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THE IMPORTANCE OF ADDRESSING ANTHROPOGENIC THREATS IN THE ASSESSMENT OF KARST GEOSITES IN THE APUSENI MOUNTAINS (ROMANIA)

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Abstract: Geosites' vulnerability and the anthropogenic threats within their perimeters are issues that arise in most of the established methods of assessment and inventory of geosites. This fact is due to the high vulnerability to anthropic pressure of some geosites, karst geosites in particular, that can be easily altered or even destroyed. Their primal, geomorphologic value is most threatened by industrial activities such as the exploitation of carbonate rocks which has had pronounced effects on some of the geosites in the Apuseni Mountains. The brutal interventions of such activities have caused changes in the physiognomy of the affected areas, considerably lowering the value of some geosites, mainly gorges which have been the main target of quarrying. Other human activities such as pastoral practices and forestry impact on the additional values of geosites (ecologic, aesthetic, geotourist etc.), thus they must also be considered in any geosite assessment. The sometimes random development of infrastructures and the damaged older constructions often lower the aesthetic value of geosites. Some tourist forms represent a perturbing factor for geosites of higher vulnerability (speleosites in particular) and also generate tourist pollution which, alongside the dumping of domestic waste represents a risk factor for karst groundwater. Covering the anthropogenic threats in geosite assessment and inventories is essential, because it provides a more complex image upon the current state and evolution of sites and it facilitates the identification of conservation priorities among the analyzed geosites.

Key words: threat, anthropogenic, geosite, karst, Apuseni Mountains

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INTRODUCTION

When assessing geosites in a given territory, an important issue, covered by most methods is the preservation degree or the integrity of the geosites. It depends on both the natural evolution of the landforms and on disrupting phenomena and processes that affect some features or even the integrity of the sites - natural and anthropogenic risk factors that threaten the geosites.

Such risks are addressed in the assessment methods of geosites by one or several criteria. In Pralong's method (2005) anthropogenic risks such as vandalism or building of

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infrastructures are addressed in a criterion regarding the integrity of geosites. Bruschi & Cendrero (2009) also mention urban-industrial development, industrial exploitation of rocks and the possibility of collecting objects, in a section regarding potential threats and protection needs, while also considering the degradation of sites due to human activities within the intrinsic quality assessment. The method elaborated by Pereira (2007) has a distinct section regarding the protection value of the geosites, analyzing the sites' integrity (the impact that natural phenomena and human actions had had in the past) and the sites' vulnerability (future threats).

Lima & Brilha (2010) highlight the importance of assessing human impacts in order to effectively prioritize management actions necessary to protect those geosites that have the greatest need for such interventions.

A substantial part of their method is dedicated to the evaluation of the risk of degradation of concerned geosites, addressing the vulnerability of sites to anthropogenic and natural factors as well as the geosites' location in relation to potential damaging sites. Cocean (2011) suggests that natural and anthropogenic risks be analyzed in a distinct section, as restrictive factors acting upon the value and potential of geosites. Their numerical value would be subtracted from the sum of the structural (intrinsic) and functional values.

Covering natural and anthropogenic risks when assessing geosites is important because their impact can manifest at many levels, upon the different values of geosites. Some human activities, on which we will focus further on in the paper, affect the geomorphologic value of geosites: industrial exploitation of carbonate rocks have a strong impact upon the integrity of geosites and can even lead to their destruction, improper water use and pollution in the perimeter of hypogean sites irreparably affect their evolution or defining features, development of infrastructures (transport, expansion of settlements) has the effect of destroying microforms etc. Such issues also affect the scientific value of geosites, the integrity of the landforms being a criterion commonly used for its assessment.

Other human activities, though not representing a direct threat to the geomorphologic value still affect the secondary values of sites: ecologic (damaging of flora and fauna by logging and intense grazing), aesthetic and cultural (damage of the cultural landscape). All of these aspects impact the potential of geosites as geotourism resources, for which the preservation degree and natural aspect are key elements.

THE VULNERABILITY OF KARST GEOSITES

Karst landscape is considered as one of the most fragile and vulnerable types of landscape (White, 1988; Urich, 2002; Parise & Pascali, 2003; Calò & Parise, 2006; Ford & Williams, 2007; De Waele, 2009; Podobnikar et al., 2009; North et al., 2009; Gutierrez et al., 2014), undergoing a gradual degradation in the current period due to anthropogenic impacts (Parise et al., 2009).

Karst geosites, as representative forms of this type of landscape are particularly vulnerable to anthropogenic impacts. For those landforms affected by some human activities such as mining or quarrying, reclamation is difficult, often impossible (De Waele, 2009), due to the irreversible anthropogenic changes (Parise, 2009; Ilieş et al., 2010) that can lead to the destruction of the landform (De Waele, 2007).

A method successfully applied for the assessment of the disturbance degree in karst areas is the one elaborated by van Beynen & Townsend in 2005 (karst disturbance index). It aims to assess the impacts on geomorphology, atmosphere, hydrology, ecology and culture by using quantitative indicators. De Waele (2009) suggests the direct reporting to disturbances instead of the indicators; such an approach partially

eliminates the main problem that may occur when applying the index, problem also signaled by van Beynen & van Beynen (2011), the lack of advanced studies and the limited access to valuable data regarding human impact on karst.

This problem also rises when trying to apply the index on the karst geosites in the Apuseni Mountains, especially for the less studied sites, with limited available data. However, anthropogenic threats and impacts must be analyzed within geosite assessment, especially since adverse impacts of past human actions are obvious for several karst geosites in the area. Besides, such activities are still ongoing in the perimeters of some geosites, representing a threat to their overall value.

ANTHROPOGENIC THREATS IN THE PERIMETERS OF KARST GEOSITES IN THE APUSENI MOUNTAINS

Among the anthropogenic risks present in the perimeter of karst geosites, the *industrial exploitation of limestone* has the most striking and often dramatic impact upon geosite integrity and karst landscape.

The spatial extent of limestones in the Apuseni Mountains (1 132 km²) and their high fragmentation has led to their exploitation in several locations.

Gorges have been the most exposed to this risk, many quarries being located in the perimeter of such geosites: Tureni quarry in the left slope of the gorge, the two quarries in Poşaga Gorge, Băiţa quarry in Crişul Negru Gorge, Poiana Galdei (inside the perimeter of Galda Gorge) etc. The impact of such quarries involved brutal interventions upon the geosites, by changing the declivity and physiognomy of the slopes and valley profile, interventions that are prominent in the Tureni Gorge (Figure 1A), Ardeu Gorge (Figure 1B) and Poşaga Gorge.

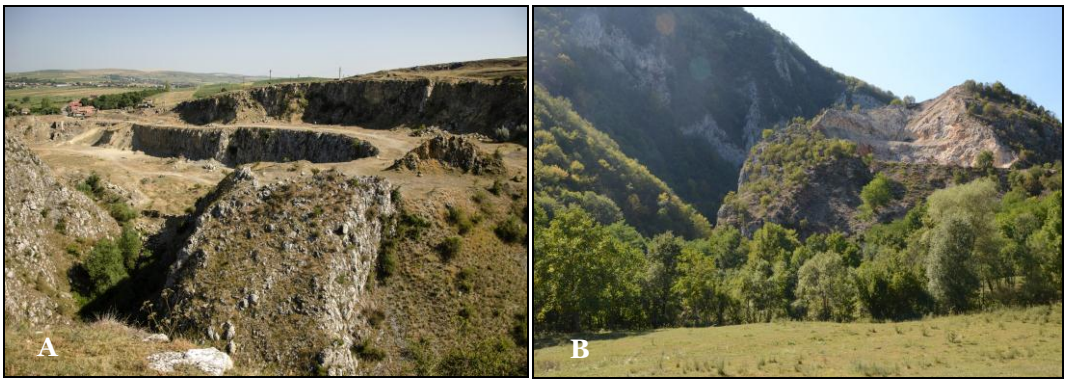

Figure 1. Limestone exploitation in Tureni Gorge (A) and Ardeu Gorge (B)

While the Tureni Gorge has a great geomorphologic value as a geosite (Cocean, 2011), the Poşaga Gorge stands out in terms of cultural value as well (due to the presence of the monastery at the entrance), aspects that should have been considered before the starting of the industrial exploitation in their perimeters. In fact, Stanton (1990) noted that in some cases the actual value of limestone is highest *in situ*, as an aesthetic factor, therefore recommends avoiding their exploitation for those cases (and we strongly believe that this applies to the gorges previously mentioned).

Quarrying also involves the genesis of anthropogenic landforms: massive dumps of crushed material (prominent in Băiţa and Poiana Aiudului), steep quarry terraces (Tureni and Sănduleşti), enclosed or semi-enclosed basins and excavation platforms (Sănduleşti). Such forms mark the surrounding landscape for thousands of years

(Parise et al., 2004) or may even be considered permanent since they require a significant geological time to return to a more natural state (Urich, 2002), thus the need for reclamation once the exploitation has been ceased.

Yet, one can note the absence of reclamation and mitigation of damages for most quarries where activity had been ceased (Tureni, Poiana Galdei, Poşaga, Pietroasa etc). The fact is all the more regrettable since quarries are often located in the perimeter of natural reserves, where landscape conservation, protection and reclamation should be high priorities. Some quarries located within the perimeters of geosites still function, the most relevant being the Băiţa-Plai crystalline limestone quarry, currently the only such exploitation in the Apuseni Natural Park and the Sănduleşti and Cheia quarries, located in the Petreşti Ridge, near the Turda and Tureni gorges.

Quarrying has of course derived impacts upon the ecologic value of sites by damaging the vegetation and fauna in the surrounding area due to dust and vibration propagation, that have also been acutely felt in the past by residents living near quarries (as it was the case of villagers living near the upstream quarry in Poşaga Gorge).

However, we should also mention the fact that sometimes quarries can become geosites, by uncovering some novel geologic or paleontological features (Gueguen & Adurno, 2010), as it was the case for the Minervino Murge, Murgetta Rossa and S. Leonardo quarries in Puglia (Italy). Quarrying also led to the discovery of caves of great scientific and aesthetic value (De Waele, 2007), as the Urşilor Cave in the study area, discovered in 1975 during work for the Chişcău limestone quarry.

The *underground exploitation of minerals* also had negative repercussions upon karst geosites in the Apuseni Mountains. Bauxite has been extracted in the Vârciorog – Răcaş – Dobreşti – Roşia area (including the Albioara gorge and nearby Vida, Cuţilor and Lazuri gorges). Although the activities had been ceased in 1996 the impacts are still present in the area: numerous cavities of diverse extent with unstable slopes, pollution of surface and groundwater that show great variations in the pH, heavy metal pollution with obvious effects on soils and vegetation (Dragastan et al., 2009).

The bauxite and uranium deposits in the Galbena area (Tărtăroaia Massif) had been prospected in the past. A possible decision regarding their extraction would imply a major risk for the Galbena Gorge, a geosite of very high scientific and geotourist value. Băiţa Plai uranium exploitation has had an insidious impact upon the area. Begy et al (2013) report radium presence over the internationally accepted limits in the brook sediments next to a gallery entrance.

In the same context, the presence of the National Radioactive Waste Repository in Băiţa Bihor is yet another risk factor for the area, as well as the limestone exploitation located inside the Crişul Negru Gorge. These issues have a negative impact upon tourism development, the tourist value of the Crişul Negru Gorge and Porţile Bihorului Cave being practically zero. This is due mainly to the restricted public access in the area as well as the discouragement of both investors and visitors due to these industrial activities and forsaken landscape around Băiţa Plai.

Logging favors erosional processes and enhances the geomorphologic risks in the exploited areas. Abandoning wood waste and sawdust influence the intrinsic value of some speleosites, mainly by clogging reported in some swallets in Padiş, Gârda, Bătrâna, Ic Ponor (ANP Management Plan, 2006). In addition, storage of logs, improper disposal of wood waste and tracing forest roads have affected the value of several gorges (Vida, Ribiţa, Pociovaliştea, Gârdişoara). Similar problems have been reported for some karst plateaus: Vaşcău, Răcaş, Poieni (Cocean, 2001).

Pastoral practices, widespread in the Apuseni Mountains do not generate substantial changes in the physiognomy and structure of geosites, but still have an

impact marked by the grazing terraces in the slopes (Figure 2A), trodden paths and degradation of soils and vegetation. These impacts are not present on the steep rocky slopes; however, Başnou et al. (2009) remark the intensifying grazing on the steeper slopes of the Apuseni Mountains in the recent years.

The same authors, in a study conducted in the Intregalde Commune (that includes the Intregalde, Găldiţei and Turcului gorges) highlight the fact that the vulnerability of limestone grasslands is higher than for the other types of bedrocks (flysch and volcanic), and their recovery takes much longer. The cause indicated by the authors is the specificity of the vegetation in limestone areas, also containing relict and endemic plants which are not adapted to grazing.

Grazing and overgrazing are unfortunately common in the territory of protected areas, where they becomes a risk factor to plant associations, threatening the ecologic value of some geosites in the Apuseni Natural Park (Călineasa or Bălileasa uvala) or the Trascău Mountains: Turda Gorge, Pleaşa Râmeţului-Piatra Cetii Ridge etc.

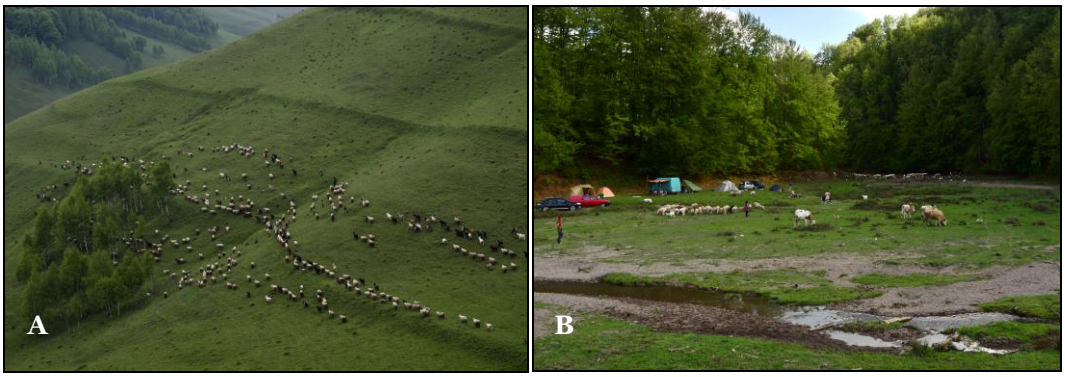

Figure 2. Grazing in the area nearby Vânătara Swallet (A) and at the Runcşor Swallet (B)

Water contamination with organic substances is yet another problem associated to the pastoral practices, due to the fact that areas near water sources, cave entrances and swallets are also used for grazing (Figure 2B).

In areas where such infiltrations are conjugated to *discharge wastewater* from households or tourist infrastructures (due to the lack of access to sewage networks) the quality of groundwater is scarce. Epure & Borda (2014) analyzed the groundwater in the Ocoale-Gheţar-Dobreşti plateau, indicating the presence of E.coli (associated with faecal contamination), which makes the seven analyzed sources improper for usage according to the national standards of water quality. The authors draw attention to the fact that these sources are used in households, and to the implications they may have due to the high permeability of karst areas.

Pollution of karst waters is also caused by waste disposal along rivers that later cross gorges where waste accumulates in the narrow sectors and in lateral marmites with a direct impact upon their aesthetic and geotourist value (Ardeu, Râmeţ, Tureni).

Tourist pollution characterized by leaving garbage in camping spaces or along trails and roads is another problem. Its intensity is strongly correlated to the intensity of tourist flows within geosites and with the main types of tourism. In less touristy areas from the Trascău or Metaliferi Mountains it has a lower impact as opposed to the intensely visited areas in the Apuseni Natural Park, that are the most susceptible to this type of pollution. In fact most gorges and easily accessible caves in the Gârda-Scărişoara-Albac area are prone to this type of pollution (ANP Management Plan, 2006).

Among other negative effects that *tourism* has in certain areas we must also mention the inscriptions on cave walls or gorge slopes, collecting endemic plants and tracing paths towards climbing sectors or by leaving the road with off-road vehicles.

Tourism is often a risk factor to speleosites due to the fragility of the underground landscape, in particular of those caves rich in helictites, speleothems, crystals etc. that can easily be altered. These impacts are limited either by totally restricting the access of the public to such caves or by controlling the access by means of organized visits. However, the poor planning and circumstantial arrangements of caves can also represent a threat. Some past cave arrangements have caused the degradation of the underground landscape in some sectors of caves (Cocean, 2001). One obvious example is Huda lui Papară cave where the degraded structures stirred up by a flood have had a repulsive impact upon the aesthetic of the geosite until their complete removal.

Tourist capitalization of speleosites must also be correlated to the conservation capacity of the karst systems (Cocean, 2001) and their maximum visitor capacity (Gutiérrez et al., 2014). Parise (2011) highlights the fact that this capacity is unique to each cave and should result from a monitoring program conducted on longer periods.

One particular issue is raised by the ice caves in the Apuseni Mountains and the impact that tourism has on the underground ice deposits. For the Scărişoara Ice Cave, the complex studies conducted by the staff of the Speleology Institute of Cluj between 1983 and 1988 revealed a major sensitivity of the cave environment to the anthropogenic factors (the presence of tourists). This fact in not completely endorsed by Perşoiu & Onac (2011), that show that the impact that visitors have is not propagated to more than 10 meters away from the access path, so it does not noticeably affect the ice block.

Cave arrangement for tourism purposes also impacts the biota of caves, one common issue being the development of lampenflora, easily noticeable in the Urşilor Cave for example. For some caves, tourism had a negative impact upon the ecologic value by affecting the bat population, such as the Poarta lui Ionele cave.

Borda et al. (2009) noted that the tourist access to the upper level of the cave for 20 years led to the bat colonies extinction. In fact, after restricting access to that level, removing of artificial lighting and obstruction of the artificial entrance to the upper level, the cave was re-inhabited by bats.

However the impact of tourism activities is still low when compared to the acts of vandalism or theft that had taken place in caves: the massive removal of Ursus spelaeus remains from the Onceasa and Igriţa caves, the vandalism acts in Fagului Cave in 1973, the damage of the footprints of the prehistoric man in Ciur-Izbuc cave etc.

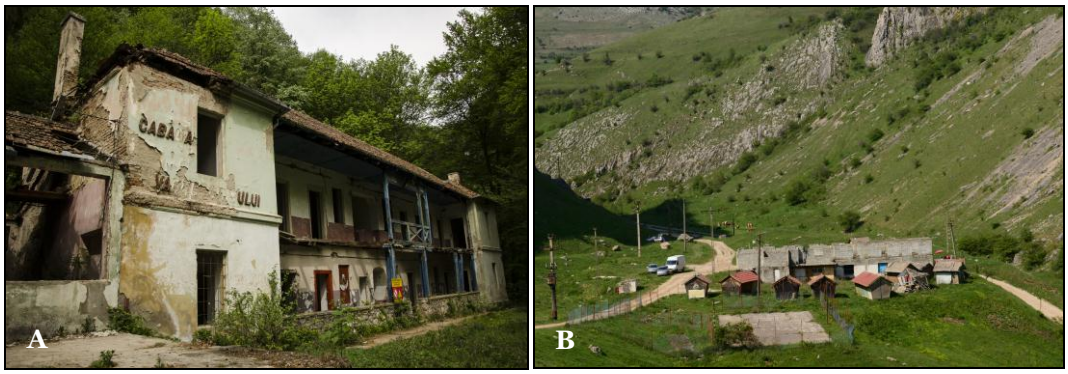

Figure 3. Derelict tourism infrastructures near Vadul Crisului Cave (A) and in the Vălişoara Gorge (B)

Another type of an anthropogenic threat, mainly to the aesthetic value of geosites is represented by various *infrastructures* built in the perimeters of geosite that lead to the degradation of the scenery. Old, abandoned and damaged households, like the ones located inside geosites (in the Poieni Plateau) or near the sites (the abandoned village Cheia near the Râmeţ Gorge) stand out as degraded cultural landscapes. Derelict tourist units have a negative impact upon the aesthetic features of several geosites: Intregalde cabin, Vadul Crişului cabin (Figure 3A), the camping in Vălişoara Gorge (Figure 3B) etc.

New buildings (often tourist guesthouses) can also have a negative impact upon the scenery when having an entirely different architectural line, different materials and a contrasting coloring in comparison to the traditional architecture of the area. The examples are numerous in the Boga-Padiş area, on the Gârda, Râmeţ, Ampoi valleys etc. The lack of authorizations and construction permits, the *ad-hoc*, illegal construction of secondary homes are other issues of concern for the representatives of protected areas, the Apuseni Natural Park in particular.

CONCLUSIONS

Integrity and vulnerability of geosites are issues which arise in many geosite assessment methods. Many of these methods include criteria targeting anthropogenic risks that act as limiting factors on one or several types of values.

For karst geosites, as representative forms of the karst landscape (one of the most vulnerable types of landscape) these limiting factors have specific features and impacts. Considering these factors when assessing geosites is essential and represents a first step towards mitigation of anthropogenic risks and impacts.

Various human activities, from the industrial ones to the urban extend, tourism, logging or traditional activities such as grazing have had negative impacts upon some of the karst geosites in the Apuseni Mountains affecting their overall value.

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