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Geoheritage and overtourism: a case study from sandstone rock cities in the Czech Republic



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Abstract: Sandstone districts are among the most visited and popular geosites in the Czech Republic. Unfortunately, they are often affected by the harmful effects of mass tourism, referred to as overtourism. Sandstone geosites are very vulnerable owing to the rock's relative softness, and large numbers of visitors can be a threat to them as they accelerate the intensity of their degradation. The overtourism situation then brings other negatives not only to the geosites but also to their surroundings. This paper describes the reasons for the overtourism situation in Czech rock cities, the effects of overtourism on geosites and communities living in their vicinity, and possible solutions from the perspective of nature conservation and tourism management. The data come from field observations, interviews, and publicly available data on the development of the number of visitors to tourist destinations. The results showed that overtourism is a widespread problem in the Czech rock cities, damaging these geosites and negatively affecting the residents of the surrounding villages. In addition, it is necessary to act quickly because the number of visitors to these geosites is continuing to grow in the long term. The article proposes three measures that should mitigate the harmful effects of mass tourism: communication with the visitors, destination management and the protection of geosites. However, for these measures to work, a strategy must be developed that will be respected by all of the main actors in the local tourism industry, and these measures should be targeted at specific problems. This example is typical of the general problems encountered in any geotourism site, and such remedial strategies provide an example of what could be applied to avoid problems elsewhere.

Geoheritage has long been an object of human fascination. Many nations have created various legends, customs or rituals, an essential part of which were unusual objects of inanimate nature (Kirchner and Kubalíková 2015; Khoshraftar and Farsani 2019, etc.). Although some geosites that have become mainly places of worship of various religions have been visited extensively in the past (see Mathieu 2006; Berner 2020), these are entirely incomparable attendance values compared with modern tourism. The significant increase in interest in spending free time in the form of travel, which has its roots in the nineteenth century (Štemberk 2013), is currently intensifying to a hitherto unknown intensity. The effects of this phenomenon can be both positive when tourism supports local rural communities and negative when nature and local communities suffer from an overgrowing number of visitors. Unfortunately, more and more natural sites are being damaged by the harmful effects of mass tourism, so-called overtourism. One such affected collection of sites is the sandstone 'rock cities', jewels among Czech geosites.

The term 'rock city' has been used in the Czech environment to describe large sandstone rock formations, which form a relief resembling a city's

skyscrapers. Although it is not a technical term, it has also adopted by the Czech professional literature (e.g. Adamovič *et al.* 2010), which distinguishes solitary clusters of sandstone rocks from the most valuable large areas. In Central Europe, these areas are mainly connected to the Bohemian Cretaceous Basin sedimentary area, which covers an area of about 14 600 km² between Dresden (Germany) and the northern surroundings of the city of Brno. This largest sedimentary basin in Czechia contains block sandstones in certain places, which are prone to deep erosion and have given rise to beautiful geomorphological shapes of rock cities (Chlupáč *et al.* 2002; Košťák *et al.* 2004; Naadaskay and Uličný 2014). Today, the most valuable ones are located in the Bohemian Paradise UNESCO Global Geopark, the National Geopark Broumovsko and the National Park Bohemian Switzerland (see Fig. 1).

Unfortunately, these attractive locations have suffered from overtourism to a large extent in recent decades. The low abrasion resistance of sandstone and its relative softness is why rock cities are devastated by crowds of tourists. Migoń (2022) identified as major threats to these rock landforms: (1) quarrying, (2) physical alterations/shape modifications, (3) vandalism/rock surface defacing, (4) rock climbing,

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Fig. 1. Overview map of geosites and regions mentioned in this article. Map processed by author.

(5) uncontrolled vegetation growth, (6) natural disintegration processes and (7) negligence/lack of interpretation. Factors (2)–(6) are highly relevant even for the most visited rock cities. This text describes how this situation occurred, what the main factors are that influenced it, and what can be done to improve this situation in the future. Although the case study addresses specific geomorphosites in a selected region, its findings may be applicable in other world regions.

Overtourism: concept explanation

As [Dodds and Butler \(2019\)](#) note, overtourism is a new term for old problems with excessive tourism in attractive destinations that have been known since the nineteenth century. Like other phenomena, tourism can have both positive and negative effects. While many regions see tourism development as a chance for economic growth and an improvement in the local labour market, other areas are experiencing the destructive effects of mass tourism, disrupting local communities and damaging natural and cultural sites. There are significantly more localities that suffer from ‘undertourism’ than those affected by overtourism ([Volgger 2020](#)). It could be said that sites affected by overtourism are certain hotspots

in an otherwise relatively less-visited landscape ([Boháč and Drápela 2022](#)). However, the rock cities are so unique, exciting and beautiful in their geomorphology that they are often such hotspots.

The World Tourism Organization (UNWTO) defines overtourism as ‘the impact of tourism on a destination, or parts thereof, that excessively influences perceived quality of life of citizens and/or quality of visitors’ experiences in a negative way’ ([UNWTO 2018](#)). This definition is very general; therefore, the term overtourism is often overused ([Koens *et al.* 2018](#)). Because the negative impacts of mass tourism on local communities are more attractive in the media than nature damage, overtourism is talked about more often in connection with cities ([Namberger *et al.* 2019](#); [Smith *et al.* 2019](#); [Diaz-Parra and Jover 2021](#)) than with rural regions ([Oklevik *et al.* 2019](#); [Drápela 2020](#); [Insch 2020](#)). However, the consequences can be severe in both cases. In the case of rock cities, there is a risk of irreversible destruction of the site.

The main problem in defining overtourism is finding the limit of what is already ‘over’. Different destinations have different capacities, so a smaller number of visitors to geosites with narrow paths and passages (such as rock cities) creates a problematic situation. The critical factor in these situations is the so-called tourism carrying capacity (or tourism

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load capacity, see [Matos Marcuez and Perez Colme- nares 2019](#)), which UNWTO defines as ‘the maximum number of people that may visit a tourist destination at the same time, without causing destruction of the physical, economic, socio-cultural environment and an unacceptable decrease in the quality of visitors’ satisfaction’ ([UNWTO 1981](#)). Since this definition is again very general, several different indicators are used to try to objectively quantify this concept (e.g. [Mexa and Coccossis 2004](#)), but there are also several works that criticize it (e.g. [Lindberg and McCool 1998](#)).

Depending on the nature of the destination, individual components of tourism carrying capacity are distinguished: physical, social, economic and environmental. Physical carrying capacity indicates the number of people the destination can hold without stopping their movement ([Mowforth and Munt 2016](#)). The physical carrying capacity is exceeded in the high season in some rock cities, and thus there are long queues in narrow passages. The social carrying capacity describes the response of local residents to the number of tourists ([Saveriades 2000](#)), usually measured in the irritation index ([Shaw and Williams 2002](#)). In some localities around the rock cities, various local movements advocate restricting tourism near residential areas. The economic carrying capacity describes the destination’s ability to accept additional tourist infrastructure without local residents losing civic amenities ([Mathieson and Wall 1982](#)). This process, called touristification, causes the transformation of vibrant rural communities into mere tourist attractions, thereby depopulating these areas ([Lorenzen 2021](#)). The environmental carrying capacity deals with the amount of damage that the natural environment is able to regenerate ([Zacarias et al. 2011](#)). As indicated later, while living nature can regenerate relatively well, geosites such as rock cities cannot.

Residents in smaller villages are usually bothered by a relatively minor number of tourists than residents of large urban areas. In such a case, however, it is difficult to determine the extent of real overtourism and the NIMBY (not-in-my-backyard) effect ([Kim and Kang 2020](#)). Although the NIMBY effect usually occurs in large transport and infrastructure projects, it has also been observed in well-visited tourist areas in recent decades. While the harmful effects of mass tourism can be objectively defined in the urban environment, where the touristification and marginalization of local people occur ([Nilsson 2020](#); [Žemla 2020](#)), these phenomena may not always manifest in rural regions themselves. For example, in the village of Karlštejn, where the most famous Czech castle is located, the situation is similar to an urban environment ([Krajčková et al. 2022](#)), while in the UNESCO Global Geopark Bohemian Paradise, the problem is different

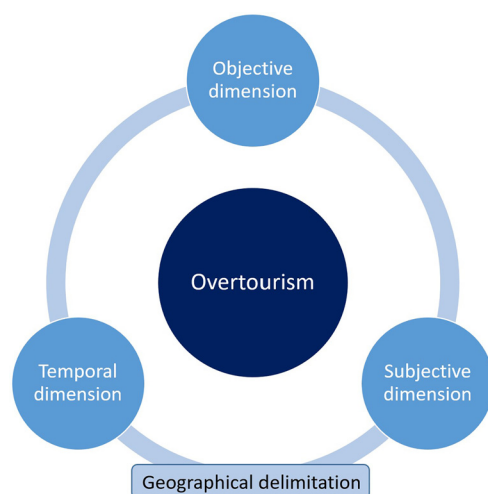


Fig. 2. Three-dimensional model of overtourism. Adapted from [Boháč and Drápela \(2022\)](#).

([Drápela et al. 2021](#)). It can also be stated that most indicators describing overtourism are based on the reality of the urban environment ([Gonzalez et al. 2018](#); [Koens et al. 2018](#); [Milano et al. 2019](#)), focusing mainly on the social area and is therefore not very suitable for rural regions and nature reserves.

Although the definitions of overtourism are different, the authors usually agree that the specific objective manifestations of it are limited in time and affect the perception of tourism by local people. Based on these facts, [Boháč and Drápela \(2022\)](#) created a three-dimensional model of overtourism (see [Fig. 2](#)). This model explains the emergence of overtourism as a situation that, in some respects, transcends the tolerance of the local population in one of three dimensions: objective, subjective or temporal. The objective dimension includes transport and tourism infrastructure problems, damage to the natural environment and deteriorating living conditions. Most of them are problems with parking, congestion on local roads, damage to nature around hiking trails, garbage pollution, vandalism, the transformation of living communities into tourist destinations, etc. The subjective dimension expresses the feelings of residents and tourists from living and staying in the locality. Locals often perceive noise from tourism negatively, feel uprooted from their homes, have problems tolerating environmental changes, lose authenticity and feel transformed into a ‘tourist product’, etc. Tourists may feel stressed in an overcrowded environment, tired of the crowds, and disappointed with a visit that does not meet their expectations. The temporal dimension expresses

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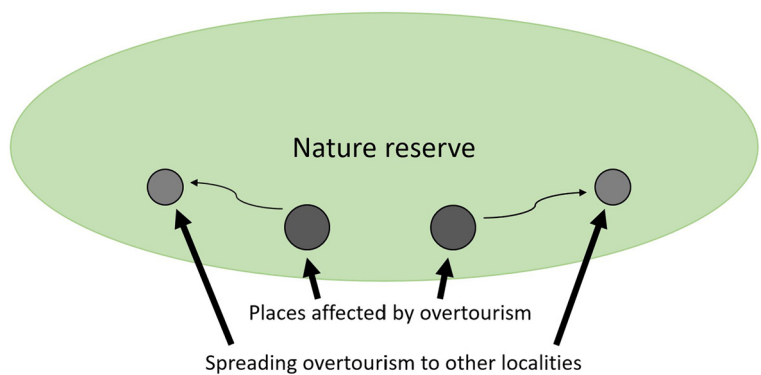


Fig. 3. Overtourism spread model.

the duration of the most significant influx of tourists when short-term situations (e.g. only a few weekends in summer) are better tolerated than long-lasting phenomena. If any of these dimensions exceed the tolerance limit, locals start talking about overtourism. And once a destination is perceived by locals as being overwhelmed by tourists, it is complicated to reverse this situation.

Overtourism is always delimited geographically and often affects relatively small localities, which may also damage their surroundings with their problems. These localities are known as ‘overtourism hotspots’ (Kaufmann *et al.* 2019; Vu *et al.* 2021) and are also typical for areas of sandstone districts (Duszyński and Migoń 2022). From the point of view of nature reserves, the usual problem areas are parking lots at the geosite entrances or nearby villages. This is where the local infrastructure collapses most often, leading to conflicts or illegal visitor behaviour. The area’s character determines one of the variants for the spread of overtourism. If there are multiple accesses to a given site and one or more of them are congested, overtourism spreads widely as visitors begin to use other access points (Fig. 3). This distribution method is typical for more extensive nature reserves; in the Czech Republic, the Krkonoše National Park is affected in this way (Kohoutek *et al.* 2010). More access points lead to less pressure on municipalities or car parks, but it has even more intensive effects on the places visited, by increasing visitation even further.

The second variant, which is more frequent in the areas of rock cities, is the escalation of the problem of overtourism in a limited number of localities (Fig. 4). This is typical of smaller nature reserves with few entry sites. Tourists cannot choose an alternative place to start their trip, so the situation at the entry points deteriorates. However, the limited capacity of the entry points protects the destinations of the trips to a certain extent, as the collapses occur on the transport infrastructure rather than directly in

the nature reserve. On the other hand, this situation can be very frustrating for locals.

Despite all the criticism of the concept of overtourism, based on the subjectivity of the delimitation of its boundaries, it is a term understandable to the public, which is used in the debate about the impact of mass tourism on the destinations visited. This debate is also fundamental because of the need to protect nature, whether living or inanimate. From the point of view of geoconservation, it is necessary to monitor the manifestations of overtourism on geosites to prevent their damage. As the following section shows, mass tourism starts to endanger geosites in a short time, so it is necessary to anticipate the situation and act preventively.

Data and methods

This paper mainly uses descriptive methods, observations and field interviews, sharing experiences

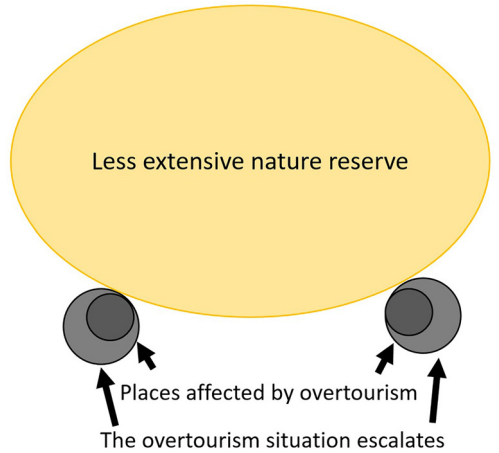


Fig. 4. Overtourism escalation model.

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between entities involved in protecting and promoting geoheritage in different parts of the Bohemian Cretaceous Basin, publicly available data from various sources (see below) and good practices published in the literature.

Field observations are part of mapping the impacts of overtourism in the Czech Republic within the 'Proactive solutions to the negative effects of overtourism' project. They aim to precisely identify the harmful effects of excessive tourism on destinations and local communities. Sandstone rock cities are only one of the various destinations affected by overtourism, but they are very important because of their uniqueness and vulnerability. As part of field observations, research activities are complemented by interviews with local residents ($N = 183$), mayors (34), or local nature conservation authorities (9). The information obtained from these narrative interviews serves to specify the duration of overtourism, its form, and its impact on the local population. Observations and interviews are a source of qualitative information that helps create a deeper insight into the local situation.

Other qualitative data describe local authorities' attempts to deal with overtourism and mitigate its adverse effects that come from various events at which multiple institutions operating in geotourism and nature conservation exchange their experiences. These are the main events of the Czech–German–Polish cross-border network GECON (geological cooperation network), founded in 2017 and currently having several dozen members from many geoparks, universities, nature conservation authorities, local associations, museums, environmental non-profit organizations, etc. There is an exchange of experience at these events with the implementation of various measures, forms of positive visitor motivation, sustainability on geosites and other related topics. Therefore, the information contained in this paper should not be the sole subjective view of one author but the consensus of a wider group of experts.

The quantitative data used in the paper come from four publicly available sources. First, these are data published by the Czech Statistical Office on the number of guests in collective accommodation establishments. In this context, it should be noted that these data only include establishments with at least five rooms or 10 beds used for tourism purposes. These statistics do not include the fashionable sector of cottages rented by small owners. In recent decades (even in connection with the expansion of services such as Airbnb), this accommodation type has experienced a big boom. Still, it is not yet included (practically) in any statistics.

The second type of data used is from infrared pedestrian counters located directly in the field on hiking trails. These counters usually cover the territory of national parks and other nature reserves to a

lesser extent. The paper presents data only for the Bohemian Switzerland National Park, a multi-year continuous series of quality data (the number of counters has changed over the years; the article uses data for the six most visited locations in 2013–19). Unfortunately, they are unavailable for other localities because counters often do not work all year round. They are continuously removed and re-installed, or their owners do not want to share these data with the public (e.g. in the case of municipalities affected by overtourism).

Another type of traffic data are those on paying customers, which operators of these 'attractions' publish. Fees for entering rock cities are collected in some of the most attractive locations. These data need to be seen only as informative data on the number of visitors in the main tourist season, as it is usually free outside of this time. In addition, many locations can be reached outside the official entrances, so some tourists bypass the official entrances so they do not have to pay. The reliability of these data is, therefore, relatively low.

The last type of quantitative data used in the paper is data from the analysis of the number of visitors to the tourist areas of the Liberec Region in 2019 (KROKEM 2020). These data use statistical data from mobile operators, the so-called geolocation signaling data. The analysis was processed once, so it is not a regular survey. These data are very accurate and reliable, but they are processed only at the level of tourist regions and territorial units of hundreds of square kilometres. Unfortunately, they are not available for smaller regions.

Results

From romantic fascination to mass tourism: development of tourism in Czech rock cities

The Czech national anthem is somewhat unusual, as its content is a hymn to the beauties of the Czech landscape. To the rhetorical question, where do they come from, the singer answers by describing the three most incredible beauties of the Czech landscape: the rivers that flow between the green meadows, the pine forests roaring on the rocks and the flowering orchards in the spring. At the same time, pine forests are typical only for areas of sandstone rocks. Already in 1834, when this song was written, the rock cities were among the iconic parts of the Czech landscape.

From the second half of the eighteenth century, there was a growing interest in society in learning about the homeland, to which book producers and artists responded. The first books describing interesting places were created, and vedutas (images or views) appeared to a greater extent – realistic

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Fig. 5. Veduta of Pravčická brána Arch, undated (first half of the nineteenth century). Author C. Köhler, engraver G. M. Kurz. Author's collection.

depictions of real places, the forerunners of today's photographs or postcards (see Fig. 5). Although the most common motifs for vedutas were cities, castles and chateaux, sandstone rocks were relatively abundant in the minority depicting natural attractions. Often displayed places included the sandstone rocks in the Elbe Gorge near Hřensko, Pravčická brána Arch, Sloup Rock Castle, Jestřebí Rock Castle, Hrubá Skála Rock City with a chateau and Adršpach Rock City. In addition, many cultural monuments (especially castles) were often depicted with attractive surroundings of sandstone rocks.

Another impulse to increase awareness of rock cities was romantic literature, which set the plots of novels, short stories and poetry in the environment of the rocks. Today, one of the regions with several rock cities is called Mácha's Region, according to the most important Czech romantic poet Karel Hynek Mácha (1810–36), who often visited it and wrote about it (Ivanov 2021). Many viewpoints in the rock cities are named after influential personalities of the Czech cultural scene of the nineteenth century who once visited them.

The relationship of the Czechs to the rock cities has always been very positive. As the territory of the Czech Republic is located in the middle of Europe, where various war operations often occurred, the local population sought protection from the looting troops in the rocks. These days, some war shelters are tourist attractions, as are the places of rock chapels where services of persecuted

branches of Christianity (mainly the Hussites) took place. The rock city as the protector of the local population also appears in a gigantic painting with elements of a diorama called 'The Slaughter of the Saxons under Hrubá Skála', which was created by a group of painters led by Mikoláš Aleš (1852–1913) (Aleš *et al.* 1895). The 10 × 8.5 m canvas depicts a fictional historical scene in which the Czech warriors, stationed on the rocks, are victorious over the larger Saxonian army (see Fig. 6). Although this painting depicts an event that never happened (it is described in an allegedly medieval book, which was later revealed to be a forgery), it is evidence of the Czechs' relationship to the rock cities at the time as protectors and an essential part of national pride.

During the nineteenth century, more and more people could afford to spend their free time travelling. At first, only wealthy townspeople travelled. Later less affluent parts of the population were able to travel. Influenced by romantic literature and encyclopaedic geographical works, the first tourists also travelled to the rock cities, where hiking trails were quickly created. Influenced by the beauty of the rocks, visitors began to come up with different names for these regions, so terms like Bohemian Paradise or Bohemian Switzerland were created. By the end of the nineteenth century, it was already clear that tourism was becoming a new social phenomenon. Therefore, local tourist clubs and 'local beautification societies' (Kubalíková 2018) sought to build a tourist infrastructure. However, this marked

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Fig. 6. 'The Slaughter of the Saxons under Hrubá Skála'. Oil on canvas with assemblages by Mikoláš Aleš (1895). Wikimedia Commons, public domain.

a turning point in people's relationship with the rocks when the mysterious labyrinths, in which only local experts could find their way, became an admired tourist product.

During the twentieth century, regions with rock cities experienced a continuous development of tourist infrastructure capacity. The only exception is Bohemian Switzerland, which was part of the border zone from 1948 to 1989, where entry was very limited. The significant development of climbing, further promoted in pop culture, also contributed to the popularity of the rocks. In particular, Bohemian Paradise was used to make several popular films for children and adults, making many localities iconic. There were also created songs about hiking and climbing in rock cities, which are still very popular. On the other hand, pop culture contributed significantly to the one-sided perception of these rural regions, as if nothing was engaging in them other than rock cities (and, in some cases, castles and chateaux).

In the 1990s, the long-term trends changed (see Kolodziejczyk 2020). At first, there was a decline in interest in domestic tourism because, after 40 years of a lack of freedom, it was possible to travel worldwide again. This decline in interest can be seen in Figure 7, where between 1990 and 1995, the number of guests in collective accommodation establishments decreased by about 1.5 million. Since then, however, the number of guests has

grown, reaching a peak in 2019. This is almost 2.5 times more than in 1990. In addition, the data show only guests in collective accommodation establishments, which the Czech Statistical Office defines as 'establishments with at least five rooms or ten beds used for tourism purposes'. Small-scale accommodation establishments (cottages, cabins, farms, etc.), which in 1990, owing to the previous ban on private enterprise, practically did not exist, today form a substantial part of the offer of accommodation in rural regions and are not included in these statistics.

In the last 25 years, the increase in visitors has been even more intense in the rock cities. Although relevant data were not available before 2013, after the expansion of automated infrared visitor counters, even in this relatively short period, an increase of 250% or more can be observed in some geosites (see Fig. 8). Data for 2020 and 2021 are not presented owing to the significant impact of the Covid-19 pandemic when in some periods, tourism was practically absent owing to restrictions on movement. Unfortunately, data for rock cities in other regions (outside the Bohemian Switzerland National Park) are unavailable in this quality, as automated counters are used sporadically outside the national parks.

The significant increase in the number of visitors to the sandstone rock cities has led to the rise in the intensity of the negative impacts of mass tourism on

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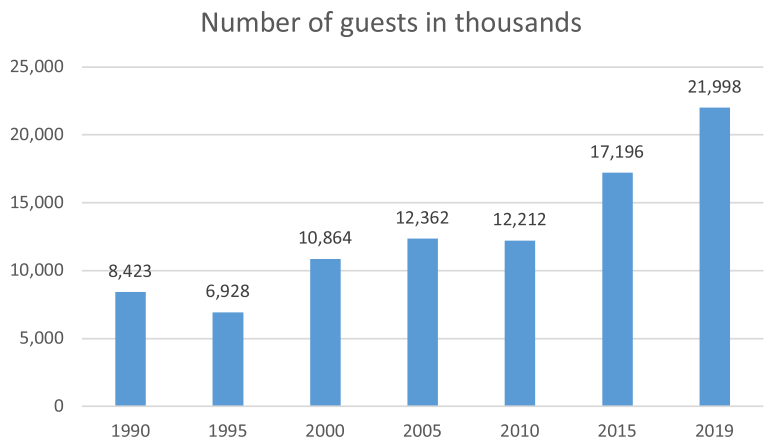


Fig. 7. Number of guests in collective accommodation establishments in the Czech Republic in 1990–2019. Source: Czech Statistical Office.

these geosites. The rocks are being damaged more and more quickly by anthropogenic abrasion, engraving on the rocks and even spraying paint (graffiti). The vegetation on the rocks is damaged by unruly tourists who walk off the marked hiking trails. The parking lots around the rocks are crowded, and the access roads are completely blocked in traffic during the high season. Also, the inhabitants of the surrounding villages are increasingly frustrated by this situation and talk about overtourism. Nature conservation authorities are trying to respond to this situation, leading to various entry bans and restrictions.

If you compare [Figures 5 and 9](#), you will find that the main difference between the state of the Právčická brána Arch in the first half of the nineteenth century and 2021 is the absence of railings today. While in the nineteenth century, it was possible to walk along the top of the rock gate; at present, it is

no longer possible. Entry was forbidden after the anthropogenic abrasion caused by millions of incoming visitors dug into the sandstone a 60 cm deep (!) furrow; without intervention, the gate would be in danger of collapsing ([Juda et al. 2012](#)). We can find more similar situations in the environment of the Czech sandstone rock cities.

According to data published by the Liberec Region ([KROKEM 2020](#)), 1 958 505 tourists visited the Bohemian Paradise tourist area (a slightly different delimitation from the UNESCO Global Geopark of the same name) in 2019, who spent a total of 5 980 663 person-days here. Bohemian Paradise is thus the most visited sandstone area in the Czech Republic. Roughly 1 million tourists visit the Bohemian Switzerland National Park each year (according to estimates of the national park itself), and several hundred thousand many other regions. The most visited geosite, for which data on the number

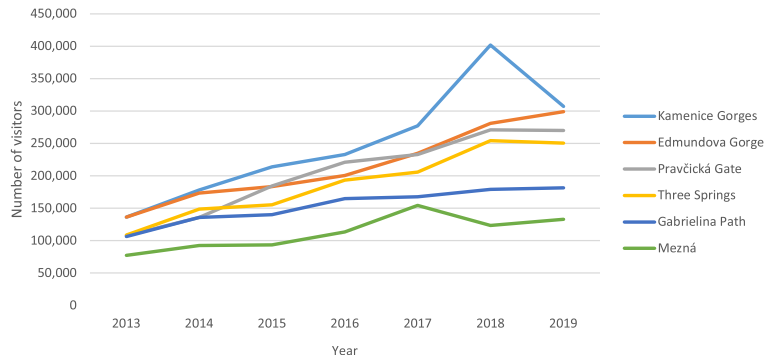


Fig. 8. Number of visitors to the six most visited Bohemian Switzerland National Park localities in 2013–2019. Source: Bohemian Switzerland National Park via CzechTourism annual reports.

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Fig. 9. Pravčická brána Arch in 2021. Photo by author.

of paying visitors are available, is the Adršpach Rock City, with 550 000 visitors in 2019 (according to the operator, the municipality of Adršpach) in Broumovsko National Geopark. However, this number does not include visitors who entered the rock city area without payment, which is also possible (see the ‘Data and methods’ section). These numbers mean more people visit well-known geosites in a year than in the nineteenth century. This is, of course, reflected in the condition of these geosites.

Manifestations of overtourism in Czech rock cities

Manifestations of overtourism can be divided into two categories according to where its effects occur: (1) directly affecting the environment in rock cities and (2) affecting the surrounding areas. Because rock cities are natural localities where no people live, many adverse effects of mass tourism do not work here. On the other hand, these are vulnerable geosites that the sheer quantity of visitors can damage.

What does a situation described as overtourism look like right in the rock cities? Typically, many visitors occur in a specific place, and therefore the movement through the narrow passages of the rock city causes queues and long waiting times. Owing to these delays, tourists start to get bored and come up with various alternatives to have fun while waiting, which often leads to illegal behaviour and damage to the rocks. The high number of visitors also means faster abrasion of the rock surface in places with hiking trails and more frequent occurrences of socially pathological phenomena such as vandalism,

spraying and garbage disposal. Examples of rock damage are shown in [Figure 10](#)

[Figure 10a](#) shows a relatively atypical example of rock painting, most likely caused by children playing. [Figure 10b](#) is an example of damage caused by bored visitors who began to rub the soft rock with their feet until they deformed it into this shape. Tourists who did not want to wait in line for a lookout created an illegal path shown in [Figure 10c](#). The track is located on a very steep rock, but they still wanted to risk their health to overtake the queue. A significant problem in rock cities is the destruction of carved stairs created in the past ([Fig. 10d](#)). Crowds of tourists can turn them into almost smooth surfaces within a few decades. One way to protect the stairs is to manage the trampled holes with concrete ([Fig. 10f](#)). However, in addition to the aesthetics (it doesn’t look very nice), people’s reluctance to use official stairs can also be a problem if they are too high (see [Fig. 10f](#)). In such a situation, people try to use small protrusions on the surrounding rock, leading to additional steps around the path. [Figure 10e](#) then shows another widespread problem: engraving into rocks (there is even a catalogue of rock carvings and inscriptions in Bohemian Paradise; [Jenč *et al.* 2008](#)). The picture shows the top plateau of the Drábské Světníčky rock castle, which is wholly covered with engraved inscriptions. If another tourist decides to carve something in the rock to make it legible, he must make a more extensive inscription and deeper grooves. Unfortunately, this leads to increasingly intense site devastation, to which nature conservation authorities have responded by closing it entirely in 2021.

A more detailed description of the various types of rock damage by unruly visitors is given by

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Fig. 10. Different types of rock damage caused by mass tourism: (a) rock painting, (b) damage to natural rock shapes, (c) illegal paths, (d) destruction of stairs, (e) engraving on rocks and (f) damage to rocks around paths. Photos by author.

Drápela (2021), who also notes that there is no direct relationship between the number of tourists and the damage to the rocks. Particularly at risk are localities visited by tourists who do not have a strong relationship with nature but still visit the rock city as it is a well-known and iconic highlight. Disrespect for nature and ignorance leads to reprehensible damage to extremely valuable geosites. Unfortunately, the occurrence of overtourism also contributes to this.

Too many visitors affect not only the geosites but also their surroundings. The problems are most often caused by the ever-increasing demands on the capacity of the tourist and transport infrastructure, where local governments cannot respond to the ever-increasing number of arriving tourists. In the villages around the rock cities, overcrowded parking lots, illegal parking, traffic jams and public transport congestion by many visitors are widespread. Examples of these situations are shown in Figure 11. Municipalities' efforts to improve infrastructure are limited by their budget and available space near the starting points of hiking trails. In many cases, the expansion of car parks would negatively affect the surrounding nature and contribute to the intensification of overtourism directly in the rock cities. Therefore, nature conservation authorities are trying to limit the expansion of tourist infrastructure, which has a negative impact on the surrounding communities.

People living in villages around rock cities suffer from the aforementioned manifestations of congested transport infrastructure during the primary tourist season (Drápela *et al.* 2021). This means delays of several hours on their journeys home, or the impossibility of using public transport, as the vehicles are already fully occupied. The surroundings of their houses are spontaneously 'flooded' by parked cars, and in some cases, it is challenging to drive between them. Furthermore, people feel a loss of privacy; they are bothered by the noise caused by tourists and the garbage that remains after them. All these influences harm the psyche of the local population and create a negative attitude towards them (or the subjective dimension of overtourism).

An example of a village that has 'declared war' on tourists based on constant complaints from locals is Malá Skála in the Bohemian Paradise UNESCO Global Geopark. The village has introduced many strict restrictions on the opening hours of restaurants and entertainment attractions, abolished the famous music festival and introduced a blanket ban on parking in the built-up area. However, the municipality has also introduced this general ban on parking where locals usually park (e.g. at a grocery store) or at a tourist information centre (Fig. 11d). The ban is recalled every 50 m by a white sign (located on a street lighting pole in Fig. 11d), which,

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Fig. 11. Manifestations of overtourism around rock cities: (a) illegal parking in nature, (b) blockage of the lane on the local road by parked cars, (c) traffic jam on a local road and (d) specific expression of resistance to tourism (description in the text). Photos by author.

however, is only in Czech, so foreigners do not understand it. Maybe that is why fines for illegal parking are very common in this village.

The temporal dimension of overtourism must also be mentioned. In rock cities, the main summer season lasts a relatively short time, from the beginning of July to the end of August, when there is a summer vacation in the Czech Republic. Therefore, if the situation with overtourism is not exacerbated, many locals will come to terms with the summer onslaught of tourists and perceive it as a temporary inconvenience. However, with the ever-increasing number of visitors, overtourism is becoming more frequent even outside the main summer season, which causes considerable frustration for the locals as the duration of these difficulties continues to increase, for example [Figure 11a–c](#) documents the situation in the Bohemian Switzerland National Park in March 2021. Although more people went for walks at that time, as many entertainment facilities were closed owing to the Covid-19 pandemic, March can be described as one of the least attractive months for tourism in the Czech Republic. Nevertheless, an overtourism situation arose in a part of the national park. The duration of the adverse effects affects the perception of tourism by local communities and the living nature of the geosites. If wildlife

and flora do not have the opportunity to regenerate in the off-season, they degrade faster and are threatened with extinction.

Possible solutions to the situation with overtourism

The mayors of municipalities and nature conservation authorities are trying to reduce the devastating influence of overtourism on geosites and their communities. They use various measures (entry restrictions, paid entrance fees, prohibitions on parking outside designated areas, etc.) that reduce the number of visitors or forbid entry to certain parts of the rock cities. However, the effects of these measures are debatable, as rock cities are large areas with several paths, and visitors who do not respect the rules can get to them outside the official entrances. On the other hand, it is impossible to fence them, as it would be extremely expensive and endanger the local fauna. In addition, various restrictions annoy visitors and increase their aggressiveness and unwillingness to follow the rules. Instead, research conducted within the project mentioned above on the territory of Czech rock cities in the years 2019–22 identified three main areas where improved activities

can achieve positive results, namely (1) communication with the visitors, (2) destination management and (3) the protection of geosites.

The main mistake that arises when communicating with a future visitor is promoting the region only based on the most famous and most visited localities. As the visitor decides which region to go on holiday to, the regional tourism development agencies try to impress them with the most beautiful photos bought from professional photographers. However, professional photographers offer significantly more pictures of the most famous places than the lesser-known ones because photos of famous places sell better. This is one of the reasons why websites and information materials for tourists are full of photos of the most prominent localities, often threatened by overtourism, further increasing this threat.

Leaflets in information centres are also unbalanced in content. Figure 12 shows a brochure to inform visitors about the possibilities of tourism in the rock cities of the Bohemian Paradise tourist area (it is, therefore, not a product of the geopark of the same name). The three most famous localities are presented on its front, which suffer from strong overtourism in the main season. On the contrary, on the back of the leaflet, we learn from the map that there are a total of 15 rock cities in this area,

while all the others together are given the same space as one site on the front. From such a leaflet, the visitor will understand that it is essential to visit the three sites listed on the first page and the remaining places are not so attractive. Unfortunately, this method of promotion is quite common in many other regions of the world affected by overtourism.

However, the traditional promotion of the most famous sites leads to another severe phenomenon: reducing the stay in the region to a quick visit to the ‘must-see’ sites. This is an example of the Bohemian Paradise UNESCO Global Geopark, which is unfortunately easily accessible from Prague. This leads to most foreign visitors visiting it as part of a day trip, and they do not sleep here. The economic benefits of day trips for the local region are negligible. Tourists are constantly driven by the schedule and do not even have the opportunity to spend money in the area. On the other hand, day trips create all kinds of adverse effects of mass tourism, which damage the locality.

The purpose of any communication between the local tourism agency and the visitor should be focused on the presentation of the beauties of the whole region, preferably in such a way that the visitor gets the impression that there are many exciting things to see in the area. The information should

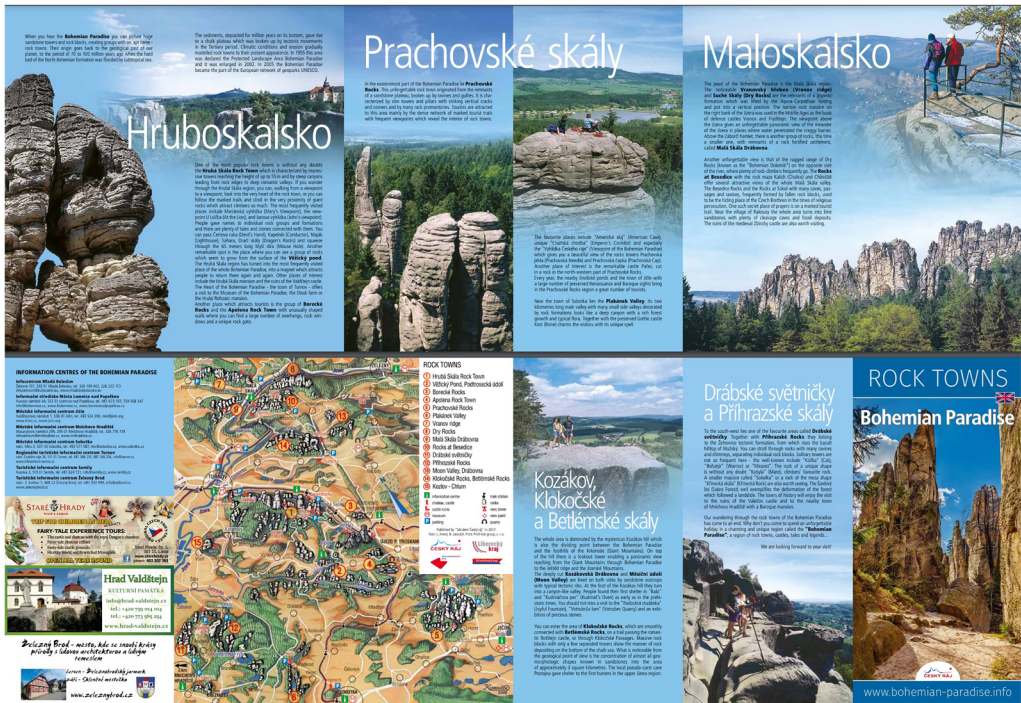


Fig. 12. The front and back of the leaflet informing about the possibilities of tourism in the rock cities of Bohemian Paradise. Bohemian Paradise Association, publicly available.

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Fig. 13. An example of a map informing tourists about parking places around the village Polevsko, Ski Polevsko, publicly available.

motivate future visitors to spend more time in the region. During the first days, they will probably visit the most famous locations, and later they will have time for the lesser-known ones. Emphasis should be placed on the sustainability of tourism and the cultivation of the visitor – information material should entice the tourist to stay and teach responsibility for the condition of the site after the visit.

The second option is represented by measures aimed at improving the management of the situation in the destination during the main tourist season. It is necessary to consider whether incoming tourists know about different parking options, whether in case of congestion of one parking lot, the diversion of tourists to the next one is arranged, and whether the location of the tourist infrastructure is satisfactory and does not bother residents, etc. Various unpleasant traffic situations escalate in many cases because they are not controlled when they arise. Some municipalities solve these situations with paid temporary workers who channel incoming tourists to free parking spaces; mobile applications are also beginning to appear, which inform visitors to the region about the current occupancy of the most visited localities (such applications including the Broumovsko National Geopark are currently being developed).

An essential task is to prevent illegal parking, which damages the nature around the entrances to the rock cities and annoys the locals. However, many tourists park in places where they should not, out of necessity, not out of ruthlessness. They do

not have any opportunity to park in official parking places that are full, so they are looking for other places. An example of good practice can be the village of Polevsko (located in the Bohemian Cretaceous Basin but outside the rock city in the vicinity), where there was overtourism in the winter owing to the popularity of the region for cross-country and downhill skiing. Illegal parking and blocking of local roads by parked cars took place around the starting points of tourist routes, so the village set up several new car parks using simple landscaping, created a map of parking areas (Fig. 13) and tried to solve the situation in the field with the help of volunteers. Thanks to these measures, manifestations of overtourism in the vicinity of the village were suppressed.

The third type of activity mitigating the harmful effects of mass tourism are represented by field measures aimed at protecting the geoheritage. In addition to the generally applicable geoconservation tools that can be found in the literature (see [Henriques et al. 2011](#); [Ólafsdóttir and Dowling 2014](#); [Brown et al. 2018](#), etc.), it is necessary to take into account the rapid abrasive wear of sandstone in rock cities, leading to irreversible changes in rock shapes. The demarcated corridors on the rocky lookouts thus often resemble trenches (Fig. 14a) or basins (Fig. 14c). Tourists walking outside the marked trails leave a polished top on the rocks that is visible from afar, which attracts other tourists to visit these places (Fig. 14b). Finally, essential sites, such as the most beautiful views, attract vandals who dig into the

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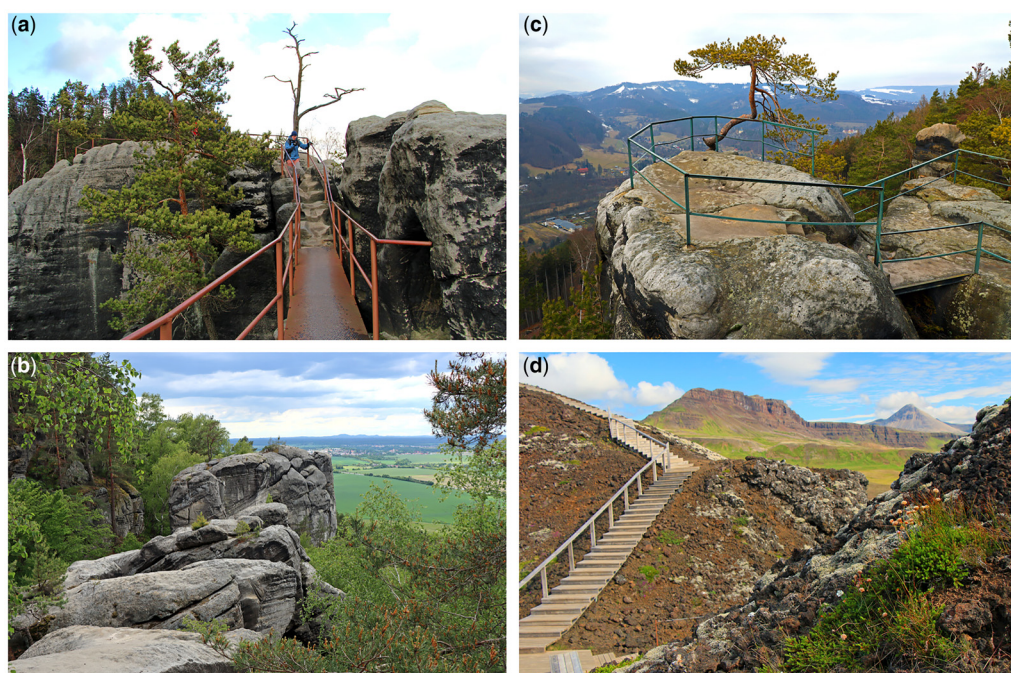


Fig. 14. Problems and possible solutions for rock protection: (a) damaged stairs on the tourist route, (b) views outside the permitted route, (c) depression created by tourists on the lookout and (d) protection of relief shapes in soft rock (Stóra Grábrók, Iceland). Photos by author.

rocks (Fig. 10e). Some of the problems mentioned above cannot be solved by field measures alone (especially vandalism), as their roots are more profound. Only long-term work with at-risk groups and education can significantly reduce them in the future. In some cases, however, the adverse effects of mass tourism can be considerably mitigated.

First, rock degradation can be reduced by not stepping on the surface of the rocks but by walking on artificial stairs and platforms. The inspiration could be the modification of the hiking trail on the volcanic cone Stóra Grábrók in Iceland (Fig. 14d), formed from an even softer material than sandstone. Similar solutions are currently being implemented at the Šaunštejn rock castle in Bohemian Switzerland National Park, from which the example in Figure 14a comes. This geosite has already been so damaged that the national park administration has completely closed it to the public. A new form of tourist infrastructure is currently being created to prevent further degradation.

Second, tourists sometimes leave the marked routes because they do not want to wait in queues (e.g. in front of sightseeing platforms). Instead, they try to find other places with exciting views and enter sites where entry is prohibited. A possible solution to this situation is to increase the capacity of

these places, where their area does not have to be limited by the width of the rock tower on which it is located. If the viewing platform (raised above the rock's surface) slightly exceeds the outline of the rock below it, it will be more attractive for visitors (they will see better below), and it will prevent engraving into the rocks. At the same time, the capacity of such a prospect will expand. The construction of the trail (e.g. its elevation above the surface of the rocks) should make it difficult to leave it, i.e. to climb from one rock to another.

Thirdly, tourists are ill-disciplined in some cases because what they see from the official prospects is considered insufficient, and they try to find an even better view for their photos. These exaggerated expectations are triggered by a large wave of drone photos showing rock cities from a height slightly higher than the surface, where more rocks are visible because they are not hidden by vegetation. It is true that in the past much more could be seen from these prospects because the landscape was much less forested. At present, only the branches of the surrounding forest can be seen from some viewpoints and not distant views as in the past. Rock cities are often strictly protected in nature reserves, where the completely natural development of these sites without human intervention is expected. When

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these localities are threatened by mass tourism, it is appropriate to maintain the attractiveness of the views by cutting down the obscuring vegetation. This small intervention protects significantly more extensive areas of nature reserves.

Finally, the design of the places where people take photos most often needs to be considered to make their photos as attractive as possible. What does this mean? Nowadays, people expect to take amazing photos and videos on their travels. Often, their experience of the place is influenced by whether or not they could take a great picture of it, which many friends on social networks praise. Although we do not have to approve of this superficial fashion, it must be considered when tackling inadvisable visitor behaviour.

A typical example is a situation where an ordinary railing spoils the 'awesomeness' of the photo, and therefore tourists climb it to take a picture on a rock without fences. However, it is often enough that the railing looks not ordinary but aesthetically pleasing, and then illegal behaviour does not occur. Another option is to place a glass railing in the direction of the best view. The most advanced option is to arrange the whole scene so that the tourist only comes to a prepared position (for example, sits in a permanently attached chair), and during the moment, he takes a photo that will always look good. Increased care for the places where tourists most often take photos pays off because they do not want to leave the marked trails to look for alternative views.

Discussion

Sandstone geosites are widely distributed throughout the world. However, they are rarely perceived as so iconic as in the Czech Republic. From the beginning of Romanticism, through the period of the emergence of the first tourist associations to the current overtourism situation, sandstone rock cities have constantly enjoyed great public interest. However, this great interest can paradoxically cause irreversible damage to these fantastic geosites. If we want to avoid measures where the rock walls are artificially strengthened (e.g. by epoxy resin, see [Ietto et al. 2018](#)), it is necessary to create long-term management plans and meet their goals.

Looking for inspiration for mitigation of the consequences of overtourism in other regions of the world, the literature describes different forms of entry regulation in particular. If it is a location that is isolated enough that tourist arrivals can be easily regulated, such as in the Galapagos Islands, such regulation brings positive results ([Mestanza-Ramon et al. 2019](#); [Burbano and Meredith 2020](#)). A similar type of regulation is the sale of permits, the number of which is limited. An example could be the Great

Barrier Reef in Australia, where restrictions of this type exist and slightly improve the state of local ecosystems ([Parker 2002](#)). Another type of regulation is the limitation of the number of collective accommodation facilities or the number of beds in them. An example could be the city of Barcelona, which stopped allowing the construction of additional accommodation facilities. However, the response was the extensive development of short-term rentals through services such as Airbnb, so this measure did not help much ([Gralak 2018](#); [Anguera-Torrell et al. 2021](#)).

Can these types of regulation be beneficial in the case of Czech rock cities? Unfortunately, rather not. Regulating access to these geosites is not very realistic, as the many entrances to them cannot all be guarded or the area fenced off. In addition, the regulation would negatively affect the residents of the surrounding municipalities, who use the rock cities for their daily recreation. A more appropriate regulation could be limiting the number of beds in accommodation facilities. However, as the example of Barcelona shows, it is necessary to regulate small and private short-term rentals simultaneously; otherwise, the benefit of this measure is debatable.

The second possible approach to the problem of overtourism is communication with the visitor by manipulating the information he receives, whether in printed materials or on the Internet. Limiting or completely canceling the promotion of the most visited sites is called demarketing ([Gulsen et al. 2021](#)), known, e.g. from some American national parks ([Drugova et al. 2021](#)). Development strategies in such cases target tourism degrowth ([Blazquez-Salom et al. 2019](#)). In recent years, mobile technologies have also been promoted ([Camatti et al. 2020](#)) that can provide visitors with information on the current occupancy of car parks or tourist attractions. This should have a preventive effect from the point of view of various traffic complications.

The positive effect of demarketing rock cities is not very realistic owing to their continuing popularity, which has lasted for over two centuries. Domestic demand is not dependent on current marketing but a long-term relationship with one of the natural jewels of the Czech Republic. Moreover, despite all attempts to mitigate the adverse effects of overtourism, it can be stated that destinations are largely losing the fight against it, as tourism shows a significant growth trend worldwide. A partial solution to overtourism could be mobile applications that inform visitors about the current occupancy of car parks or tourist attractions. One such is currently being developed at the University of Hradec Králové. Based on the results of its pilot testing, it will be possible to say whether it is a valuable tool or just a dead end. Experiences from abroad ([Camatti et al. 2020](#)) have not yet yielded very positive results.

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The third type of possible measure is the improvement of the infrastructure directly at the geosites. These are mainly different modifications of hiking trails so that there is no anthropogenic erosion of the rocks. There are many studies on this topic from other parts of the world (Tronkov and Sinnyovsky 2012; Gunn *et al.* 2020; Duszyński and Migoń 2022, etc.). Still, the principle is simple: anthropogenic abrasion does not occur if the visitor does not walk directly on the rock, but on some artificial platform (like in Fig. 14d). Every time a visitor touches a rock in any way, there is a risk of damaging it. Tourists' contact with rocks should be avoided in the most valuable parts of rock towns.

Currently, the belief prevails among nature conservation authorities in the Czech Republic that the growing number of tourists to natural sites cannot be reversed. Therefore a strategy is considered to 'sacrifice' selected most visited places to keep others in acceptable condition. In practice, this would mean that many rock cities will be chosen where the overtourism situation has already occurred. In these selected localities, transport and tourist infrastructure capacity will be increased. Tourist conditions will be significantly improved (public toilets, baskets, benches, shelters, prospects, photo points, etc.). The choice will depend on many objective criteria (like in Kubalíková *et al.* 2021), but the decisive factor should be the current traffic. However, this 'sacrifice' must not mean a reduction in geosite protection requirements; on the contrary, in many cases, good tourist infrastructure has a protective effect (e.g. in blocking access to vulnerable sites, social control as prevention of vandalism). It is expected that tourists who visit several similarly equipped rock cities will not want to visit lesser-known sites where infrastructure at a similar level will not be available. This will reduce the burden of tourism, at least in these lesser-known locations.

Conclusion

Overtourism is one of the challenges that popular geosites have to face today. Overcrowding of rock cities leads visitors to inadvisable behaviour that harms these valuable geosites. Therefore, in addition to the usual geoconservation strategies, it is necessary to apply other measures to mitigate the effects of overtourism. The paper described the reasons for the emergence of overtourism in the rock cities of the Bohemian Cretaceous Basin, its manifestations, and its impacts on geosites and local communities living in their vicinity. Furthermore, suggestions were made for possible solutions that could help improve the situation. Regarding these proposals, it should be noted that their effectiveness could not be scientifically verified, as no single locality in the

Czech Republic could successfully deal with the consequences of overtourism. However, the situation across the world is quite similar.

The proposed solutions include measures taken in three areas: communication with the visitor, destination management and the protection of geosites. As part of communication with the visitor, it is appropriate to promote the beauty of the entire region rather than pointing out the most famous highlights. Many tourists are 'optimizing' their vacation and focusing only on trips to the most famous locations, which significantly supports the emergence of overtourism. The aim of communication towards a potential visitor should be to portray the whole region as a place that offers a variety of goals and activities and where it makes sense to spend a more extended holiday.

Measures aimed at improving destination management usually address the issues of how to deal with collapsing tourist and transport infrastructure or how to correctly separate tourists from residents so that they are not frustrated by the presence of tourists. These measures tend to be limited by rock city space and nature protection requirements. Nevertheless, various solutions can usually be devised to improve the comfort of visitors while protecting the natural heritage. The purpose of these measures is, among other things, to prevent the illegal behaviour of tourists because if they break the rules as soon as they arrive at the destination, they are very likely to break them on geosites as well.

The third type of measure is changes in the tourist infrastructure directly at the geosites, the aim of which is, on the one hand, to protect the valuable geomorphology of the rock cities and, on the other hand, to provide the visitor with the expected experience. Often, the illegal behaviour of visitors is caused by their frustration from long waits in queues, overcrowded rock views or vegetation-covered views of the landscape. To avoid this behaviour, it is advisable to consider what can be done to make the visitor's experience of the given place amazing and unspoiled. The reward for this should be a decent and restrictive nature conservation respectful visitor who does not harm the geosite in any way.

All three types of measures mentioned above must be aimed at solving specific problems and continuously evaluated to see if they have a positive effect. All key actors must then agree on the measures taken: geoparks, nature protection authorities and representatives of municipalities. One of the main reasons why measures against overtourism do not work very well in the Czech Republic (except for actions that target a single municipality or city) is that these actors often work against each other with their decisions. In the case of the Bohemian Paradise geopark, for example, there are efforts by nature conservationists to limit mass tourism in the

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most visited locations; on the other hand, municipalities in the region pay the local destination agency to promote these locations. However, long-term strategies for sustainable tourism development in the region cannot work without a general consensus. Unfortunately, this is precisely why the situation with mass tourism in the Czech sandstone rock cities has not been solved satisfactorily so far. Hopefully, it will improve in the near future.

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Author contributions ED: conceptualization (lead), data curation (lead), formal analysis (lead), funding acquisition (lead), investigation (lead), methodology (lead), project administration (lead), resources (lead), software (lead), supervision (lead), validation (lead), visualization (lead), writing – original draft (lead), writing – review & editing (lead).

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