



# Assessment of Urban Geotourism Resources: An Example of Two Geocultural Sites in Brno, Czech Republic

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## Abstract

Geodiversity and geoheritage within urban areas have some specific characteristics in comparison to those in natural and rural areas. They influence and are influenced by urban development, they are strongly modified by human activities and they are usually closely related to the culture, architecture and history (cultural heritage). Geoheritage (especially geosites or geoheritage ex situ) is the most important resource for urban geotourism development, together with cultural heritage represented by monuments built of stone or Earth materials. Nevertheless, other sites that are not included in geoheritage inventories may be relevant too. Analysing, inventorying and assessing sites of geotourist interest (including the related aspects) within urban areas can bring new possibilities to the development of geotourism and geoeducational activities. These can help the acceptance of geoconservation measures to particular sites which are often problematic in the urban areas and justify the sustainable management of these resources. The paper briefly presents the issues and opportunities of urban geotourism, and it offers guidelines for identifying, inventorying and assessing geotourist and geoeducational resources within urban areas accompanied by SWOT analysis. Two examples – geocultural sites Špilberk and Petrov (Brno City, Czech Republic) – are presented.

**Keywords** Urban geotourism · Geocultural site · SWOT analysis · Brno · Czech Republic

## Introduction

The importance and influence of geodiversity in urban areas have been widely discussed in and supported by numerous monographs, reports and papers (e.g., Harris 1956; McGill 1964; Cooke 1976; De Mulder 1993; Thornbush and Allen 2018; Habibi et al. 2018). The main functions of geodiversity in urban areas partly overlap with ecosystem services of geodiversity in general (Gordon and Barron 2012; Gray et al. 2013) and can be summarized as following (for an overview see London Geodiversity Partnership 2014; Reynard et al. 2017; Gordon 2018):

- Geodiversity provides invaluable natural resources and thus contributes to the mining, industry development, agricultural and other activities.
- Water, mineral resources and landforms have an important role in influencing the location of towns and cities themselves, including the location of main buildings and main communications, with the geomorphological context of cities often reflected in their image.
- Landforms (including anthropogenic ones) allow the interpretation of urban landscape memory in relation to the historical development, and they bring evidence of the landscape and land use changes.
- Urban sprawl interacts with (and it is also limited by) geomorphological processes.
- Geodiversity influences biodiversity and location of parks and greenery.
- Geodiversity within urban areas is closely linked to the culture, architecture and history (cultural heritage in general), and thus it offers numerous cultural services.
- Particular sites of geotourist interest have a high potential for recreation, tourism and education, urban geotourism can serve as an alternative to the “traditional” tourism or

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destinations and they are accessible and available to a large number of people.

These functions, services and importance have been already recognized, and in some cases, the local communities and authorities are involved in the geoconservation and related activities (Prosser and Larwood 1994; Prosser et al. 2011; Worton and Gillard 2013). Nevertheless, in other cases, they are not accepted, respected or even known by authorities or public. One way to raise awareness of geodiversity's importance within urban areas is to develop urban geotourism with strong geoconservation and educational aspects. Urban geotourism and related activities can contribute to the better understanding of geodiversity's functions in towns and cities; the interpretation of the relationships between geodiversity, biodiversity and culture may help the acceptance of conservation measures applied to different sites (Reynard et al. 2017). In these terms, developing urban geotourism is in accordance with Agenda 2030, Goal 11 "Make cities and human settlements inclusive, safe, resilient and sustainable", target 11.4 "Strengthen efforts to protect and safeguard the world's cultural and natural heritage" (United Nations 2015).

Urban geotourism is also a very effective way for the dissemination of Earth sciences to the general public of all ages (Del Lama 2019). Promoting geodiversity features within traditional tourist sites (castles, churches, representative buildings) can enrich the information about those objects (e.g. use of local natural stones and sediments), and it can increase an overall attractiveness of the city (London Geodiversity Partnership 2014; Pica et al. 2016; Del Lama 2018; Górska-Zabielska and Zabielski 2018). Therefore, geoheritage and geodiversity can be considered a full-value resource for urban tourism (Díez-Herrero et al. 2011; Habibi et al. 2018; Riganti and Johnston 2018) together with other alternative cultural and historic resources as gaols, prisons, brownfields or places where a tragedy occurred (Martinát et al. 2018; Powel et al. 2018; Ashworth and Page 2011).

The term "urban geotourism" is relatively new (used, e.g. by Liccardo et al. 2012; Palacio-Prieto 2015, Del Lama et al. 2015, Del Lama 2018, 2019; Kubalíková et al. 2017; Pica et al. 2017, 2018; Chylinska and Kołodziejczyk 2018; Habibi et al. 2018); however, the use of geology, geomorphology and related human features (building stones or anthropogenic landforms) within urban areas for tourist and educational purposes is much older (Robinson 1982; Díez-Herrero and Vegas Salamanca 2011). Del Lama (2018) presents the definition of urban geotourism: tourism of visitable places anywhere in the city boundary (be they in the form of built heritage or of rock outcrops) that is related to geological concepts and features. In present days, the number of studies that point on the use of geodiversity and geoheritage within urban areas is growing as proven by numerous papers and books from different parts of the world and from different cultural and

social settings; however, researches are focused mainly on the European cities; the rest of the world remains rather "unexplored" from this point of view (Habibi et al. 2018). Figure 1 presents several examples of urban geotourism studies. It would be problematic to include all the papers dealing with the use of geodiversity for tourism purposes as the variability of resources for urban geotourism is very high (geosites, anthropogenic landforms, building stone) and as there are many articles written in a local language.

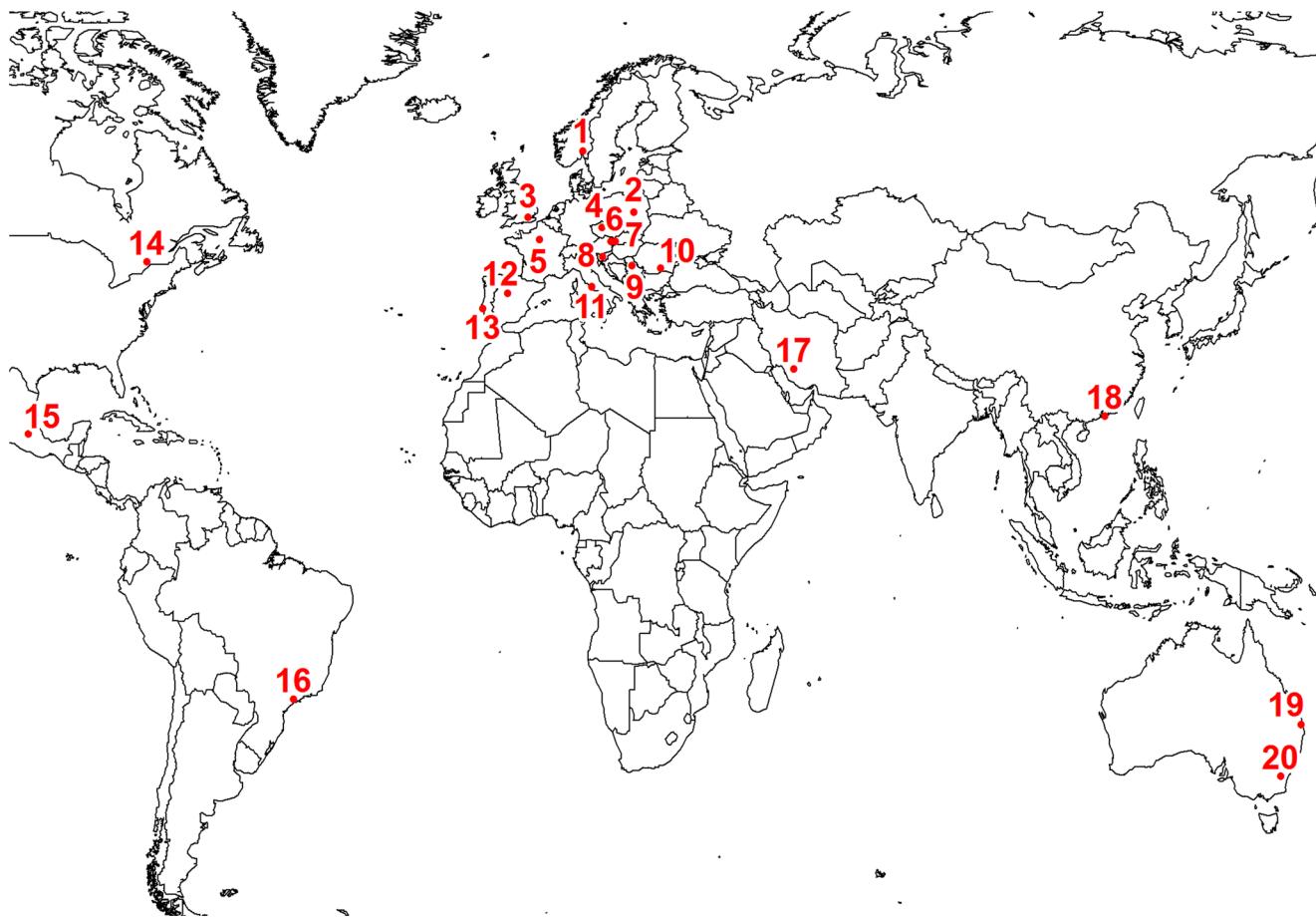
This paper presents (1) guidelines for identifying and inventorying the particular resources for urban geotourism and (2) a proposal of a set of criteria suitable for the assessment of geotourist potential of particular sites of geotourist interest. The assessment criteria are then applied to the two sites of geotourist interest in the Brno City, Czech Republic.

## Methods

To develop urban geotourism, it is necessary to (1) identify and inventory the resources, (2) select and assess the particular sites of geotourist interest and (3) propose particular geotourist activities with respect to conservation measures and potential rational use of the particular sites. The simplified scheme of this procedure is presented in Fig. 2.

Identifying and inventorying resources for geotourism are based on fieldwork and a detailed review of published literature and maps (both actual and historical). It should not be focused only on traditionally accepted geodiversity features, but it should also cover aspects reflecting the interactions between geodiversity, biodiversity and culture. According to the present holistic concept of geotourism (Martini et al. 2012; Dowling 2013; Dowling and Newsome 2018), the inventory of geotourism resources should take into account (1) natural features, geological, geomorphological, hydrological (Testa et al. 2019; Simić et al. 2012) or palaeontological (Henriques and Pena dos Reis 2015), and ecological aspects related to geodiversity, and (2) cultural aspects related to geodiversity and geoheritage, e.g. churches and cemeteries (Del Lama 2019), pavements and building stone (Hawley 1996; Bennett et al. 1996; De Wever et al. 2017) or toponyms that are linked to the geodiversity. Special attention should be paid to the anthropogenic landforms because they are very common in the urban areas and they also possess a high geotourist and education potential and are also interesting from the nature conservation point of view (Osborne 2000; Petersen 2002; Lóczy 2010; Kubalíková et al. 2017, 2019). Viewpoints should be also taken into account as they allow the observation of geosites, the large portions of urban landscape and interpretation of landscape history (Migoń and Pijet-Migoń 2017).

It is obvious that all these resources cannot be practically used for geotourism purposes; tourist use is generally made



**Fig. 1** Selected studies, projects and papers related to the use of geodiversity within urban areas: 1, Oslo: Erikstad et al. (2018); 2, Pruszków: Górska-Zabielska and Zabielski (2018); 3, London: Robinson (1982), Siddall et al. (2014); 4, Prague: Chlupáč (1999); 5, Étampes: Bille et al. (2008); 6, Vienna: Hofmann (2013); 7, Bratislava: Pivko (2005); 8, Ljubljana: Tičar et al. (2017); 9, Belgrade: Petrović et al. (2017); 10, Bucharest: Comanescu et al. (2017); 11, Rome: Pica et al.

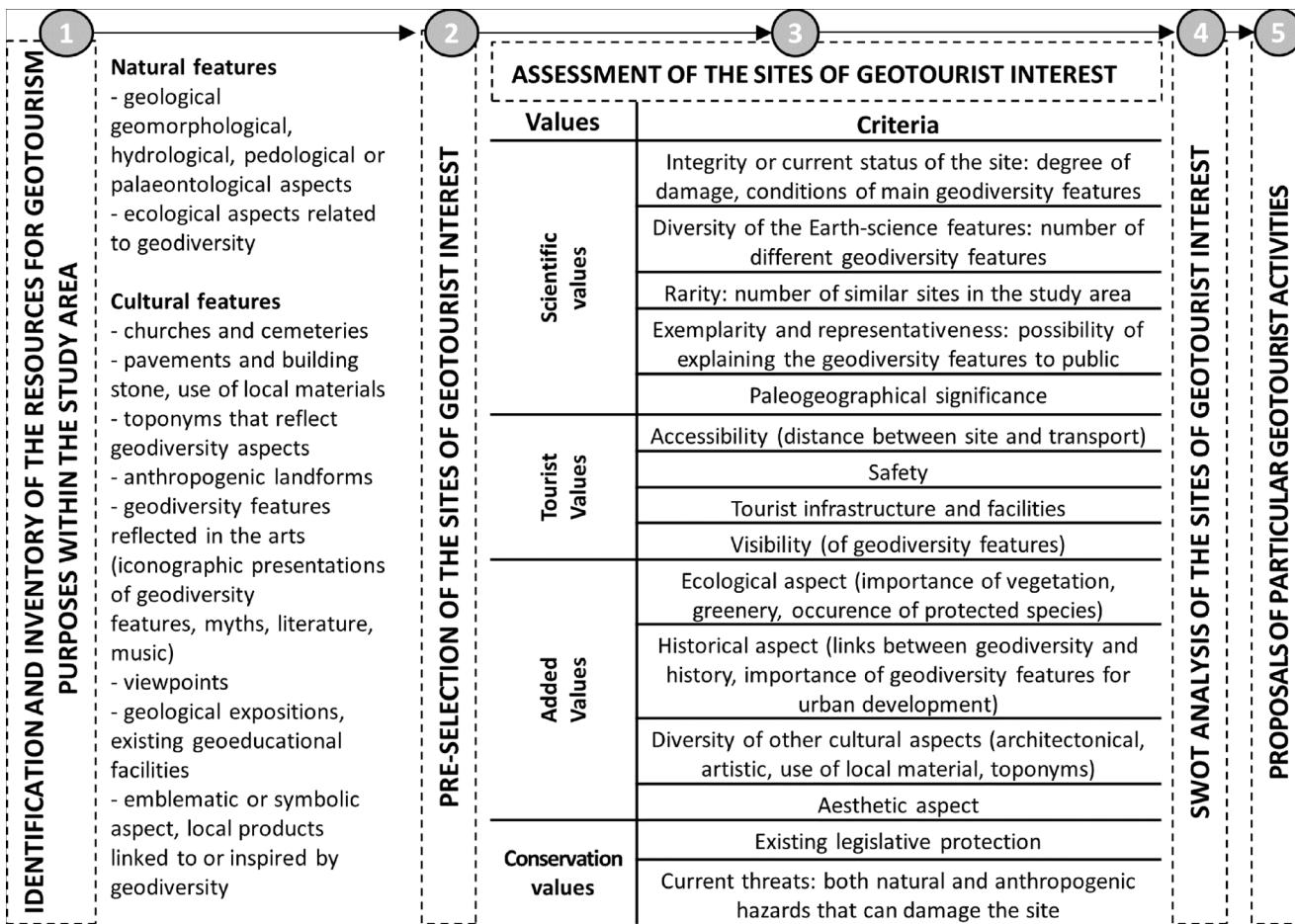
(2016); 12, Segovia: Díez-Herrero and Vegas Salamanca (2011); 13, Lisbon: Rodrigues et al. (2011); 14, Ottawa: Gall (2009); 15, Mexico City: Palacio-Prieto (2015); 16, São Paulo: Del Lama et al. (2015); 17, Shiraz: Habibi et al. (2018); 18, Hong Kong: Ng et al. (2010), Wang et al. (2015); 19, Brisbane: von Gnielinski and Siemon (2012); 20, Canberra: Mayer (1996)

through the exploitation of particular sites of geotourist interest. The preselection of the sites is also based on the detailed map and literature review and fieldwork. These sites can be divided into several groups: (1) geosites in sensu stricto (already inventoried, assessed and legally protected); (2) sites included in the national database of geological localities (Czech Geological Survey 2018a) which do not have any legal protection (category B, C); (3) other natural sites (not included in the points 1 or 2), especially outcrops or hydrological features that can have a geotourist relevance due to their good accessibility and visibility; and (4) geocultural sites (as defined by Reynard and Giusti 2018), usually anthropogenic landforms, e.g. quarries with strong cultural relevance (resources of local building stone) sites with architectonic relevance or landforms which influenced the urban development (e.g. important elevations with strong historical or religious aspects). These sites are then subject to assessment.

Numerous methods for geosite and geomorphosite assessment have been introduced and critically reviewed (for an

overview see Kubalíková 2013; Štrba et al. 2015; Brilha 2016; Reynard et al. 2016; Zwoliński et al. 2018). Nevertheless, these methods were used mainly in natural and rural areas (Serrano and González-Trueba 2005; Uña-Álvarez et al. 2017; Kubalíková 2019), so the use of some criteria is disputable and problematic in urban areas (Reynard et al. 2017). There are very few methods and approaches (Pica et al. 2016, 2017; Kubalíková 2017; Clivaz and Reynard 2018; Kirchner et al. 2018; Kubalíková et al. 2019) which are designed and used directly for the urban areas or are applicable for anthropogenic landforms or landforms considerably changed by humans which are common in most of towns and cities.

For the assessment of the sites of geotourist interest, a set of criteria based on methods presented by Pereira and Pereira (2010) and by Reynard et al. (2016) were applied. Both methods have been verified in several studies and used on different types of sites, including the geocultural ones (Boukhchim et al. 2018). Some criteria are modified in order



**Fig. 2** Scheme for identifying, inventorying and assessing the geotourism resources within the urban areas

to reflect the specifics of the urban settings, e.g. inclusion of the “diversity of cultural values” criterion and emphasizing the “historical aspect” criterion (Fig. 2). These aspects are not evaluated only as “present/absent” as proposed by other methods (Reynard et al. 2016), but the number and diversity of various cultural or historical aspects are taken into account. The inclusion of anthropogenic threats into the assessment may be also viewed as more suitable for urban areas.

The method is applicable to the sites which are both well conserved and partly damaged or modified by human activity. However, the degree of damage, change or destruction of these sites has to allow the assessment in the present time: the site (or landform) has to exist (it cannot be totally destroyed), and it has to be (at least partially) visible. This can be seen as a disadvantage in comparison with approaches presented by Pica et al. (2017) which allows assessing the invisible or destroyed landforms or Clivaz and Reynard (2018) which reflects the concept of invisible geomorphosites or landforms that disappeared due to the natural or anthropogenic processes – invisibility in the proper sense (Cayla et al. 2012).

Concerning numerical assessment, to every criterion, a value from 0 to 1 can be attributed, and no weight was given to a specific group of the criteria. A site can obtain max. 15 points.

The site that acquires ten and more points is considered relevant for urban geotourism development.

The method is accompanied by SWOT analysis which has been already used within the geotourist research (Kubalíková and Kirchner 2013, 2016; Boukhchim et al. 2018; Carrión Mero et al. 2018; Ateş and Ateş 2019). The main reasons of elaborating SWOT analysis can be described as follows: (1) SWOT provides an overview of the assessment by highlighting strengths, weaknesses, opportunities and threats; (2) it serves as a basis for incorporation of these aspects into other planning documents or as a basis for management of the sites, updating of care plans (where applicable), or it can serve as a basis for an extended SWOT analysis (Kubalíková 2019) that is also common within urban planning in general; and (3) it is understandable for wider public, authorities, administration and other institutions which are not familiar with concepts of geodiversity and geoheritage. The assessment and SWOT analysis thus serve as a basis for proposals of geotourist and geoeducational activities and can also provide the justification for applying specific conservation measures (both natural and cultural) to particular sites. Subsequently, these sites can be declared as protected; the legal protection then assures that the values of the site are respected and incorporated into the urban planning strategies.

## Study Area

Brno is the second largest city in the Czech Republic (population approximately 380,000 inhabitants), and it is situated in the south-eastern part of the Czech Republic (Fig. 3a, b). It lies on the contact of the two different geological units: Bohemian Massif and Carpathian Foredeep. The geology of the relatively small area of the city is quite complex and varied: Neoproterozoic Brno Massif (composed of metabasalts, diorites and granodiorites), Palaeozoic cover (represented by Devonian clastic sediments and limestones) and Mesozoic limestones of Jurassic age and Cenozoic sediments (Neogene sediments of the Carpathian Foredeep, e.g. Ottangian gravels, Badenian calcareous clays and Quaternary sediments, e.g. loess, fluvial deposits and anthropogenic deposits) are represented here (Novák 1991; Müller and Novák 2000; Hanžl et al. 2011; Czech Geological Survey 2018a, b). The city centre partly reflects this diversity (Fig. 3c).

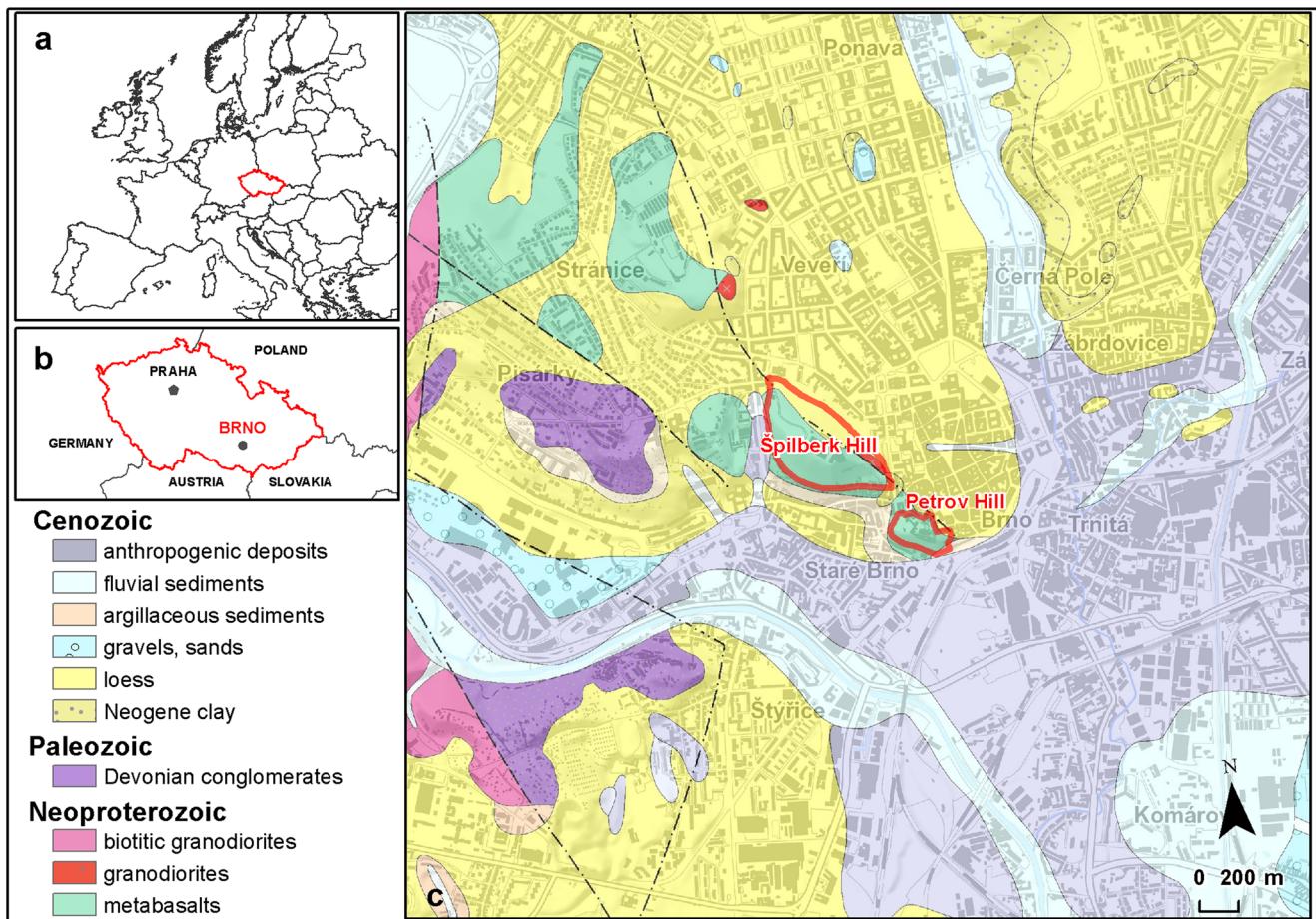
The study area belongs to the two different geomorphological provinces: Bohemian Highlands and Western Carpathians (Demek and Mackovčin 2014) which implicates a variety of landforms. In the northern and central parts, the relief is

tectonically influenced (occurrence of horsts, grabens and tectonically conditioned valleys) and more pronounced; the southern part is rather flat, and it was formed largely during the Neogene and Quaternary. The uniqueness of the relief of the Brno City lies in the “chessboard” layout of the ridges and valleys which influenced the situation of the important communications, buildings and urban development in general (Buček and Kirchner 2011; Ivan 1982).

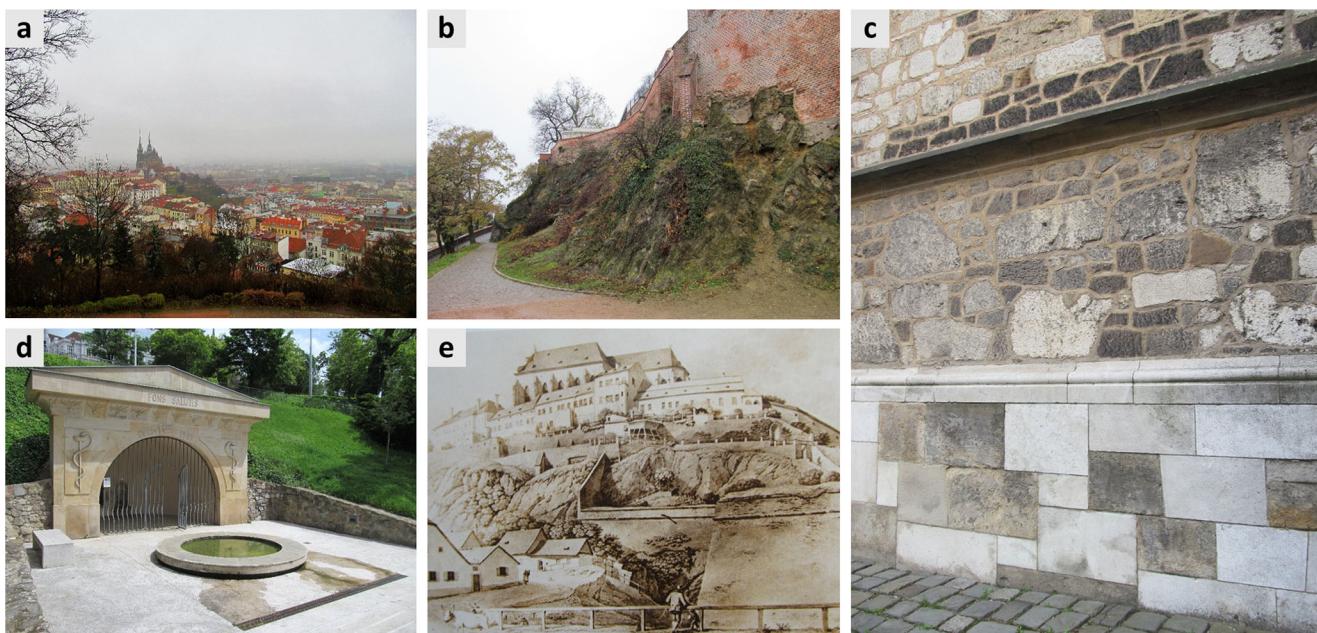
## Špilberk and Petrov: Two Sites of Geotourist Interest in the City Centre

Two geocultural sites – Špilberk and Petrov Hills – are probably the most important landmarks within the Brno City, and they represent the inherent part of the city’s image (Figs. 4a, 5a). These elevations are noteworthy both from Earth sciences and cultural/historical point of view.

Geologically, both Špilberk and Petrov Hills are a part of metabazite zone of Brno Massif (Müller and Novák 2000; Hanžl et al. 2011). They are built of Cadomian basalts of Late Neoproterozoic age (Fig. 4b) which were intensively deformed and metamorphosed into the green slates, and they



**Fig. 3** (a, b) Location maps; (c) geological scheme of the study area and position of Špilberk and Petrov within the city centre (source data: Czech Geological Survey 2018b)

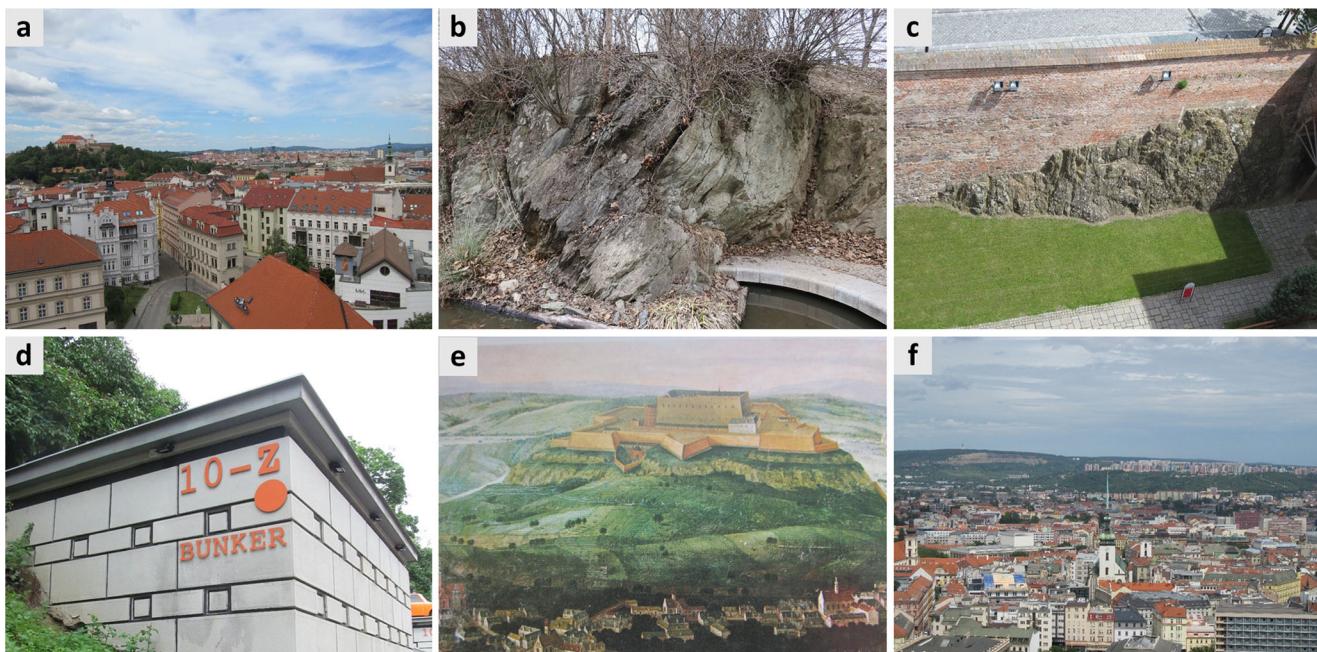


**Fig. 4** Petrov Hill: (a) A view on Petrov Hill with the Cathedral; (b) natural metabasalt outcrops incorporated into the ramparts, protected as Significant Landscape Element; (c) use of local material in the Cathedral's walls (dark-red conglomerate, grey-green metabasalts, white

blocks of limestone); (d) Studánka Spring; (e) Petrov Hill in 1850 (F.X. Rektóřík). Photographs by Lucie Kubalíková (a, b, c, d) and Samek and Hrubý (1982) (e)

represent one of the oldest rocks in the study area (Hanzl et al. 2011). The basalts on the top of Špilberk Hill (Fig. 5b) represent one of the best examples of pillow lavas within the Czech Republic. On the eastern slope of Špilberk Hill, granodiorites occur, and eastern slopes of both elevations are

covered by loess. Geomorphologically, both sites are considered tectonic horsts elevated above the flat relief of Dyje-Svratka Valley (Demek and Mackovčin 2014; Ivan 1982). The original landforms (macroforms) are still visible and distinctive (Figs. 4b, 5b); however, parts of the elevations



**Fig. 5** Špilberk Hill: (a) A view on Špilberk Hill with the Castle; (b) natural metabasalt outcrops with pillow lavas; (c) natural outcrops incorporated into the ramparts; (d) anti-atomic shelter 10-Z; (e) Špilberk Castle around 1690 (one of the numerous iconographic presentation of

the site; author: Folpert von Allen); (f) a view on the city from Špilberk's courtyard. Photographs by Lucie Kubalíková (a, b, c, d, f) and Samek and Hrubý (1982) (e)

(including natural outcrops) have been modified by human activities that document the land use and landform changes in the past.

Since the eleventh century, the top part of Petrov Hill was remodelled and adapted, first (probably) for the Premyslids' Castle and Romanesque church and then for the Cathedral of St. Peter and Paul (started in the fourteenth century, finished in 1908). During the seventeenth century, the slopes of Petrov Hill were modified by constructing the bastions and ramparts (Hálová-Jahodová 1971; Kuča 2000). Concerning the underground spaces, Petrov Hill is quite unique: since fourteenth century, numerous cellars of residential houses, pubs and inns have been constructed; in the nineteenth century, on the southwestern slope, an underground water reservoir was built; in the 1950s, the anti-atomic shelter "Denis" was created (Svoboda 2008).

Petrov Hill has also important hydrogeologic features: a tectonically conditioned spring on the north-eastern part of the site offered the water for the former pub called "U Fajfky" (By the Pipe). There are some legends that refer to this spring (e.g. about the underground lake). Another spring was situated on the western slope (today a part of the park "Studánka" – which means "small well", Fig. 4d). During the Early Middle Ages, the "Studánka" spring offered water for large part of the city, and until the nineteenth century, this spring was very rich. After the construction of the road in the twentieth century, the discharge decreased (Müller and Novák 2000).

The soil cover is represented by luvisems (mostly transformed to the anthroposols) and occasionally rankers on the rocky slopes. The original vegetation was converted into the parks and greenery. On the southern slopes, the grapevine was cultivated (by using the agricultural terraces). Currently, these steep slopes are covered with wild wine, and rock outcrops remain practically without vegetation.

The cultural and historical importance of the site is very high (see above); the architectonical value of the site is represented by the use of traditional local building and decorative stone (Fig. 4c): limestone and sandstone for statues, conglomerate and granodiorites for the walls and marbles for the decoration of the Cathedral's interior. All the material comes from the nearby quarries as Červený Kopec, Šumbera and Stránská Skála (Mrázek 1993). On the top of Petrov Hill, in front of the Cathedral, the slightly inclined metabasalt outcrops are used as a "natural pavement" for parking. The elevation with its cultural issues is one of the landmarks within the Brno City, and it forms an inseparable part of the city's panorama; thus the site is often depicted in old paintings, etchings and photographs (Fig. 4e). It appears very frequently on the postcards, promotional items of the city and also on the Czech currency (10 Czech Crowns coin). The Petrov Cathedral is also a subject of numerous legends; the most known explains why the Petrov's bells chime the noon already at 11 o'clock, and it is

related to the Swedish siege of the city. The cultural protection of the site is related to the Cathedral of St. Peter and Paul, and it is also a part of Municipal Monument Reserve (Národní památkový ústav – National Heritage Institute 2018). Metabasalt outcrops on the southern slope (Fig. 4b) are protected as a Significant Landscape Element (Magistrát města Brna – Municipal Office of Brno 2018), and they are also included in the database of significant geological localities (Czech Geological Survey 2018a). The limited natural hazards are represented by occasional debris falls especially on the southern steep slopes.

Špilberk Hill also represents a dominant feature of Brno City, but it has a different appearance: while the Petrov Hill is incorporated into the urban area, the Špilberk Hill is "a green island" within the city. The slopes are not as steep as in the case of Petrov Hill, but as the Špilberk Castle had a fortification and defensive role in the past, the slopes are free from buildings and currently; they are covered with forests and parks.

The larger anthropogenic modifications of the relief began in the thirteenth century when the Špilberk Castle was constructed. Originally, it should have been a residential castle, but due to historical events, the castle became the fortification at the beginning of the fifteenth century (Kuča 2000; Hálová-Jahodová 1971). This resulted in other anthropogenic modifications caused by building the ramparts, bastions (natural outcrops were adapted and often incorporated into these constructions, Fig. 5c) and underground spaces, casemates (they served as a gaol – "the dungeon of the peoples" – because prisoners of various nationalities from all the Habsburg Monarchy were imprisoned here). Other underground landforms are represented by two water reservoirs. During World War II, the underground bomb shelter 10-Z was constructed (Fig. 5d); later it served as an anti-atomic shelter for the prominent people of Brno. Currently, it is used as a tourist attraction (Svoboda 2008). Another anthropogenic landform is represented by an exploratory adit for tramway tunnel (which has not been realized yet, but it is still present in urban planning documentation) – this, together with the shelter 10-Z, refers to the specific engineering-geological conditions of the Špilberk Hill. Southern slopes are adapted as agricultural terraces. Since the Middle Ages up to the end of the eighteenth century, the grapevine was cultivated here, and several years ago, this tradition was revived. On the eastern and north-eastern slopes, there were numerous loess pits and brickyards which processed local loess sediments (Novák 1991; Pecka 2012).

The vegetation cover is represented by forests and parks (with introduced species); however, it is still possible to observe how the exposition and slope inclination influence the distribution of some tree and plant species (Buček and Kirchner 2011).

As well as in the case of Petrov Hill, the cultural, historical and architectonical importance of Špilberk Hill is very high

(e.g. use of local building stones within ramparts), and the elevation with Špilberk Castle forms an inseparable part of the city's panorama. Špilberk Hill has been a subject of numerous old paintings or photographs (Fig. 5e); there are numerous myths about the underground gaol. The cultural protection is related to the Špilberk Castle (National Cultural Monument); all the site is a part of Municipal Monument Reserve. Currently, there are no important risks and threats, but in the case of deforestation, there can be a risk of accelerated water erosion (Magistrát města Brna – Municipal Office of Brno 2018). In the Castle's courtyard, there are numerous viewpoints from where the surrounding landscape with its remarkable landforms (such as quarries) can be observed (Fig. 5f).

## Results

The assessment of Špilberk and Petrov Hills was done by using the set of criteria (Fig. 2). The results of the numerical assessment are presented in Table 1. Both sites acquired more than ten points, so they can be considered suitable for urban geotourism development. Concerning scientific values, Špilberk and Petrov Hills reached similar score because main landforms are well preserved (however, in some places they are changed and damaged by building activities), and the diversity of the Earth science features is very high (lithological, petrographical, tectonic and hydrogeological aspects are present in both sites). Both sites represent very well the rock

resistance and landform itself, although some explication is needed for the public. Other geological features (e.g. pillow lavas on Špilberk Hill) are visible, but professional explication is needed as well. The landforms are important for the understanding of the development of the study area. Pillow lavas at Špilberk Hill represent one of the rare occurrences of this phenomenon in Brno city. Due to this, Špilberk Hill has reached a higher score in rarity.

Added values are higher for Špilberk Hill, because of its higher ecological value. However, the historical aspects of both sites are very important as they illustrate the development of the oldest part of the city. The diversity of cultural aspects is also very high: Castle and Cathedral represent important issues of cultural heritage, underground anthropogenic landforms bring evidence about the technical development, use of traditional local building stone document the use of natural resources in the past and both sites appears at numerous iconographic presentations. All these aspects, together with a high aesthetic quality of the sites, contribute to high added values.

The accessibility of both sites is very good (located in the centre, dense network of paved paths); only some parts can be difficult to reach by less mobile people because of the steepness of the slope. The sites are safe; the underground spaces can be problematic (currently the access is limited). In rare cases, there is a risk of debris fall that can endanger the visitors in Petrov Hill. The tourist infrastructure and facilities are present at walking distance from the sites. General visibility of landforms is partly limited by vegetation, bastions, ramparts and other buildings (on Petrov Hill).

The conservation values are average – cultural issues are protected as National Cultural Monuments – however, the metabasalt outcrop at Petrov Hill is protected in the lowest category of nature conservation (Significant Landscape Element). The outcrop with pillow lavas on Špilberk Hill is included in the Database of the Czech Geological Survey in category C since July 2019. Concerning the threats for Špilberk Hill, in the case of deforestation, there is a possibility of accelerated water erosion. Both sites can suffer from sociopathological phenomena which may be problematic when planning geotourist activities.

SWOT analysis (Table 2) is based on the assessment and serves as a basis for particular proposals of geotourist activities. The SWOT analysis was done for both sites because they have similar values (see above), and they are situated close to each other. The specifics of each site are clearly distinguished.

## Discussion

The assessment and SWOT analysis of the two sites of geotourist interest in Brno City proved that the issues of urban geodiversity and urban geoheritage are very complex as stated by Habibi et al. (2018) – within a single locality, different natural and cultural aspects can be identified. According to the results of the

**Table 1** Numerical assessment of Špilberk and Petrov Hills

Scientific values	Špilberk	Petrov
Integrity and current status	0.75	0.75
Diversity of the Earth science features	1	1
Rarity	0.75	0.25
Exemplarity and representativeness	0.75	0.75
Paleogeographical significance	0.75	0.75
Added values		
Ecological aspect	1	0.25
Historical aspect	1	1
Diversity of other cultural aspects	1	1
Aesthetic aspect	1	1
Tourist values		
Accessibility	0.75	0.75
Safety	0.75	0.75
Tourist infrastructure and facilities	1	1
Visibility	0.75	0.75
Conservation values		
Legislative protection	0.5	1
Current threats	0.75	0.75
Total value	12.5	11.75

**Table 2** SWOT analysis of the selected sites of geotourist interest

Strengths	Weaknesses
- Position in the city centre	- Lack of legal protection of natural phenomenon (Špilberk)
- High scientific value	- Sociopathological phenomena
- Important hydrological and hydrogeological features (Petrov)	- The promotion of the sites put an emphasis only on the cultural and historical aspects
- High diversity of cultural aspects (including anthropogenic landforms) and existing legal protection of them	- Weak or missing promotion of the Earth science aspects of the sites
- Various proofs of the past land use and changes	- The educational, recreational and tourist potential of geodiversity of these sites is not still fully recognized by the public
- Good accessibility, full tourist infrastructure nearby, low occurrence of natural hazards	- The bad condition of particular features (e.g. hydrological features)
- Both sites can be visited in any season	- The development of urban geotourism is not the priority of the Brno City (geotourism is not included in the urban development strategies)
- Part of authorities and municipal tourist office are aware of the geodiversity's importance, and they consider it as an important resource for geotourism and geoeducation	
- The long tradition of cooperation of universities, research institutions, non-governmental organizations and the municipal office in the issues of the natural environment and environmental education in general (successful revitalisations, water within the city and others)	
Opportunities	Threats
- The further development and deepening of conceptual cooperation between universities, research institutions, NGOs and the municipal office within the area of geodiversity, geoconservation and geotourism research and promotion	- Lack of interest in geodiversity and geoheritage from the part of authorities and public in the future
- Incorporation of the information about the sites into current tourist offer (e.g. anti-atomic shelter, engineering geology; building material, relation to the other geosites within Brno, incorporation of the natural outcrops into the ramparts)	- Lack of finances for promotion of geodiversity and geoheritage and for the new geotourist products
- Creating a new geotourist product: a geopath connecting the two sites (their most interesting issues: natural outcrops, hydrological and hydrogeological features, anthropogenic landforms, building and decorative stone)	- A geopath could be seen as a “rival” of other tourist attractions (not as an alternative or complementary product introducing the geotourism concept)
- Interpretation of links between the natural and cultural aspects (between geodiversity and cultural heritage) and interpretation of land use changes as an important resource for environmental education (used by local schools, public and tourists)	- The development of the urban geotourism concept could remain misunderstood if not explained well

assessment, Špilberk and Petrov Hills reflect this complexity. The assessment also confirmed that particular Earth science features in urban space cannot be viewed as isolated, but they are closely related to cultural heritage and anthropogenic activity (Reynard et al. 2017; Pica et al. 2017). The results also show that geocultural sites in Brno City have medium to high geotourism potential value and prestigious historical and archaeological characteristics that Pica et al. (2016, 2017) consider the most important aspect for urban geotourism development.

The criteria used for the assessment of Špilberk and Petrov Hills reflected well the diversity of natural and cultural elements that could serve a basis for geotourism development. However, the verification and suitability of these criteria for the assessment of the sites of geotourist interest in the urban areas will require that they are applied to more sites within different natural and cultural settings. As the assessment reflects the issues of geoconservation (Prosser et al. 2011), the results can bring the arguments to set the conservation measures to a particular site or its part. This was partly achieved at Špilberk, where the fieldwork and assessment served as a basis for entering the outcrop with pillow lavas in the Database of Geological Sites of the Czech Geological Survey (category C).

The SWOT analysis was originally proposed as a tool for identification of the strengths, weaknesses, opportunities and threats especially for the companies; however, currently, it is used in the regional development strategies and planning documents. The use of this tool in geotourism studies is not common; however, there are already several papers that deal with the use of both basic and extended SWOT analysis (Carrión Mero et al. 2018; Kubálková 2019). The SWOT analysis proved that Špilberk and Petrov Hill can be regarded as a complex area for the development of specific geotourism activities and for creating specific geotourist products (a geopath). Currently, the proposal of the geopath is being presented to the Tourist Information Office of Brno. According to the experiences, e.g. in Segovia (Vegas Salamanca and Díez-Herrero 2018), it can be supposed that similar geotourist activities can have success.

## Conclusions

The Špilberk and Petrov Hills are better known for their cultural and historical values, but the assessment shows that Earth

science value is also high. The assessment and SWOT analysis are going to serve as a basis for the proposals of particular geotourist activities: the geopath exploring geodiversity (including its links to biodiversity and cultural heritage) just in the city centre including the geoeducation activities on every stop. This can enrich the tourist offer of the Brno City and serve as an alternative and additional tourist attraction in comparison with traditional destinations which are rather cultural or historical.

The identification, inventorying and assessment of geotourism resources in an urban area can contribute to the available environmental education for local schools (it is accessible for the schools within the city). The incorporation of the Earth science aspects and features into the current tourist products and development of urban geotourism activities can lead to better visibility of geodiversity in the city and enrich the tourist offer of the city (without any dependence on the season). If promoted and interpreted in connection with biodiversity and cultural heritage, conservation measures can be accepted more easily. The cooperation of universities, research institutions, NGOs and municipal office and subsequent development of geotourism activities can thus help to increase the awareness of this important resource.

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