Law no. 345/2006 and the Minister's Order no. 604/2005), is limited and permitted only for exploration, mapping and other scientific purposes (Altarului Cave, Pojarul Poliţei Cave, Dârninii Cave, Ciur-Izbuc Cave, Micula Cave, Vârfuraşu Cave, etc.). "A" class caves that contain tourist sectors stand as exceptions (Urşilor Cave, Scărişoara Ice Cave and Vântului Cave).

Moreover, exploitation of caves for tourism purposes versus the need for protection and conservation of the underground environment is still a debated issue that involves a series of different factors and variables (Pulido-Bosch, 1997). Some authors point out a conflict between these two directions of action (Piccini et al., 2005; Jiménez-Sánchez et al., 2011). Others state that as long as tourism development is based on advanced studies and follows strict rules both before and during the touristic exploitation, it can be beneficial also in terms of cave protection (Cigna, 2011; Cigna and Forti, 2013). However, debates on the tourism opening of a cave and the limits to which it should be achieved must include a large number of specialists in fields related to speleology (Lobo et al., 2013).

Show caves and underground geotourism. Underground geotourism is among the most popular forms of geotourism (Garofano and Govoni, 2012), the type of tourism most involved in the protection of sites (Necheş, 2013). However, an important issue geotourism also implies is the safety of visitors. Hence, the need for arrangements and, for the analyzed landforms, the opening of show caves. Show caves represent the main way in which a high number of tourists may come to know the underground environment and understand its specific need for conservation and protection (Parise, 2011).

Cigna (2011) notes that there are three ruling principles regarding show caves: the protection of the underground environment, the safety of visitors, and profit. Summers (2012, cited by Cigna and Forti, 2013) points out that the worse scenario involving show caves is in the case of caves opened to tourism and then closed because of not being economically productive. In order to avoid such a situation, the authors suggest two questions that must be addressed prior to the decision to open a show cave:

1. Is there an actual demand for underground geotourism in the region?
2. Can the cave sustain tourism development without major problems?

In order to answer the first question, several aspects must be taken into account, starting with the location of the cave in connection to the main landmarks of the region and the tourist flows. The

proximity to other sites where geotourism is already developed is a positive factor, as is the vicinity to other speleosites, which could represent the premises for an integrated geotourism offer. The location of some caves inside protected areas is another positive factor, since these areas are already known to the tourists (Fuertes-Gutierrez and Fernandez-Martinez, 2010).

The presence of services is also important, mostly in the early stages, since services will develop and local economy will be positively impacted once the cave is opened for tourism (Cigna, 2011). This is an obvious fact in the cases of the areas around Scărişoara and Urşilor caves. Easy access to the cave is also important, a higher viability of the access road being correlated with an increase in the number of tourists in the case of Scărişoara Cave (Drăgan and Cocean G., 2015).

Regarding the second question, Cigna and Forti (2013) consider the visitor carrying capacity to be the most important factor in the decision of opening a cave for tourism. This index, regarding the maximum number of tourists that can enter the cave at a given time can also be found in the studies of other authors (Parise, 2011; Gutiérrez et al., 2014). It is based on the impact that tourists can have in relation to the resilience limit of the underground system (Lobo et al., 2013).

In addition, once a show cave is opened, the sensitive parameters of the cave must be continuously monitored (Cigna and Forti, 2013). Such studies have been conducted over several years in the Scărişoara Ice Cave to determine the impact that visitors have had on the ice block. The most recent conclusion is the one reached by Perşoiu et al. (2011), according to whom the impact of the visitors dissipates at a distance of 10m from the access footpath.

It is obvious that the opening of a show cave does not mean the cease of scientific activities (if only some sectors are being opened), contradicting the viewpoint widespread among speleologists that a cave is "lost" once opened for tourism (Cigna, 2011).

There are some important show caves in the Apuseni Mountains, the oldest one being Vadu Crişului Cave (opened at the beginning of the 20th century), followed by Meziad Cave, Scărişoara Ice Cave, Urşilor Cave, Huda lui Papară Cave (although its arrangement was destroyed by a flash-flood), Poarta lui Ionele Cave and Unguru Mare Cave. One must take note that some of the arrangements made (for Vadu Crişului Cave and Huda lui Papară Cave) have led to the degradation of the underground landscape of the caves (Cocean, 2001).

Speleosites important for recreational caving are caves with a minimally modified environment (no artificial lighting system) where visitors have an experience close to caving and speleology. Recreational caving implies the visit to a cave for the mere pleasure of the activity itself (Wilson, 2012) and involves fewer tourists than underground geotourism in show caves.

In the study area, there are some caves important for this form of tourism: Humpleu Cave, Huda lui Papară Cave, Osoi Cave, Bătrânului Cave, Cetățile Ponorului Cave, Ciur-Ponor Cave, Betfia Pothole etc. that can be found in the offer of some adventure tourism promoters in Cluj-Napoca and Oradea, specialized companies that provide equipment, technical assistance, training and guiding for the safe visiting of these sites.

CONCLUSIONS

In the Apuseni Mountains, among the 4,000 caves, there are some representative speleosites due to the exceptional values they contain. They stand out due to the spatial development, the richness and diversity of speleothems, the underground streams and lakes, fossil ice blocks or the paleontological or archaeological remains. The functional value of speleosites, between touristic exploitation of caves and the need for protection and conservation of the underground environment and scientifically important features is still under debate at an international level.

Identifying the main types of speleosites in the Apuseni Mountains is just a starting point for analysing caves as geosites. Further analyses, including detailed assessment for establishing various rankings (in terms of conservation priority or underground geotourism development) can be carried out within the defined categories. For such assessments, however, a high number of specialists from all the fields concerned, not just geomorphologists, must be involved. As Reynard (2007) noted, there are cases in which a geomorphologist cannot cover all technical aspects concerning the different values of geomorphosites and, therefore, should try to establish the possible links to other study fields.

Identifying the main types of values that caves possess and the main categories of speleosites is indeed the first step towards establishing such links in this field of research.

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