

# GEOHERITAGE ENDANGERED BY EROSION: EXAMPLES FROM THE PRACHOV AREA

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## Abstract

The paper researches the erosion of sandstone rocks through the lens of geology and geography of tourism. It examines natural erosion, erosion caused by non-tourism human activities, especially tourism-induced erosion. Erosion disrupts sandstone formations and decreases the attractiveness of an affected geosite. Concretely, the paper focuses on the Prachov Rocks, one of the most visited zones in Bohemian Paradise, famous for its sandstone towers. The core of the Prachov Rocks, the Rock City, has paid entry and several information boards with tourist instructions. Nevertheless, they do not prevent further tourism-induced unintentional or intentional damage. Another source of erosion is non-tourist economic activities in the area. The paper presents the basic theoretical framework of the geology of the studied area and damage to geosites. It also brings connected innovative typologies. The authors strive to identify the most endangered landforms and shapes within the Rock City through field research and explain the mechanism of their damage. Field research also encompasses measurements of sandstone erosion and shifts. The photographic, map and table additions amend the text.

**Keywords:** sandstone rocks, damage, overtourism, Bohemian Paradise, Czech Republic

## Introduction

The Prachov Rocks (named after the village Prachov, part of Holín Municipality), situated in the northern Czech Republic, have attracted many visitors with their distinctive rocky landscape since the 19th century. The rocks consist of Cretaceous sediments of the Upper Turonian and Coniac, shaped initially as a plateau. Natural processes such as wind and rain erosion have gradually worn away the rock, resulting in today's formations. Various types of sandstone layering and their variable grain size can be marked. Around the edges of the Rock City are several geodynamic phenomena (e.g. Leaning Tower). The base of the blocky sandstones consists of calcareous clay loams prone to landslides with thin intercalations of calcareous sandstones (ČGS 1998). The last big landslide happened in 2021 between Schlik's and Všetěčka's Viewpoints beside the tourist route.

Prachov Rocks is a protected natural reserve that is also a part of the Bohemian Paradise Protected Landscape Area and UNESCO Geopark, which are of the same name. Leaning Tower, Devil's Tower (towers with height up to 30 meters), Bohemian Paradise viewpoint, Schlik's Viewpoint, Haken's Viewpoint, Mouses Hole and Imperial Corridor, with their unique appearances, belong to the most attractive locations in the core area of the Prachov Rocks called Rock City. The Schlik noble family manages the Rock City and offers two paid excursion circuits, spanning 1.5 kilometers and 3.5 kilometers, respectively. The Rock City operates from April to December, with prolonged hours during the peak season in July and August. Especially during the summer, we can speak about overtourism there. A steady increase in tourists in the Rock City is connected to increased erosion, littering and overcrowding (Boháč, Vacek 2023).

Erosion is a significant environmental process that can affect various landscapes and surfaces. Erosion encompasses a wide range of types, each with unique characteristics and environmental impacts. We should mention water, ice, wind, gravitational, man-made and combined multiple sandstone erosion dynamics because these types are observable in the studied area.

## Material and methods

The article is based on a thorough literature and map (Mapy.cz 2024) analysis and, especially, long-term field research in the Prachov Rocks. Field research included participant and non-participant observation, photographing, and conducting measurements to monitor the erosion. The second author is a resident of Holín, where the Rock City is located. He provided valuable insider knowledge. The text is amended by a table containing relevant types of erosion, a map

created using ArcGIS software, and photographs documenting selected erosion places. The authors created all amendments to the text.

## Results

Sandstone is a weakly resistant and, at the same time, porous rock. Erosion in the past created contemporary Prachov Rocks, but nowadays, it is not desirable (except for the weathering of inscriptions on the stones, etc.). The permeability of sandstone is connected to chemical erosion manifested by the emergence of honeycombs. Physical (mechanical) erosion models all rock shapes in the area and is stronger during winter when cracks between rocks widen. The erosion causes the transport of tiny particles of sand (cf. Liang et al. 2019) as well as colossal sandstone blocks. Tiny particles of sand are noticeable at first glance on paths between rock formations. They act as shock absorbers of tourist steps, but tourists in their shoes, wind and water take them away, and they are gradually replaced by newly eroded material. Unruly tourists on illegally trodden paths create erosion grooves through which sand and stones are carried away.

The studied area is primarily natural, but some places, such as viewpoints and tourist footways with stairs and railings, were modified for the purposes of mass tourism in the past. Both genuine and modified parts suffer from erosion. Most modifications directly affected sandstone rock shapes and their natural surface crust, making them more susceptible to weathering. Erosion in the area endangers not only rocks but also soils (podzol, cambisol), which are poor, infertile and not deep. Their weathering exposes the bedrock. Forests, especially those with original composition and biodiversity, secure natural protection against erosion in the Rock City (AOPK ČR 2019). Firstly, we would like to show the types of erosion emerging in the studied area (Tab. 1) and the most prominent examples in the map (Fig. 1) because, on a small scale, the whole explored territory is affected by erosion. The most vigorous erosion is near viewpoints and choking points on tourist paths. Generally, with paid entrance, Rock City is more under control than the rest of the Protected Landscape Area, where illegal cycling outside bike trails or foresting emerges.

Tab. 1: Typology of erosion in the Prachov Rocks

Physical/chemical/biological natural erosion	Man-made erosion	
	Unintentional	Intentional
<b>Water</b> (direct – precipitation, humidity from rainfall or spring water – pseudocarst shapes, and humidity from capillary movements of solutions in sandstone pores – honeycombs and rock ledges) <b>Frost</b> (creates icefalls and tears sandstone) <b>Wind</b> (often together with water – rock windows) <b>Gravitational</b> (disturbed integrity caused by other types of erosion leads to rockslides) <b>Biological</b> (mosses and lichens slowly shaping the sandstones)	<b>Walking</b> (visible particularly on stairs) <b>Climbers activities</b> (mechanical weathering of rocks, maybe use of magnesium) <b>Logging</b> <b>Installing and maintaining tourist infrastructure</b> <b>Activities of film crews</b>	<b>Engraving in the rocks</b> (depth plays a role) <b>Painting on the rocks</b> <b>Pollution by garbage and excrements</b> (with possible chemical effects on the rocks) <b>Walking outside the official tourist paths</b> <b>Searching with metal detectors and related digging</b> <b>Building stone figures</b>

Climbers are allowed to climb on selected rocks between April and October. However, during the humid periods, climbing is forbidden because wet sandstone is prone to chipping. Using magnesium is permanently banned, although its effects on the rocks are still not thoroughly researched. Moreover, climbers are instructed to spare the rock (Prachovské skály 2024), which can sometimes be problematic. Repeated climbing on the same routes prevents rock surface crust regeneration and amplifies pre-existing erosion (see Fig. 2). In addition, the hollows used

as support points during climbing are deepened and rope rubbing against the rock creates notches. Nevertheless, the damage caused by climbers is not extensive in the studied geosite.

## Erosion in Prachov Rocks in 2024

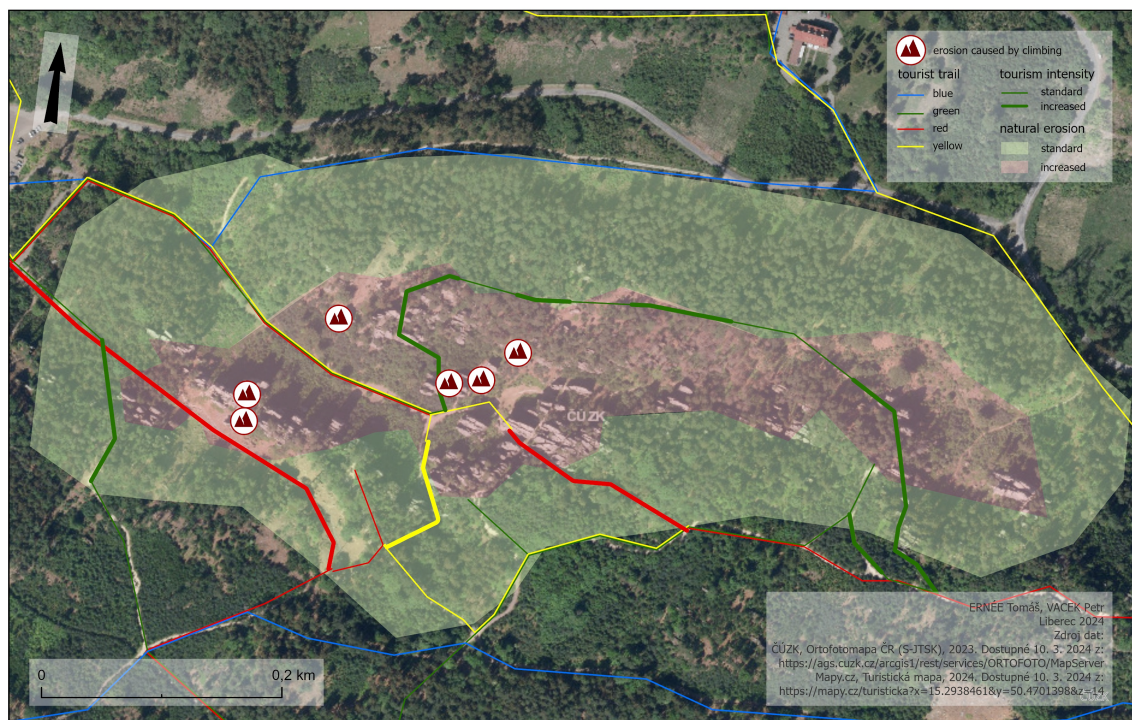


Fig. 1: Map showing the places of erosion in the Rock City and surroundings



Fig. 2: Photograph of honeycomb weathering amplified by the movement of climbers

Even recent natural erosion might bring interesting and potentially touristically attractive formation, somewhat similar to the famous Norwegian Kjeragbolten (see Fig. 3).





Fig. 3: Photograph documenting large-scale natural erosion

### Conclusion

We have identified many manifestations of erosion (of various types) and endangered places in the Prachov area. Most frequently damaged are stairs and soils (e.g. exposed tree roots) on the tourist routes. It is difficult to fight natural erosion. Still, efforts, such as eco-friendly forestry with horses, installing wooden or concrete barriers, metal cross-bracing and rockfall nettings, have emerged in the studied area. The core of prevention lies in combating overtourism, tourist and climber misbehavior (cf. Drápela 2021) leading to man-made or combined erosion. However, the current management approach is far from ideal. Rock City, despite its massive profits, suffers from a lack of investments and application of modern installations (metal walkways and bridges instead of the use of wood or even concrete and mortar, the least convenient materials, as parts of eroded sandstone stairs repairs) and strategies (tourism deseasonalization, reservation system and even guard focused on the sensitive places of the Rock City) for combating overtourism and protecting sandstone shapes (Boháč, Vacek 2023). Rock formations are essential for a significant portion of tourists visiting the region (Drápela, Boháč, Böhm, Zágoršek 2021). Irreversible changes in their shape could lead to damage to the protected landscape area, decreased interest in the geosite and, in the final consequence, the owners' profit.

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## Souhrn

Článek zkoumá erozi pískovcových hornin optikou geologie a geografie cestovního ruchu. Zaobírá se přirozenou erozí, erozí způsobenou neturistickými lidskými aktivitami a zejména erozí vyvolanou turistickým ruchem. Eroze narušuje pískovcové útvary, a tak snižuje atraktivitu zasažené lokality. Konkrétně se příspěvek zaměřuje na Prachovské skály, jednu z nejnavštěvovanějších oblastí Českého ráje, proslavenou pískovcovými věžemi. Jádrem Prachovských skal, tzv. Skalního města, je přístupné po zaplacení vstupného a navíc se v něm nacházejí informační tabule s upozorněními pro turisty. Toto však nebrání dalším turistům vyvolaným neúmyslným či úmyslným poškozením. Dalším zdrojem eroze jsou neturistické ekonomické aktivity v oblasti. Příspěvek představuje základní teoretický rámec geologie studovaného území a poškození geologicky zajímavých lokalit. Přináší také související inovativní typologie. Autoři se pomocí terénního výzkumu snaží identifikovat nejohroženější formy a tvary ve Skalním městě a vysvětlit mechanismus jejich poškození. Terénní výzkum také zahrnuje měření eroze pískovce a souvisejících posunů. Text je doplněn fotografickými, mapovými a tabelárními přílohami.

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