Geotouristic Potential of Former Quarries in Northern Bohemia

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Abstract. Former quarries are among the places that are interesting for geotourism: they are mineralogical or paleontological sites; some quarries are valuable from an aesthetic or environmental point of view. In the quarries where mining was stopped centuries ago, traces of earlier mining technologies can be found, having significant historical value. Despite all the listed values, it is a sad fact that most of the quarries in the Czech Republic are revitalized after the end of mining in a way that destroy the values of the geosite. If nature conservation authorities intervene, it is usually because geosite is also a habitat for endangered species of fauna and flora, not for the protection of inanimate nature. The article analyses the process of making former quarries accessible to the public. First, the geosite evaluation methodology is presented, on the basis of which the localities with the greatest tourist potential and the lowest risks are selected. The methodology is based on six synthetic indicators, which are scientific value, cultural-historical value, aesthetic value, educational value, tourist value and vulnerability of the site. The methodology is explained on two examples of former quarries in northern Bohemia: Panská skála and Hamerský Špičák. The purpose of the methodology is to select suitable geosites, whose values should be protected and used to popularize geosciences and for geoeducation. The discussion points to good examples of making former quarries accessible to geotourism from nearby regions (e.g. UNESCO Geopark Muskauer Faltenbogen / Łuk Mużakowa). On the contrary, the issue of safety of visit to the geosite is mentioned too, which is in some cases the biggest obstacle to access to quarries. The conclusion summarizes the strengths and weaknesses of the use of former quarries for geotourism purposes.

1. Introduction
Geotourism is a form of tourism that has experienced significant development in the last 20 years. It is defined in the Arouca declaration [1] as “tourism which sustains and enhances the identity of a territory, taking into consideration its geology, environment, culture, aesthetics, heritage and the well-being of its residents.” Generally speaking, it is a type of cognitive tourism that presents inanimate nature and its forms. In addition to the natural shapes of georelief, geotourism also deals with anthropogenic forms of relief, of which the former quarries can be mentioned in the first place. In quarries, one can look inside the Earth, see the internal structure of rock massifs and realize the connections that are not visible on the surface. In addition, the quarries are among the richest mineralogical and paleontological sites, which is interesting for many geological enthusiasts. All the sadder is the fact that most of the quarries in the Czech Republic are dumped after mining and the surface is levelled, which degrades the geological heritage of the site. In order to save at least some sites, it is necessary to identify them in time using an
appropriate methodology and then start lobbying on local public authorities so that they do not destroy the site, but save it. A methodology that could be used for this purpose is presented in this article.

Although there are a number of methodologies for assessing geosites [2-6], none of them met the need to take into account the specifics of former quarries. In contrast to conventional geosites, safety and the possibility of transforming the site into an aesthetically interesting place play a key role in making the site accessible to tourists. While we try to protect most geosites in their current form, the former quarries need to be changed - to remove dangerous mining debris and demolished equipment, secure places where people or mining walls could fall, and cultivate the area by building tourist infrastructure. This article presents two localities: (a) the national natural monument Panská skála, which is an example of the successful transformation of a former quarry into a sought-after geotourism locality, and (b) a nameless quarry at the foot of the Hamerský Špičák mountain, which is an example of a locality that has a high scientific and cultural value, but whose tourist potential has not yet been used. Both geosites are located in the region of northern Bohemia, where the creation of a cross-border geopark Neisseland is being considered [7]. In addition, both geosites lie on the borders of regions where there is a strong border effect, negatively affecting local economies [8-9]. The development of tourism is therefore not only desirable here, but also required by local councils.

2. Data and methods
The main source of data was a field survey, in which individual parameters of geosites were assessed. However, not all parameters could be determined on the spot, some could be evaluated only after a thorough search of the literature. This applies in particular to synthetic indicators of scientific value and cultural-historical value. The basic source of data for the indicator was the Database of Significant Geological Sites [10], operated by the Czech Geological Survey. This database is a signpost to studies that deal with selected geosites and are stored in the library of the Czech Geological Survey, where it is possible to study them. The database is continuously updated and is thus a valuable source of information on geosites in the Czech Republic. The scientific databases Web of Science and Scopus were also used. It was not possible to use any databases for the cultural-historical value indicator, as objects of inanimate nature are on the fringes of interest for historians and culturologists. It was therefore necessary to use the knowledge of local experts, namely employees of local museums, Protected Landscape Areas and the Ralsko National Geopark. Thanks to this, it was possible to fulfill the ABC (abiotic-biotic-culture) approach, also mentioned in the Arouca declaration [1].

The used geosite assessment method was developed on the basis of experience with the use of methods of other authors. In addition to the above-mentioned works [2-6], many other scientific articles can be mentioned as sources of inspiration [11-16]. However, the target group of these methodologies is the professional public, which corresponds to the presentation of their results. In this case, it was important not only to take into account the specifics of quarries as objects of geotourist interest, but also the target group, which are local officials who influence what happens to the quarry after mining. That's why it was necessary to work with scales that officials understand, so I chose Cantril's scales (0-10). For each indicator, guidelines were then developed as to what each item on the scale means. Due to the scope of the article, it is not possible to present complete guidelines for all indicators here, an example of these guidelines for the indicator "accessibility by public transport" is given in table 1. The indicator expresses where the best usable public transport stop around the geosite is. The fundamental factor is the distance to the stop, an additional factor of the frequency of connections. Although the description of the individual items on the scale looks directive, the explanation adds that these are still indicative values in which local conditions can be taken into account. For example, if there are two public transport stops at a distance of 0.5 - 3 km from the geosite with a frequency of 5 - 20 connections per day, and a visit to the geosite can be considered as a walk from one stop to another, it can be rated better than "7" (usually rated one degree better) because the added value of the walking route makes the accessibility of geosite more attractive. For the same reason, the table lacks the category "closer than 0.5 km" and at
the same time "less than 5 connections per day", because from the point of view of tourists is a more interesting stop, which is at a distance of 0.5 - 3 km, but where you can get better. The values on the scale are therefore only indicative.

**Table 1. Guidelines for the indicator "accessibility by public transport".**

| Value on the Cantril's scale | Meaning |
|-----------------------------|---------|
| 0                           | The public transport stop is more than 10 km away with a frequency of less than 5 connections per day |
| 1                           | The public transport stop is more than 10 km away with a frequency of 5 - 20 connections per day |
| 2                           | The public transport stop is more than 10 km away with a frequency of more than 20 connections per day |
| 3                           | The public transport stop is 3-10 km away with a frequency of less than 5 connections per day |
| 4                           | The public transport stop is 3-10 km away with a frequency of 5 - 20 connections per day |
| 5                           | The public transport stop is 3-10 km away with a frequency of more than 20 connections per day |
| 6                           | The public transport stop is 0.5-3 km away with a frequency of less than 5 connections per day |
| 7                           | The public transport stop is 0.5-3 km away with a frequency of 5 - 20 connections per day |
| 8                           | The public transport stop is 0.5-3 km away with a frequency of more than 20 connections per day |
| 9                           | The public transport stop is less than 0.5 km away with a frequency of 5 - 20 connections per day |
| 10                          | The public transport stop is less than 0.5 km away with a frequency of more than 20 connections per day |

After all indicators are evaluated, it is necessary to calculate the values of synthetic indicators from them. The indicators are assigned to the individual synthetic indicators as shown in table 2. The value of the synthetic indicator is then calculated as the arithmetic mean of the values of the (sub-)indicators. Although some indicators are named the same (e.g. uniqueness), their content is always related to a given synthetic indicator. It is therefore assessed whether the geosite is unique in terms of scientific, cultural-historical or aesthetic value. For individual indicators are listed also abbreviations, which are then used in table 3. Synthetic indicators represent different aspects of geosite qualities, so no further quantitative operations are performed with them. The result of the evaluation process is therefore six values that describe the basic qualities of geosite. However, the interpretation of these values must be done with knowledge of the local environment and the limitations arising from it.

Evaluation of geosites is the first step in the decision-making process, leading to the opening of former quarries for tourism purposes. Evaluation is used to identify suitable sites and to know of the current state of the geosite. While evaluation is sufficient for identification of interesting geosites, additional data are needed to make access decisions available. For this reason, based on data from evaluation, a SWOT analysis should be created, which clearly names the strengths and weaknesses, opportunities and threats. Due to the scope of the article, it is not possible to present the complete results of the SWOT analysis here, which is not its purpose either. Some main findings from the SWOT analysis are therefore presented in the discussion, but the main goal of the article remains the presentation of the geosites evaluation methodology.
3. Results and discussion
The above-mentioned methodology is presented on two geosites, which differ significantly in their character: Panská skála is one of the most visited natural monuments in northern Bohemia, while Hamerský Špičák is a locality which, despite its great potential, is almost unknown to the public. However, if there had been no intervention that saved the Panská skála site for future generations, it would be completely destroyed today. However, the long story of rescuing this geosite may be an inspiration for making former quarries accessible, as despite its current popularity in the past, there was often little understanding for its preservation.

Panská skála is a unique world-famous example of the very regular columnar separation of the lava flow of olivine basaltoid. The geological body of the so-called Stone Organ is only a relic of a larger basalt outflow on the Cretaceous bedrock [10]. This phenomenon was discovered by mining, which took place here from the end of the 18th century. Whole basalt columns were mined, which were a sought-after trade item: e.g. their export to the Benelux countries is documented, where it was used for the construction of seawalls, as basalt has considerable chemical resistance to seawater. The important

| Synthetic indicator                  | Indicator          | Abbreviation |
|--------------------------------------|--------------------|--------------|
| **Scientific value**                 | Uniqueness         | SU           |
|                                      | Scientific knowledge| SK           |
|                                      | Integrity          | SI           |
|                                      | Diversity          | SD           |
|                                      | Ecological value   | SE           |
| **Cultural-historical value**        | Uniqueness         | CU           |
|                                      | Knowledge of history| CK           |
|                                      | Integrity          | CI           |
|                                      | Diversity          | CD           |
|                                      | Cultural value     | CC           |
| **Aesthetic value**                  | Uniqueness         | AU           |
|                                      | Integrity          | AI           |
|                                      | Diversity          | AD           |
|                                      | Landscape value    | AL           |
|                                      | Artistic value     | AA           |
| **Educational value**                | Representativeness | ER           |
|                                      | Interpretative potential | EI         |
|                                      | Possibility to touch| ET           |
|                                      | Experientiality    | EE           |
|                                      | Possibility of own investigation | EP       |
| **Tourist value**                    | Accessibility by car| TC           |
|                                      | Accessibility by public transport | TA         |
|                                      | Tourist facilities | TF           |
|                                      | Tourist safety     | TS           |
|                                      | Tourist products   | TP           |
| **Vulnerability**                    | Stability of quarry walls | VS         |
|                                      | Vulnerability of geological phenomena | VG       |
|                                      | Vulnerability of biota | VB         |
|                                      | Tourist capacity   | VC           |
|                                      | Resistance of tourist facilities | VR     |
Czech geologist J. E. Hibsch was the first to be involved in the rescue of the geosite, and he demanded its protection as early as 1878. His activity led in 1895 to the declaration of the first geological reserve in Bohemia here and mining should be stopped. However, the law was often circumvented and mining continued until 1948, when it was definitively terminated [17]. At present, geosite has the highest degree of protection that a geological object in the Czech Republic can have, namely the National Natural Monument. Geosite is currently freely accessible and adapted into a park, in its vicinity there is a parking lot with a toilet and an information center, near the rock there are benches and educational signs. The current form of the geosite can be seen in figure 1A.

Despite its rescue from destruction in 1948, Panská skála was still very far from the popular tourist destination it is today. It was relatively little known among the ethnic Czech population, as it was located in an area that was inhabited mainly by ethnic Germans before 1948. The geosite became known to the Czech public after the film fairy tale The Proud Princess (which is still very popular) was shot here in 1952 (see figure 1B). The dramatic shapes of basalt rocks enchanted people and geosites began to be visited by more and more tourists. It is currently the largest tourist highlight between the Bohemian Switzerland National Park and the Jizera Mountains.

Figure 1. Geosites Panská skála and Hamerský Špičák: A) overall view of Panská skála, B) Panská skála in Czech film fairy tale The Proud Princess, C) one of the former quarries at Hamerský Špičák, D) detail of a “stone flower”, an iron inlay in sandstone

Hamerský Špičák is located less than 30 km east of Panská skála in the Ralsko National Geopark. Together with the nearby hills Děvín and Schachtenstein, it lies along a polzenite vein about 2 m thick, which strengthened the surrounding sandstones with its contact effects. During the weathering of the vein, minerals (limonite, clay minerals) were formed, which were mined as iron ore in the 17th and 18th centuries [10]. Some quarries are even older when building material for the nearby gothic castle Děvín
was mined in them. Today, the geosite consists of several smaller former quarries, which are remarkable from several points of view: firstly, they are very well-preserved examples of historical mining (see figure 1C), secondly geologically interesting contact between polzenite and sandstone and last but not least about the occurrence of ferrous incrustations of interesting shapes, among which are the most beautiful so-called "stone flowers" (see figure 1D). Although the geosite is promoted in the tourist materials of the Ralsko Geopark and is part of the educational trail “In the Footsteps of Iron Ore Mining”, it is very little visited because the tourist infrastructure is at a very low level. The geosite is not maintained in any way (it is a commercial forest) or secured, there is no good path leading to the quarries and good preservation of the locality is more the result of a remote location from human settlements than any care. However, when tourists arrive, they are usually excited about the beauty of the stone flowers and the genius loci of the geosite. For this reason, this geosite was included in the evaluation.

Table 3. Geosites evaluation: former quarries Panská skála and Hamerský Špičák

| Synthetic indicator | Panská skála | Hamerský Špičák | Indicator abbreviation | Panská skála | Hamerský Špičák |
|---------------------|--------------|-----------------|------------------------|--------------|-----------------|
| Scientific value    | 7,0          | 6,4             | SU                     | 7            | 7               |
|                     |              |                 | SK                     | 8            | 6               |
|                     |              |                 | SI                     | 8            | 7               |
|                     |              |                 | SD                     | 6            | 7               |
|                     |              |                 | SE                     | 6            | 5               |
| Cultural-historical value | 6,6      | 6,6             | CU                     | 6            | 7               |
|                     |              |                 | CK                     | 8            | 7               |
|                     |              |                 | CI                     | 7            | 6               |
|                     |              |                 | CD                     | 6            | 6               |
|                     |              |                 | CC                     | 6            | 7               |
| Aesthetic value     | 8,6          | 6,4             | AU                     | 9            | 7               |
|                     |              |                 | AI                     | 9            | 7               |
|                     |              |                 | AD                     | 7            | 8               |
|                     |              |                 | AL                     | 9            | 5               |
|                     |              |                 | AA                     | 9            | 5               |
| Educational value   | 8,4          | 7,8             | ER                     | 9            | 7               |
|                     |              |                 | EI                     | 9            | 8               |
|                     |              |                 | ET                     | 9            | 9               |
|                     |              |                 | EE                     | 9            | 7               |
|                     |              |                 | EP                     | 6            | 8               |
| Tourist value       | 8,6          | 4,6             | TC                     | 10           | 7               |
|                     |              |                 | TA                     | 10           | 7               |
|                     |              |                 | TF                     | 9            | 2               |
|                     |              |                 | TS                     | 7            | 5               |
|                     |              |                 | TP                     | 7            | 2               |
| Vulnerability       | 6,6          | 6,4             | VS                     | 8            | 9               |
|                     |              |                 | VG                     | 7            | 6               |
|                     |              |                 | VB                     | 6            | 7               |
|                     |              |                 | VC                     | 7            | 5               |
|                     |              |                 | VR                     | 5            | 5               |

The results of the evaluation of both geosites are shown in Table 3. First, the numerical expression of the synthetic indicator is given, followed by the values for the individual indicators. When comparing the two geosites, it should be borne in mind that Panská skála is a prime example of good presentation.
and care, while Hamerský Špičák is a relatively unknown locality. However, the results of the evaluation suggest that Hamerský Špičák also has great potential to become a valuable tourist destination. The scientific value is relatively comparable, although Panská skála is a scientifically better described locality and its composition differs from the surrounding rocks, which makes it valuable for some plant species. Both localities achieve the same cultural-historical values, while Hamerský Špičák still has the potential for growth, as we do not yet know some details from its history. Panská skála clearly dominates the aesthetic value, as the dramatic rock at the top of the hill attracts people more than quarries on the hillside. Both geosites achieve a very high educational value, as they are great examples of the processes that shaped the surrounding landscape and the history of the people living in this landscape. The biggest differences between geosites are in the tourist value, as there is a well-equipped well-known tourist destination and an almost unknown location without proper infrastructure. In the vulnerability indicator, both geosites are again comparable.

How to interpret this evaluation and learn from it, what sites are appropriate for access for tourists? The first four synthetic indicators describe the objective value of geosite. First, it is the abiotic and biotic parameters, along with cultural and historical parameters, that are also very important in secondary geodiversity objects. The first two indicators therefore describe the classic ABC approach, which must be followed by another level of objective parameters, namely aesthetics and interpretation. Although many sites of secondary geodiversity are very valuable for experts, only some geosites are of interest to the general public. Most of them are places that are also aesthetically valuable, because it is the beauty of these sites that leads people to desire to know how these places came into being. Similarly, the objective professional value of a place may be uninteresting to people, as it is hidden in some way, not visible in the field, or simply understood from what the tourist sees. Therefore, the educational value is also very important, because it expresses how much the phenomenon the tourist can see, touch, experience or at least imagine. Although many obstacles can be overcome in this matter through good interpretation [18], understanding is easiest when the phenomenon is clearly visible. The values of the first four indicators thus show the primary tourist potential that geosites have.

Secondary tourist potential is expressed by a synthetic indicator "tourist value". Low values of the indicator indicate the unpreparedness of the locality for tourism. However, the values of this indicator can be most easily influenced - in short, by improving the tourist infrastructure here. Low values may be the reason why the site is not very visited by tourists – they prefer to visit places where the infrastructure is good. The last of the synthetic indicators, vulnerability, describes the resistance of geosite to damage and threats, a property that is necessary for its sustainable operation. Overall, it can be said that the first four synthetic indicators describe the potential of the site, the fifth indicator the fulfillment of this potential and the sixth indicator uncertainty and risk. Based on this knowledge, a SWOT analysis can then be created for those geosites that have been identified as promising.

Appropriate realizations from the surroundings can be an inspiration on how to make the former quarries accessible to the public. In the area of northern Bohemia, there are mainly a number of basalt quarries, in which, similarly to Panská skála, there are popular “stone organs”. A number of other quarries, sand pits and gravel pits have been converted into bathing sites. Caves have been discovered in some limestone quarries, which are used for wintering bats. Some former quarries have been turned into amphitheaters, places to sit or picnic. In some quarries you can admire the diligence of our ancestors, who with primitive tools in the Middle Ages were able to extract large blocks, from which they then built their castles. And even the site of the former opencast brown coal mine, which is very devastating for the landscape, has been transformed into such an attractive tourist area as the UNESCO geopark Muskau Arch. There are many examples of good realizations, it is only necessary to have the will to take advantage of the opportunity and not to perceive the former quarry only as a place where waste can be brought.
4. Conclusions
Former quarries can be attractive geosites that provide ecosystem services to biota, are an example of cultural and historical events, valuable aesthetic elements and a places of education. This fact was realized by many authors who draw attention to the values of abandoned quarries in their works [19-21]. Some of them also addressed the issue of methodology for assessing their geotouristic potential [22-23], while their procedures are often very sophisticated. Due to the fact that the rescue and access, or the planning, backfilling and destruction of the geosite are often decided by representatives of small municipalities and cities, this article introduced a methodology that is sufficiently comprehensive, but understandable even for an ordinary official. This methodology serves primarily for the identification of suitable localities, resp. to choose the best of several similar sites. This is therefore just the first step in the process of transforming an abandoned or just closed quarry into a future tourist destination.

The methodology was presented on two geosites, which are located not far from each other in northern Bohemia. Panská skála is a well-known and popular tourist destination, which has a very good tourist infrastructure. On the other hand, Hamerský Špičák is a relatively little-known geosite, which, however, has a certain tourist potential, which is not yet used, because the tourist infrastructure is almost not present here. If the quarry is being made accessible to tourists, it is useful to compare potential geosites with existing tourist destinations so that officials can imagine what the outcome of this process will be. The methodology includes a section describing the primary potential of the geosite, the current secondary potential and the degree of threat to the site or tourists. Based on this knowledge, it should be possible to identify suitable geosites and create a SWOT analysis for them, which will address the site in more detail.

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