



Contribution to the Assessment of Geomorphosites in the Czech Republic (a Case Study of the North-eastern Part of the Novohradské Mountains)

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Abstract

It is widely accepted these days that to a nature conservation protection of an abiotic nature, less attention is paid than to the protection of a biotic nature. But components and processes of an abiotic nature are together with human activities deciding factors influencing significantly the landscape in general. Hence, it is necessary to inventory, identify, and evaluate specific geological and geomorphological sites in order to protect abiotic nature. For these purposes, the concept of geomorphosites may be used. This contribution brings new information from the territory of the north-eastern part of the Novohradské Mountains, aimed on the issues of geomorphosites. Geoheritage values which were attributed to the individual localities in the target territory can serve as a significant foundation and source of the information for the appropriate authorities for the management of these geomorphologically interesting localities.

Keywords Assessment · Abiotic nature · Geodiversity · Geomorphosites · Geoheritage values

Introduction

In the current period, significant progress in discovering of the geodiversity of the Czech Republic has been achieved. Geomorphological landscapes of the whole territory of the Czech Republic have been elaborated (Pánek and Hradecký 2016), and data obtained provide a good basis for more de-

tailed research of partial areas and localities. At the first time in the whole territory of the Czech Republic, the geomorphodiversity was evaluated by Demek et al. (2011). Evaluation based on the concept of geomorphosites has been used also for assessment of landforms at regional and local scale. These surveys mentioned above bring much new knowledge about high geodiversity of the landscape (especially its abiotic parts), and they offer good information for geoconservation and legal protection of geological and geomorphological heritage (Kubalíková 2016).

There are regions with valuable landforms within the Czech Republic, but so far, less attention has been dedicated to assessment of landforms with respect to their geoconservation. The Novohradské Mountains in the Czech–Austrian border area are among these territories. The mountain granite relief in the southern part of Bohemian Massif with many meso- and microforms has been geomorphologically mapped and inventoried (Rypl et al. 2014, 2016, 2017; Rypl and Kirchner 2017); *the concept of geomorphosites with evaluation of selected sites was presented at the first*. In this context, we can mention the article by Migoń et al. (2017) that deals with similar landforms on the granite of the Bohemian Massif in the region of Waldviertel in Lower Austria.

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In our elaboration of the studied area, we start from the concept of geodiversity, which is accepted by geoscientific specialists and was discussed in detail in a number of publications (for the more detailed overview of the issues, see, e.g. Reynard et al. 2016; Reynard and Brilha 2018). Geodiversity is defined as “the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes), soil and hydrological features. It includes their assemblages, structures, systems and contribution to landscapes” (Gray 2013).

In our approach, we use a broader concept of the geodiversity (respectively geomorphodiversity) as “the critical and specific assessment of the geomorphological features of a territory, by comparing them in an extrinsic and intrinsic way, taking into account the scale of investigation, the purpose of the research and the level of scientific quality” (Panizza 2009). The specific assessment of geomorphological sites in the area of interest of the Novohradské Mountains is linked to the concept of geosites and geomorphosites in the sense of Reynard (2005), Panizza (2001), Reynard and Panizza (2005), Reynard et al. (2009), Reynard and Brilha (2018).

Evaluation of geomorphosites in the Novohradské Mountains is connected to the research of Kubalíková (2012), elaborating the methodological approach of geomorphosites and applying it to the characteristic relief features of the Czech Republic (for details, see “[Methodological Approach](#)”).

Regional Settings

The studied area is the north-eastern part of the geomorphological unit of the Novohradské Mountains. The unit of Novohradské Mountains belongs to the Šumava System (Balatka and Kalvoda 2006; Demek and Mackovčín 2006) according to the geomorphological classification of the Czech Republic. The wider part of this unit called *Freiwald* is located in Austria. *Freiwald* is the part of the “Granit- und Gneis-Hochland” (Weber and Duyster 1990). The location of the Novohradské hory Mountains within the scope of the Czech Republic is represented in Fig. 1.

From a geological point of view, the area of the Novohradské Mountains stretches across the southern part of the Moldanubian Pluton (Pavlíček 2004). Late Variscan migmatites of this magmatic body cover the largest area within the Novohradské Mountains. They are represented by several types (e.g. the Weinsberg-type granite, the Mrákotín-type granite) and partly covered with cordierite gneisses and nebulitic migmatites, which are the remains of the original pluton mantle (Heřmánek and Matějka 1998) (Fig. 2). The oldest geological unit of the territory is the crystalline basement of the Moldanubicum,

dominated by heavily metamorphosed gneisses and migmatites, sometimes with numerous inserts of quartzite, marble, amphibolite, orthogneiss, and other materials (Cháb et al. 2008).

The massifs of Mt. Vysoká, Mt. Kraví hora, and Mt. Kuni hora (northern part of the Novohradské hory Mountains) and the massifs of Mt. Myslivna and Mt. Kamenec (southern part of the Novohradské hory Mountains) are made of the medium-grained biotitic granite, known as Weinsberg-type granite (Staník 1991; Vrána 1987; Cháb et al. 2008).

The basic relief of the Novohradské Mountains has characteristic elements of a fault-block mountain range with delimitations marked strongly by erosion, whereas it is also clearly polygenetic. It is possible to find here recent forms (rounded blocks of different sizes, alcoves, grooves), as well as fossil forms like exfoliation joints, tors, and frost-riven cliffs (e.g. Demek and Mackovčín 2006; Huber 1999; Chábera and Huber 1999; Ryppl and Kirchner 2017).

The basic soil types in the Novohradské Mountains are cambisols, cryptopodzols and podzols, gleyish cambisols and pseudogleys, gleys, and organosols (the nomenclature system by Němeček et al. 2001), with the most important being cambisols and cryptopodzols. Cambisols are among the most common soil types in the mountain range. They are formed from slope sediments of all solid rocks, mainly in the areas with rather large slopes. Cryptopodzols dominate the peak areas of the mountain range displaying different subtypes of poorly developed soils (Šefina 2004).

According to Culek (1996), the Novohradské Mountains belong to the Novohradský bioregion, which is defined by the same way as the geomorphological unit of the Novohradské Mountains. In this bioregion, the represented biota is one of the fir-beech vegetation zones, accompanied by the biota of the beech vegetation zone at lower elevations and the biota of the spruce-fir-beech vegetation zone at higher elevations. The vegetation zone of zonal spruce woods has not evolved here due to the relatively low elevation of this mountain range.

In the consequence of the process of European integration, the Novohradské Mountains have become the centre of interest for the public, investors, and also environmentalists, especially because of its proximity to the Austrian border and also because of its natural rarity. The Novohradské Mountain region is a unique area, which was until today very rarely influenced by the industrial and agricultural activity of humans. Because of this, a lot of rare plant and animal species as well as unique forms of non-living nature are known to be found in this area. The Act No. 114/ 1992 allows the protection of the nature of the Novohradské Mountains. The area is declared as “Natural Park”. The Czech Government officially refused to declare this area as “Nature Conservation Area” in 2005.

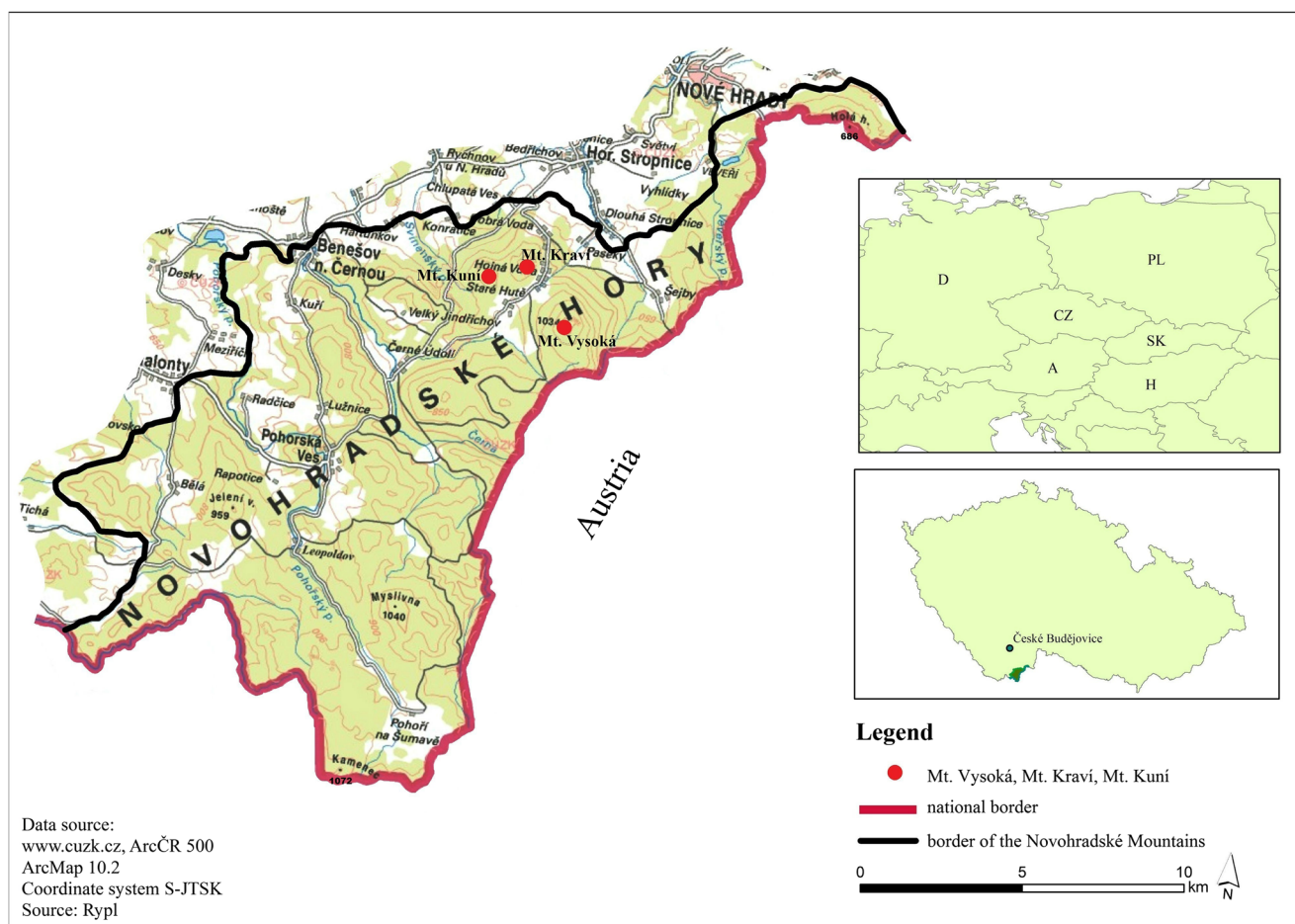


Fig. 1 Location of the Novohradské Mountains within the scope of the Czech Republic

Methodological Approach

The main tasks of the assessment of geomorphosites are especially the inventory of significant localities itself and recognition of the significance of geomorphological heritage for human society. The assessment can be used as a base for the preservation of non-living nature; a base for the proposal or declaration of legal protection of lesser known geomorphosites or as a base for the management of such localities or as a base for the geoeducation and the geotourism (e.g. Kirchner and Kubalíková 2011).

This conception of geomorphosites seems suitable for an assessment of geomorphosites in our target area. Geomorphosites can be single geomorphological objects (e.g. rock structure, blockfield) or wider landscapes (parts of the valley, the castellated rocks). Geomorphosites can be either well preserved in original form, modified, damaged, or even destroyed under the impacts of human activities (e.g. old mining areas) (Reynard and Panizza 2005).

Geomorphosites are defined as portions of the geosphere, possessing a particular importance for the comprehension of Earth history, geological or geomorphological objects, which have acquired a scientific, cultural/historical, aesthetic, and/or

social/economic value due to human perception or exploitation. Geomorphosites are landforms to which a value can be attributed and which can be used by society as a geomorphological resource (Panizza 2001; Reynard et al. (2009)).

Reynard et al. (2007) divide values into two main sets: a central set dealing with “scientific value” and a set of “additional value”. Scientific or intrinsic value is significant for the understanding of the history of the Earth, as well as for understanding of the life evolution, former and present processes, and the reconstruction of the climate and landscape. In particular, the possibility to study the former as well as present processes (the dynamic of the site) is of crucial significance in the case of geomorphologically significant localities. Scientific value covers also the condition (i.e. well-preserved state) of the site, its representativeness, rarity, and palaeographic significance (Reynard et al. 2007) and is closely related also to the possibility of the educational use of the site or further geodidactic activity (Pralong 2004).

A set of additional values takes into consideration cultural, economic, aesthetic, ecological, and social value. Cultural value is based on the reciprocal relationship between the human activities and relief. The cultural constituent can impact the geomorphological one (and vice versa) and is related to the

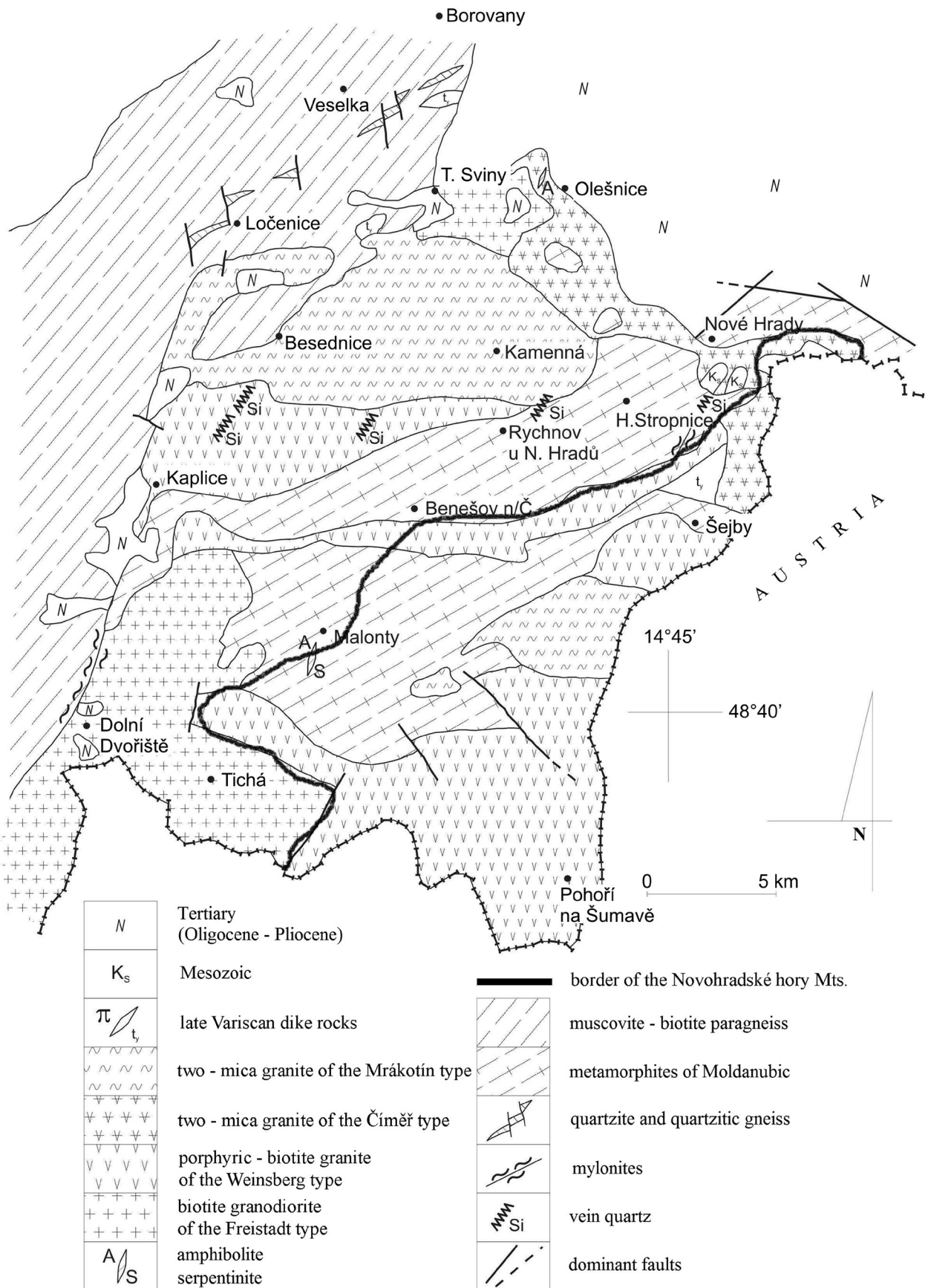


Fig. 2 The geological map of the Novohradské Mountains

archaeological, historical, religious, and symbolic significance of the site, or further cultural aspects (such as the locality as art inspiration or the locality as a venue for some historical event). Ecological value is based on the relationship between the geomorphological and living constituent of the locality. Economical value or potential for the use is related to the possibility to use the site particularly as a resource for the geotourism (Pralong 2005; Panizza and Piacente 2008). Significant economical values of the locality are its accessibility, infrastructure, and service, for example. The most problematic one is the aesthetic value: it is based in particular on the colours, colour contrasts, and the structure of the area. Therefore, it is very subjective and dependent on the frame of the mind of the observer (Panizza 2001). Aesthetic value can be crucial for the economic significance of the locality and for geotourism.

The methodology of Kubalíková (2012) was used in the Podyjí National Park (Kirchner and Kubalíková 2011) and further developed in other areas of the Czech Republic. This methodology uses for the evaluation of the following procedures:

- The selection of the geomorphologically significant localities in the target area based on the study of the literature and maps as well as field research, with the aim to choose the most significant geomorphological localities from the scientific or cultural point of view.
- Detail inventory of the chosen localities, data sampling, and recording: (a) general information, (b) geological description, (c) geomorphological characteristics (morphology and genesis), (d) ecological characteristics, (e) description of the cultural constituents of the site, (f) aesthetic aspect, (g) information relating the accessibility, infrastructure, and services, and (h) recent state of the site, potential risks, and hazards.
- Numeric evaluation of the sites: each criterion is evaluated in specified range of points; the evaluation is divided into four groups (scientific values, additional values, potential for the use, threats and vulnerability). A partial as well as total summaries enables to compare different sites in the target area or in the region. The total number of the points can range from 0 to 30 (Table 1).
- Synthesis: This last step of the assessment enables the possibility to order the localities according to their assessment and based on their natural, cultural, aesthetic, or economic significance or a composition of proposal for a management or legal protection of the site.

The methodology of Kubalíková (2012) was also applied in the north-eastern part of the Novohradské Mountains for the three most interesting localities: Mt. Vysoká, Mt. Kraví, and Mt. Kuní.

Results

On the basis of geomorphological reconnaissance in the study area, the unique sites, Mt. Vysoká, Mt. Kraví, and Mt. Kuní, were selected to the detailed field research and geomorphological inventory. The rarest geomorphological meso- and macroforms were recognised in the mentioned sites. In the target area, the landforms, e.g. tors, frost-riven cliffs, castle koppies, blockfields, cryoplanation surfaces and terraces, and mushroom's rocks, were mapped. These landforms are defined in international scientific literature as cryogenic landforms (Traczyk and Migoń 2000). According to Demek and Mackovčín (2006), the territory of the Czech Republic was situated not far from the frontal part of continental glacier during the Pleistocene, where the climate was cold and hence cryogenic processes were conducted. This geomorphological processes formed cryoplanation terraces with frost-riven cliffs, tors, castle koppies, and blockfields (Demek and Mackovčín 2006). These landforms are developed also in the Novohradské Mountains. They are situated next to the Šumava Mountains, which were covered by alpine glacier in young Pleistocene sequence (Demek and Mackovčín 2006). The thickness of the regolith was not considered in the research because the regolith was removed by etching in the period of Saxonic tectonics and the planation surface of type stripped etchplain was created (Migoń 2004; Demek and Mackovčín 2006). The target area is practically without regolith originated by chemical weathering in the Paleogene (Demek and Mackovčín 2006). Mapped landforms have a great importance and high scientific value in the following assessment. Their short descriptions of the unique sites of Mt. Vysoká, Mt. Kraví, and Mt. Kuní are given below and are shown in more details in Fig. 3a–c).

Mt. Vysoká

Location: 1.8 km southeast of the Hojná Voda village

Cadastral area: Hojná Voda

Altitude: 1034 m a.s.l

Bedrock: migmatites of the Central Moldanubian Pluton—medium grained, porphyritic Weinsberg granites. Top rounded ridge (500 m long) elongated in the direction NE-SW with two distinctive elevations (peaks) creates a part of the Mt. Vysoká. Two well-developed castle koppies (up to 15 m high) are situated on higher peak (1034 m a.s.l.). The fissure cave (wide 2 m, length less than 6 m) originated in the larger castle koppie. The cryoplanation plain extending from the foot of the castle koppies complements a manifold mosaic of landforms. The minor lower peak is formed by the massive tor (high up to 6 m), surrounded by cryoplanation terrace.

The north-eastern slope of the lower peak reaches low to the steep fault slope with a many cryogenic landforms

Table 1 Overview of the assessed criterion

Criterion	Points
1. Scientific value	
1.a Representativeness	Max. 1
1.b Conservation (current state of the site, condition)	Max. 1
1.c Exemplarity, educational value	Max. 1
1.d Rarity (number of similar sites in the target area)	Max. 1
1.e Presence and diversity of meso- and microforms	Max. 1
1.f Presence of further geological and pedological features	Max. 1
1.g Geological significance (for the understanding of the geological evolution)	Max. 1
1.h Palaeographic significance (possibility of landscape or climate reconstruction, etc.)	Max. 1
1.i Popularity of the site from the point of view of Earth sciences, scientific publications	Max. 1
1.j Level of the legal protection due to the geomorphological reasons	Max. 1
Total scientific value	Max. 10
2. Additional values	
2.a Aesthetic value	
The colours, number of colours	Max. 0.5
The structure, number of clearly differentiable components	Max. 0.5
General aesthetic value	Max. 1
2.b Ecological value	
An impact of geomorphological features on biota	Max. 1
The presence of significant preserved species of plants and animals	Max. 0.5
The level of legal protection due to ecological reasons	Max. 0.5
2.c Cultural value	
Historical and archaeological significance	Max. 1
Religious and symbolic significance	Max. 1
Literature and artistic significance	Max. 1
2.d The popularity of the site from the point of view of ecological, aesthetic, and cultural value	Max. 1
Total additional values	Max. 8
3. Potential for the use	
3.a Recognisability	Max. 1
3.b Accessibility (by walking, by car, by public transport)	Max. 1
3.c Infrastructure	Max. 1
3.d Actual use of geoscientific values of the site, approximate number of the visitor per year	Max. 1
3.e Actual use of additional values of the site	Max. 1
3.f Propagation and existence of commercial products presenting the site	Max. 1
3.g Limits for the use, possibility of access, entrance, coming close to, possibility of the guided tours	Max. 1
3.h Number of the possibilities for the use of the site (geoeducation, geotourism, sport, culture, etc.)	Max. 1
Total potential for the use	Max. 8
4. Threats and vulnerability	
4.a Existence of the natural threats leading to the devaluation of the site	Max. 1.5
4.b Existence of the anthropogenic threats leading to the devaluation of the site	Max. 1.5
4.c Existence of the legal protection of the site (any kind of legal protection)	Max. 1
Total threats and vulnerability	Max. 4
Total value	Max. 30

Source: Kubalíková 2012

conditioned by rock structure (castle koppies, mushroom's rock (Fig. 4), etc.) Other frost weathering landforms are

located especially on the west to northwest erosion—denudational slope (slope inclination 10°–20°) of Mt.

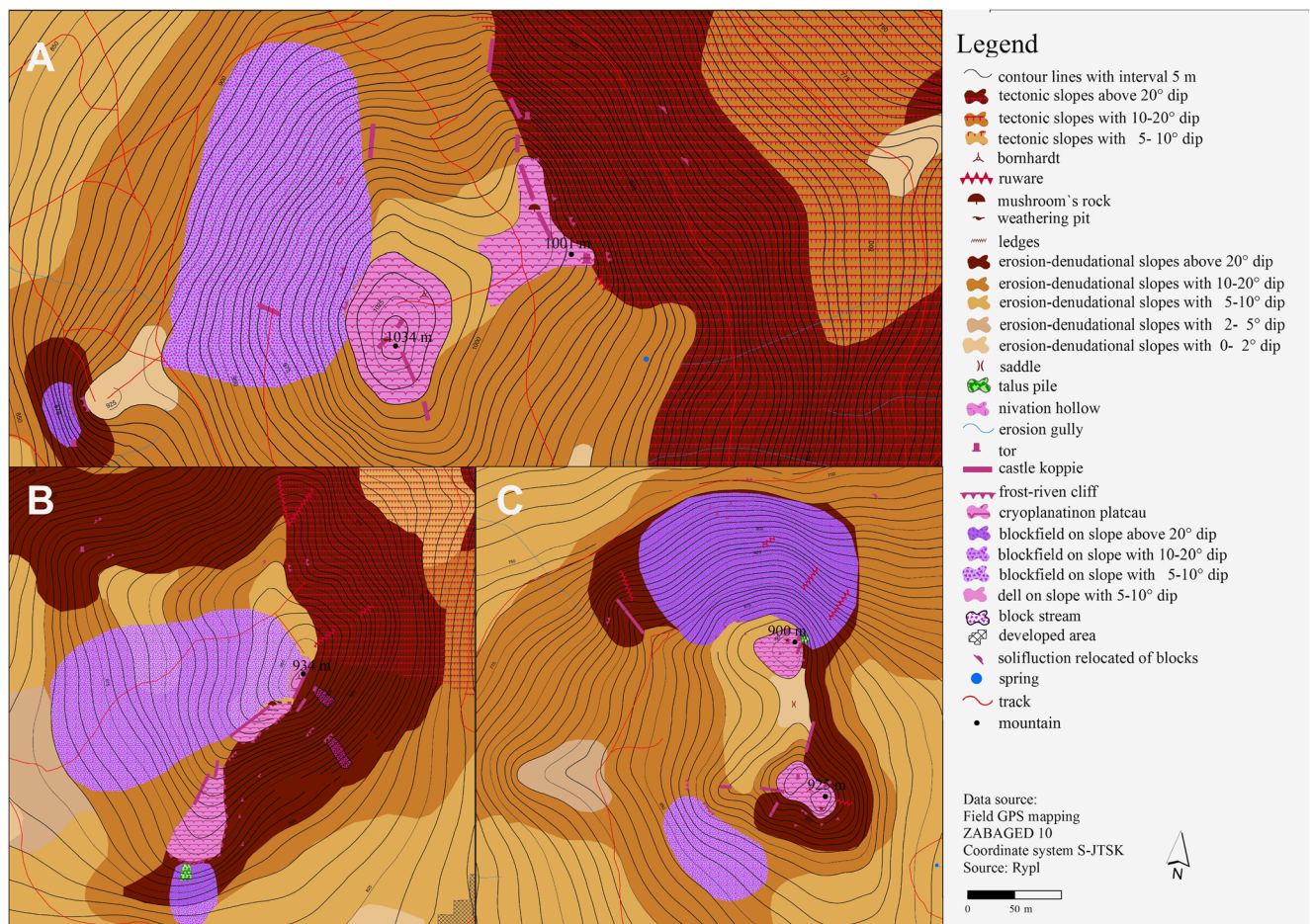


Fig. 3 a The geomorphological map of Mt. Vysoká. Source: Rypl 2015. b The geomorphological map of Mt. Kraví. Source: Rypl 2015. c The geomorphological map of Mt. Kuní. Source: Rypl 2015

Vysoká. There are several well-developed frost-riven cliffs (high up to 8 m), large blockfield (600 × 350 m), and block stream with length 240 m.

Mt. Kraví

Location: 0.5 km west of the Hojná Voda village

Cadastral area: Hojná Voda

Altitude: 953 m a.s.l.

Bedrock: migmatites of the Central Moldanubian Pluton—medium grained, porphyritic Weinsberg granites

Bornhardt of Mt. Kraví rises distinctly above the north-eastern fault slope and above the north-western edge gentler slope of the Novohradské Mountains. There are many different forms, especially of frost weathering and erosion of granite on the steep southeast slope of Mt. Kraví and on the top part. The northern part of the top and the slope of Mt. Kraví consists of ruware. The upper part of the southeast slope has stepped shape with some frost-riven cliffs.

The characteristic castle koppie is situated on the rocky ridge leading to the top, from where frost-riven cliffs are leading to the south-east and further continue to the northwest.

There is a developed and moderately inclined (5°–7°) cryoplanation terrace (width till 50 m) at the foot of the frost-riven cliffs which caused cryogenic processes in the Pleistocene. Under the top of Mt. Kraví stands a conspicuous mushroom's rock called Napoleon's head (Fig. 5). The inherent top of Mt. Kraví forms the large castle koppie with walls up to 10 m in height. The rock walls are lined with the nivation hollow with a diameter of about 60 m. The castle koppie and tors continue to the northern slope of Mt. Kraví.

Mt. Kuní

Location: 1.5 km southwest of the Hojná Voda village

Cadastral area: Hojná Voda

Altitude: 925 m a.s.l.

Bedrock: migmatites of the Central Moldanubian Pluton—medium grained, porphyritic Weinsberg granites

On the top of Mt. Kuní, a rounded ridge is formed, which extends in the direction of N-S and has a length of about 430 m. There are two provided prominent tops on the ridge. The north, lower, and therefore the secondary top has an altitude of 900 m a.s.l. The southern, higher, and therefore the



Fig. 4 Mushroom's rock on Mt. Vysoká—the map marker for the mushroom's rock on the geomorphological map in Fig. 3a (photo by Jiří Ryppl)

main peak has an altitude of 925 m a.s.l. On the secondary top, the cryoplanation terrace is formed which is separated from the outside ridge by a significantly high step (up to 4 m). This step consists of some frost-riven cliffs. There are three smaller tors rising to a height of about 4 m and one small castle koppie with dimensions of $25 \times 10 \times 10$ m above the cryoplanation terrace. The main top is formed by the cryoplanation terrace as well, where two smaller tors were carved of a height of up to 6 m. Several castle koppies extend from the cryoplanation terrace. The most striking castle koppie extends from the eastern part of the northern border of the cryoplanation terrace to the north. The castle koppie has dimensions of $70 \times 20 \times 15$ m and connects the lower northern top of Mt. Kraví with the higher southern top of Mt. Kuní.

Other significant frost landforms are found mainly in the northwest to the northern slope of Mt. Kuní. Then, whole range of frost-riven cliffs with heights to 10 m occur to an altitude of 750 m a.s.l. There is, in addition, a distinctive blockfield with dimensions of 560×330 m on the northern slope.

All three locations are recorded by the Czech Geological Survey as geological (geomorphology) significant sites, i.e. locations with a significant geodiversity, which have been recommended for protection.



Fig. 5 Mushroom's rock called Napoleon's head on Mt. Kraví—the map marker for the mushroom's rock on the geomorphological map in Fig. 3b (photo by Adéla Peřtová)

The evaluation of the sites was done after the completion of the inventory and all available data acquisition (Table 2). Among the evaluated values, the most significant is the group identified as scientific value of geomorphological sites. Among other values, aesthetic, environmental, and cultural values are calculated. The economic value or potential for the use is particularly important in terms of management and geotourism of sites. The last parameter group consists of threats and vulnerable locations.

Scientific Values

The criterion 1a, representation, reached in the case of all individual sites the level of 0.5 points (middle representation—mainly for the scientific community). The particular geomorphological components are well visible, but the processes are understandable only to the part of public possessing at least a basic knowledge of geomorphology. The criterion 1b, conservation, reached the value of 0.75 points (locality slightly disturbed). The conservation of the sites was influenced mainly by their location within the scope of the Czech Republic and long-standing human disinterest. The location of the sites near of the Czech–Austrian border was the reason for the limited human activity under the times of so-

Table 2 Geoheritage values of Mt. Vysoká (A), Mt. Kraví (B), and Mt. Kuní (C)

Criterion	Points	Points	Points
1. Scientific value	A	B	C
1.a Representation	0.5	0.5	0.5
1.b Conservation (current state of the site, condition)	0.75	0.75	0.75
1.c. Exemplarity, educational value	0.5	0.5	0.5
1.d. Rarity (number of similar sites in the target area)	0.5	0.5	0.5
1.e Presence and diversity of meso- and microforms	1.0	1.0	1.0
1.f Presence of further geological and pedological features	0.5	0.5	0.5
1.g Geological significance (for the understanding of the geological evolution)	0.5	0.5	0.5
1.h Palaeographic significance (possibility of landscape or climate reconstruction, etc.)	1.0	1.0	1.0
1.i Popularity of the site from the point of view of Earth sciences, scientific publications	0.5	0.5	0.5
1.j Level of the legal protection due to the geomorphological reasons	0.5	0.5	0.5
Total scientific value	6.25	6.25	6.25
2. Additional values			
2.a Aesthetic value			
The colours, number of colours	0.25	0.25	0.25
The structure, number of clearly differentiable components	0.25	0.25	0.25
General aesthetic value	0.25	0.25	0.25
2.b Ecological value			
An impact of geomorphological features on biota	0.5	0.5	0.5
The presence of significant preserved species of plants and animals	1.0	0.5	0.5
The level of legal protection due to ecological reasons	0.5	0.5	0.5
2.c Cultural value			
Historical and archaeological significance	1.0	1.0	1.0
Religious and symbolic significance	0.5	0.5	0.5
Literature and artistic significance	0.0	0.0	0.0
2.d The popularity of the site from the point of view of ecological, aesthetic, and cultural value	0.5	0.5	0.5
Total additional values	4.75	4.25	4.25
3. Potential for use			
3.a Recognition	0.5	0.5	0.5
3.b Accessibility (by walking, by car, by public transport)	0.5	0.5	0.5
3.c Infrastructure	1.0	1.0	1.0
3.d Actual use of geoscientific values of the site, approximate number of the visitor per year	0.5	0.5	0.5
3.e Actual use of additional values of the site	0.5	0.5	0.5
3.f Propagation and existence of commercial products presenting the site	0.5	0.5	0.5
3.g Limits for the use, possibility of access, entrance, coming close to, possibility of the guided tours	1.0	1.0	1.0
3.h Number of the possibilities for the use of the site (geoeducation, geotourism, sport, culture, etc.)	1.0	1.0	1.0
Total potential for the use	5.5	5.5	5.5
4. Threats and vulnerability			
4.a Existence of the natural threats leading to the devaluation of the site	1.0	1.5	1.5
4.b Existence of the anthropogenic threats leading to the devaluation of the site	0.5	1.0	1.0
4.c Existence of the legal protection of the site (any kind of legal protection)	0.5	0.5	0.5
Total threats and vulnerability	2.0	3.0	3.0
Total value	18.5	19.0	19.0

Source: Peštová 2015

called Iron Curtain, before the year 1989, because this area was a part of the frontier zone. As follows from the historical sources, this area was also very sparsely populated because of soil infertility. In the past, the main human activities in this area were wood processing and glass making. Another reason for the long-standing lack of human interest was also the vicinity of the more attractive touristic area, the Šumava Mountains.

The criterion 1c reached the value of 0.5 points. Individual components and processes are visible and illustrative, but the explanation of an educator (a teacher or any other specialist being able to describe and explain exemplarily individual components and processes) is necessary. There are three similar localities in the target area, Mt. Kuní, Mt. Kraví, and Mt. Vysoká, and from this reason, the criterion 1d reached the value of 0.5 points (three localities in the area). The criterion 1e (presence and diversity of meso- and microforms) reached the value of 1 point. There are representative mesoforms (e.g. castle koppies, tors, frost-riven cliffs) as well as microforms of the relief (e.g. weather pits, rock ledges) in the area of all three localities.

The three target sites were assessed differently according to the criterion 1f, presence of further geological and pedological features: Mt. Vysoká, Mt. Kuní, and Mt. Kraví were assessed according to this criterion only by 0.5 points: there are just partial non-geomorphological aspects in this area. From the geological significance point of view (criterion 1g), the localities reached the value of 0.5 points—existing geological significance. It is possible to observe the consequences and processes of geological evolution, but in order to understand, knowledge of the geological evolution of the extended area (the Šumava Mountains, the Třeboňská pánev basin, and the Českobudějovická pánev basin) is necessary. The target area introduces a part of larger geomorphological area of the Novohradské Mountains, beyond the Czech–Austrian border and stretching to the Danube River, and from this reason, this area is also suitable for palaeographic research (the value of criterion 1h is 1 point).

The criterion 1i, popularity of the site from the point of view of Earth sciences and scientific publications, was evaluated according to the number of publications in scientific databases Web of Science and Scopus and reached the score 0.5 points—there have been references registered in the scientific community. From the point of view of legal protection due to the geomorphological reasons, the target area introduces the part of the protected area of the Natural Park of the Novohradské Mountains. There is also a small protected area of National Natural Monument Hojná Voda within the slope of Mt. Vysoká.

The legal protection is aimed more at the living components of the nature, though all the three target localities were declared by the Czech Geological Survey as geologically (geomorphologically) significant. Hence, criterion 1j was awarded by 0.5 points.

Additional Values

The criterion 2a, expressing the aesthetic values, is based on the field research and on the subjective opinion of the evaluator, and therefore, the results are debatable. As for as the number of the colours, the green tints are characteristic for this area, due to the typical spruce monoculture spread on this area with only a small impact of anthropogenic factor (buildings, fields, water areas, infrastructure, etc.). For this reason, the value of 0.25 points was chosen (two to three colours). Of course, the colouring has changed during the year. The number of clearly differentiable components was evaluated as 0.25 points; there are individual components such as forests, meadows, and areas of anthropogenic activity (traffic infrastructure, residences, etc.). The general aesthetic value reached the middle score—0.25 points.

The criterion 2b, ecological values, was assessed as follows: An impact of geomorphological features on biota was awarded by 0.5 points as geomorphological and biotic components of the sites are affecting each other. The target area represents a part of the Novohradské Mountains, an area with a great amount of protected species of animals and plants. For this reason, the criterion assessing the existence of protected species was evaluated as 0.5 points for the sites Mt. Kuní and Mt. Kraví. The site of Mt. Vysoká was assessed at 1 point because of the presence of the highly preserved non-geomorphological elements in the part of this area—National Natural Monument Hojná Voda (preservation of the beech forest). In the case of the criterion assessing the legal protection for ecological reasons, the target area was assessed as a locality with existing legal protection; hence, the chosen assessment was 0.5 points.

The criterion 2c, cultural values, was based on the field research and survey of the available literary sources. The survey was aimed at the notice of literary and artistic significance of the target area. No reference of archeologic significance was found. It could be considered as historically significant that this area was a part of the frontier zone under the Cold War with no possibility of public admission. This is one of the reasons for the well-preserved state of living as well as non-living nature in this area. For this reason, the evaluation of 1 point was chosen. There is a pilgrimage church of Assumption of Virgin Mary (Dobrá Voda Village) in the target area as well as a statue of St. John of Nepomuk and a religious chapel under the foothills of Mt. Kuní and Mt. Kraví. These religious elements have no direct relation to geomorphological elements; hence, the value of 0.5 points was chosen. No literary or artistic significance was found; hence, an assessment of 0.0 point was chosen.

The evaluation of the criterion 2d, popularity of the site, based on the factors mentioned above is debatable. The target locality is not absolutely unknown, but on the other hand, it is not very popular on a national or even international level.

From this reason, the middle evaluation of 0.5 points was chosen—“popular on the regional level”, taking into account the fact that the target sites are located near of the border with Austria, a highly popular touristic area.

Potential for the Use

The criterion 3a, recognition, reached a value of 0.5 points—individual sites are well recognisable, but for the observation of individual geomorphological components, it is necessary to walk through the localities directly. Criterion 3b, describing the accessibility of the site, is based on the fact that all three localities are very accessible either by the use of public transport (public buses) or by individual transport. The nearest bus stops are Horní Stropnice Village—Hojná Voda Village and Horní Stropnice Village—Staré Hutě Village.

Distance from the bus stop—Hojná Voda Village

Mt. Kuni—3.2 km
 Mt. Kraví—1.4 km
 Mt. Vysoká—2.8 km

Distance from the bus stop—Staré Hutě Village

Mt. Kuni—2.5 km
 Mt. Kraví—2.2 km
 Mt. Vysoká—4.3 km

An advantage of the use of individual transport is a parking area under the foothills of Mt. Kraví. All three sites are well accessible from this parking lot. For this reason, the criterion 3b reached the score 0.5 points. The municipalities Hojná Voda Village and Dobrá Voda Village in the vicinity of the sites (up to 5 km) offer the following services: accommodation, eating, and public transport. Extended services and infrastructure are further offered by the municipality Horní Stropnice Village placed in the distance up to 7 km from the sites. Because of the proximity of the municipalities offering basic services, the criterion 3c infrastructure reached the score 1 point.

The criteria 3d and 3e—the actual use of the geoscientific and additional values of the site reached the value 0.5—partially used. None of the two criteria prevailed. Criterion 3f, the existence of commercial products presenting the site and propaganda, reached the value 0.5 b. The area is shown in tourist guides of the Novohradské Mountains. The tourist information offices in the neighbouring towns, especially in Nové Hradky, offer leaflets aimed at the promotion of tourist routes, bike routes, and cross-country skiing routes. Mt. Kraví is depicted in a postcard of the municipality Dobrá Voda Village. The purity of the air in the Novohradské Mountains is often publicised by TV commercials promoting the mineral water, “Dobrá Voda”. Despite the great propaganda of the target area, according to the method used for an assessment

of the site, the criterion cannot reach the maximum because no evidence for the presence of any part of target area on emblem or logo of some municipality or community were found.

No general limitation has been detected in the target area, apart from entering into the forest at one’s own risk; therefore, the criterion 3g reached the value 1 point. Similarly, the criterion 3h—the possibilities of the use—reached the score 1 point, because there are lot of possibilities for the use in this area—tourism, biking, and cross-country skiing during the winter, there are some objects of geocaching, and there are no restrictions for climbing.

Threats and Vulnerability

The criterion 4a, existence of the natural threats leading to the devaluation of the site: this locality is quite well preserved. Neither during the field research nor in the literature was any nature hazard detected which could influence the components and features of the landscape in target area. For this reason, the criterion 4a reached the highest possible score of 1.5 points in the case of Mt. Kraví and Mt. Kuni. Protected beech woods in the area of National Natural Monument Hojná Voda on the slope of Mt. Vysoká are injured by game; hence, the criterion of the existence of nature hazards reached the score of 1 point.

The criterion 4b, existence of the anthropogenic threats leading to the devaluation of the site, is significant today, especially in the area of Mt. Vysoká. Logging, which started in this area at the end of 2014 and continues to the present, can disturb individual components of the landscape. For this reason, this criterion in case of Mt. Vysoká achieved only 0.5 points. In case of Mt. Kraví and Mt. Kuni where no remarks of anthropogenic activity are visible, this criterion reached 1 point.

The criterion 4c, already existing legal protection of the site, reached the value of 0.5 points in the case of all sites. The target area is a part of the Natural Park of the Novohradské Mountains, and all the three localities have been declared as geomorphologically significant localities by the Czech Geological Survey, in addition to the National Natural Monument Hojná Voda on the slope of Mt. Vysoká. It is not possible to assign higher value of this criterion in this case because this area is not declared as a national park, nor does it appear on the list of UNESCO.

Conclusions

Based on the results of the numerical evaluation, some management measures and possibilities of the rational use of the sites were proposed.

Generally, the sites have a relatively high scientific value (especially thanks to high conservation value, presence of meso- and microforms, and palaeogeographical importance), which represent a good basis for the geoeducational purposes.

Due to the palaeographic significance, it can be mentioned that cryogenic landforms (frost-riven cliffs, block streams, blockfields) are occurred in the selected localities and they serve as evidence of an effect of a periglacial climate in the cold period of the Pleistocene. We suppose that extensive development of mentioned landforms is connected with cold climate in the LGM (Last Glacial Maximum—the period approx. 24,500 – 19 - 18,000 BP). Although the exemplarity and representation of the sites were evaluated 0.5, the presence of the explanation materials could remarkably increase the overall potential for geoeducation. So, the first step for the rational use of the localities is to explain the evolution and the main macroforms and mesoforms which are visible there. This can be achieved through installation of information panels situated on the sites or in their proximity.

As the surroundings of the research area is interesting and both culturally and ecologically rich (the existence of the pilgrimage church, the springs, wells, and some legends about it; beech forest—legally protected area on Mt. Vysoká), there is a possibility to connect these specific sites and geomorphosites and to create an educational path. On the south-eastern part of Mt. Vysoká, there is a short educational path, but it is focused only on living nature. If the extended version of the educational path included the cultural and geoscientific values of the wider area, it would probably attract more visitors. Other (equally important) purposes of this proposed extension of the educational path are to present not only the natural heritage of the area, but also other issues and features that are worthy of attention (this complex approach is corresponding with an idea of geotourism).

Another possibility how to present this important local heritage to the public (not only to the tourists, but also to the local/regional weekend visitors) is to offer guided walks (there is a good possibility to connect the geoscience component of the area with the hydrological and cultural components). The guided walks would be organised by university (University of South Bohemia in České Budějovice) with cooperation of the locals who know the area very well (both nature and history), e.g. primary and secondary school teachers, local patriots, and scientists.

The sites are included in the database of the geologically important localities, kept by the Czech Geological Survey, but it does not assure any legal protection. The legal protection is partly covered by the tool for general protection of the landscape—the Novohradské Mountains Nature Park was officially declared in 2003; however, this category does not have strict rules as the territorial protection. As the sites are exposed to tourists during some periods of the year, they would probably deserve the basic degree of territorial protection (in the category “natural monument” which is defined by the Act No. 114/1992 Coll., on nature conservation and landscape)—it could lead to the better planning of the management of the sites and it could probably help to avoid some problematic

effects of tourist activities—although the sites are quite well preserved, there are certain threats caused especially by undisciplined visitors (disturbance of the vegetation cover, the influence of the climbers, littering). The legal protection together with the suitable and well-targeted educational activities can lead to the better understanding of the conservation of the sites.

The position of this research area on the Czech–Austrian border and the existence of similar localities in the Austrian region also open the possibility of cross-border cooperation in regard to the issues of geotourism.

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