

The Evaluation of Geomorphosites with using Geomorphological Heritage (a Case Study of the Southern part of the Novohradské Mountains, the Czech Republic)

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Abstract

At present, the protection of a biotic nature is more preferred than the protection of an abiotic nature. However, processes of a biotic nature and an abiotic nature are together with human activities deciding factors influencing significantly the landscape in general and therefore it is necessary to identify and evaluate specific geological and geomorphological sites in order to protect abiotic nature.

This article dealt with new information from the territory of the Southern 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 geomorphosites.

1. Introduction

Geoheritage values are the basic indicators by which we evaluate geomorphosites with using geomorphological heritage where a broader definition of geomorphosites is like emphasizing not only their intrinsic significance but also the 'symbolic' value they assume or have assumed. Italian authors (Panizza 2001; Panizza and Piacente 2008) define geomorphosites as landforms with particular and significant geomorphological attributions, which qualify them as a component of a territory's cultural heritage (in a broad sense)'.

According to these authors, the attributes that may confer value to a geomorphosite are scenic, scientific, socioeconomic, cultural. This larger definition, which considers all values as interrelated and interdependent within a holistic conception, is suitable in a popularization context (geotourism, education, promotion, geoparks).

Geomorphosites can also be defined as geomorphological landforms that have acquired a scientific, cultural/historical, aesthetic and/or social/economic value due to human perception or exploitation (Panizza 2001; Reynard and Panizza 2005). They can be single geomorphological objects or wider landscapes and may be modified, damaged, and even destroyed by the impacts of human activities (Reynard and Panizza 2005). The value of geomorphosites, which are currently termed as geoheritage values, is poorly known to the public and to scientists from other disciplines. There is therefore a need to heighten the public profile of geomorphosites, to develop new methods to assess their scientific, cultural, aesthetic and social/economic values, and finally to protect them under a legal framework (Reynard and Panizza 2005).

In the case of the Czech Republic, Geomorphological landscapes of the whole territory of the Czech Republic have been elaborated (Pánek and Hradecký eds. 2016) and data obtained provide a good basis for more detailed research of partial areas and localities.

The first assessment using the concept of geomorphosites for the whole territory of the Czech Republic 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 (e.g. Rypl et al. 2019). 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.

Methods of assessment of landforms in terms of their geoconservation used on the Czech side of the Novohradské Mountains can serve as methodological material for the same assessment on the Austrian side of the Novohradské Mountains.

2. Study Area

The studied area is the southern part of the geomorphological unit of the Novohradské Mountains (Fig. 1). The unit of Novohradské Mountains belongs to the Hercynian Mountains (Demek and Mackovčín eds. 2014) in the Czech Republic.

From the geological point of view, the area of the Novohradské Mountains stretches within the southern part of the Moldanubian Pluton, which represents the southern part of the Bohemian Massif formed during the Variscan Orogeny. The most common bedrock types of this area include the late Variscan magmatites such as the Weinsbergtype granite or Mrákotín-type granite. Other bedrock types include cordierite gneisses to nebulitic migmatites, which are the remnants of the original pluton mantle (Heřmánek and Matějka 1998).

Cryogenic processes in the Pleistocene accelerated the exposure of resistant cores of igneous rocks and created shapes different from those typical for current morphoclimatic zone. These shapes are still well preserved in many places of the Novohradské Mountains (e.g., Rypl et al. 2017, 2020). The current relief of the Novohradské Mountains is clearly polygenetic not only with numerous forms of recent origin such as slightly rounded boulders of diverse sizes, chambers, gullies, and laths, but also with preserved fossil shapes such as ruwares, tors, and castle koppies. Cryogenic landforms created in the glacial period of the Pleistocene prevail among land relief morphosculptures (e.g., Rypl et al. 2017, 2020).

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).

3. Methodological Approach

We start from the concept of geodiversity in our elaborating of the studied area, which is accepted by geoscientific specialists and was discussed in detail in a number of publications (e.g., Reynard et al. 2016; Reynard and Brilha eds. 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 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 southern part Novohradské Mountains is linked to the concept of geosites and geomorphosites. This concept is theoretically developed mainly in the works e.g. Reynard (2005), Panizza (2001), Reynard and Panizza (2005), Reynard, Coratza and Regolini-Bissig eds. (2009), Reynard and Brilha eds. (2018).

The evaluation of geomorphosites is also significantly conceptually developed by the Chingombe (2019) in South Africa (Mpumalanga Province), Bouzekraoui et al. 2017, 2018 in the Moroccan central High - Atlas, De Una – Alvarez et al. 2017 in a Spanish-Portuguese border region, Cetiner et al. 2018 in the Biga Peninsula (Northwestern Turkey), Ertekin 2021 et al. in the Nemrut Volcano (Bitlis, Eastern Turkey), Chrobak et al. 2021 in the Western Carpatians (the Czech – Slovak border region), Moradi et al. 2021 in the Damavand Volcano (Iran). Values, conservation and management issues of viewpoint geosites is addressed by Migoń and Migoń (2017), Jankowski et al. (2020) addresses Geodiversity Assessment with Crowdsourced Data and Spatial Multicriteria Analysis and so Migoń et al. (2018) addresses Conservation and Geotourism Perspectives at Granite Geoheritage Sites of Waldviertel (Austria).

Reynard et al. (2007) divides 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. Scientific value covers also the condition (i.e. well-preserved state) of the site, its representativeness, rarity, paleographic 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. 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 2004; Panizza and Piacente 2008). 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).

We understand geomorphological heritage in accordance with the concept of Reynard et al. (2009a), 'the geomorphological heritage may be considered as the set of landforms worthy of being protected and transmitted to the future generations'. The geomorphological heritage is so presented as part of the

geoheritage, itself a 'component of the natural heritage' (Reynard et al., 2009a). In accordance with the further development of knowledge (see in more detail Coratza and Hobléa 2018) the geomorphological heritage includes not only geomorphological objects sensu stricto but also cultural components with heritage value that is partly determined by the geomorphological context in which they are inserted.

In accordance with the definition approach, our methodological approach includes - identification and selection of the significant Geomorphosites, - inventory of these sites, - assessment of the scientific and additional values, - synthesis.

This methodological approach (including numerical evaluation) was applied to selected parts of the landforms of the Czech Republic and brought objectively comparable results from different types of relief (e.g. Kubalíková 2012; Kirchner and Kubalíková 2013, 2016; Rypl et al. 2019 etc.)

Table 1
Overview of the assessed criterion

(source: Kubalíková 2012, so applied in Rypl et al. 2019)

1. Scientific value	
Criterion	points
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	
Criterion	Points
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

1. Scientific value	
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	
Criterion	points
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	
Criterion	Points
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

4. Results

The unique sites (Mt. Kamenec, Mt. Myslivna and Mt. Jelení) were selected to the detailed field geomorphology research and geomorphological inventory in the study area (e.g. Rypl et al. 2014, 2016, 2020; Rypl and Kirchner, 2017) Their short and simplified descriptions of the unique sites of Mt. Kamenec, Mt. Myslivna, Mt. Jelení are given below and are shown in more details on Fig. 2. (A, B, C).

4.1 Localities

Mt. Kamenec

Location: 3.5 km southwest of the Pohoří na Šumavě village, at the Austrian border

Cadastral area: Pohoří na Šumavě village

Altitude: 1 072 m a. s. l., the highest top on the Czech side of the Novohradské Mountains

Bedrock: magmatites of the Central Moldanubian Pluton - medium grained, porphyritic Weinsberg granites.

The top rounded ridge elongated in the direction NE-SW with two cryoplanation platforms at two altitude levels (1 050 m a. s. l. and 1 072 m a. s. l.). The distinctive castle koppie (60 x 10 x 12 metres) is created on the cryoplanation platform at the altitude level 1 050 m a. s. l. The distinct group of seven tors (up to 15 m high) is created on the cryoplanation platform at the altitude level 1 072 m a. s. l.

Mt. Myslivna

Location: 3.5 km northwest of the Pohoří na Šumavě village

Cadastral area: Pohoří na Šumavě village

Altitude: 1 040 m a. s. l.

Bedrock: magmatites of the Central Moldanubian Pluton - medium grained, porphyritic Weinsberg granites.

The top rounded ridge elongated in the direction NNW-SSE with two distinctive elevations creates part of the Mt. Myslivna. The higher peak is situated on the north with the altitude 1 040 m a. s. l. The lower peak is situated on the south with altitude 1 025 m a. s. l. The particular lower peak is created the cryoplanation platform with the rock fragment.

Mt. Jelení

Location: 2.5 km south of the Leopoldov village

Cadastral area: Dolní Příbraní village

Altitude: north top of Mt. Jelení 939 m a. s. l.

Bedrock: magmatites of the Central Moldanubian Pluton - medium grained, porphyritic Weinsberg granites.

The north top of Mt Jelení is stretched into the top ridge in the direction W – E with two distinctive elevations. The higher peak is situated on the east with the altitude 939 m a. s. l. The lower peak is situated on the west with altitude 920 m a. s. l. There are group of ten frost – riven cliffs (height up to 10 m) on the southwest erosion – denudational slope of the lower peak.

4.2 Geoheritage Values

Geoheritage values are shown in Table 2 for localities of southern part of the Novohradské Mountains and are characterized below.

Table 2
 Geoheritage values of Mt. Kamenec (A), Mt. Myslivna (B) and Mt. Jelení (C).

(source: modified by Stejskal 2016).

1. Scientific value	A	B	C
Criterion	points	points	points
1.a Representation	0.5	0.5	0.5
1.b Conservation (current state of the site, condition)	1.0	0.75	0.75
1.c. Exemplarity, educational value	1.0	1.0	0.5
1.d. Rarity (number of similar sites in the target area)	1.0	1.0	1.0
1.e Presence and diversity of meso- and microforms	1.0	1.0.	0.5
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	7.5	7.25	6.25
2. additional values			
Criterion	points	points	points
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	1.0	0.5	0.5
2.b Ecological value			
An impact of geomorphological features on biota	0.5	1.0	1.0
The presence of significant preserved species of plants and animals	0.5	0.5	0.5
The level of legal protection due to ecological reasons	0.5	0.5	0.5

1. Scientific value	A	B	C
2.c Cultural value			
Historical and archaeologic significance	0.5	0.0	0.0
Religious and symbolic significance	0.0	0.0	0.0
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	4.0	3.5	3.5
3. POTENTIAL for use			
Criterion	points	points	points
3.a Recognition	0.5	0.5	0.5
3.b Accessibility (by walking, by car, by public transport)	0.0	0.0	0.0
3.c Infrastructure	0.5	1.0	0.5
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	0.0
3.g Limits for the use, possibility of access, entrance, coming close to, possibility of the guided tours	1.0	1.0	0.5
3. h Number of the possibilities for the use of the site (geoeducation, geotourism, sports, culture etc.)	1.0	1.0	0.5
Total potential for the use	4.5	5.0	3.0
4. THREATS And vulnerability			
Criterion	points	points	points
4.a Existence of the natural threats leading to the devaluation of the site	1.5	1.0	1.0
4.b Existence of the anthropogenic threats leading to the devaluation of the site	0.5	1.0	1.0

1. Scientific value	A	B	C
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	2.5	2.5	2.5
Total value	18.5	18.25	15.25

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 sites are included in the database of the geologically important localities, kept by the Czech Geological Survey. The criterion 1b Conservation, reached the value of 0.75 points, (locality slightly disturbed) at Mt. Myslivna and Mt. Jelení. 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-called „Iron Curtain“, before the year 1989. 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 most conservative landforms are located in Mt. Kamenec where the criterion 1b reached the level of 1.0 points.

The criterion 1c reached the value of 1.0 points on the Mt. Kamenec a Mt. Myslivna because landforms have a clear genesis and have direct use in geodidactic or geotourism. 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 on the Mt. Jelení where the criterion 1c reached the level of 0.5 points.

There are three localities in the target area Mt. Kamenec, Mt. Myslivna and Mt. Jelení and each locality has a different depiction of landforms, from this reason, the criterion 1d reached the value of 1.0 points. (3 different localities in the area). The criterion 1e (Presence and diversity of meso- and microforms) reached the value of 1 point on Mt. Kamenec and Mt. Myslivna. 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). The criterion 1e reached the value of 0.5 points on Mt. Jelení because the presence of mesoforms and microforms is not as representative.

The three target sites were assessed just the same according to the criterion 1f, Presence of further geological and pedological features: Mt. Kamenec, Mt. Myslivna, and Mt. Jelení were assessed according to this criterion only by 0.5 points: there are just partial non- geomorphological and abiotic 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 basin and the Českobudějovická 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 river Danube and from this reason, this area is so 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. The all three sites are included in the database of the geologically important localities, kept by the Czech Geological Survey. Hence, criterion 1j reached 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 (2 to 3 colours) for all sites. Of course, the colouring has changed during the year. The number of clearly differentiable components were evaluated as 0.25 points for all sites; there are individual components as forests, meadows etc. The general aesthetic value reached the middle score – 0.5 points on Mt. Myslivna and Mt. Jelení and the high score – 1.0 points on Mt. Kamenec because of its frequency frost weathering landforms.

The criterion 2b, Ecological values was assessed as follows: An impact of geomorphological features on biota reached by 0.5 points on Mt. Kamenec. As geomorphological and biotic components of the sites are affecting each other and 1.0 points reached on Mt. Myslivna and Mt. Jelení, because geomorphological and biotic components of the sites are affecting each other so that on the site Mt. Myslivna and Mt. Jelení are declared Natural Monument (preservation of the beech forest). 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 point for the sites. 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 historical and archeologic significance was found on Mt. Myslivna and Mt. Jelení and because here was chosen an assessment of 0.0 points. There was found remains of a castle and an inn near the top of Mt. Kamenec and because here was chosen an assessment of 0.5 points. No reference of

religious and symbolic significance and of literary or artistic significance was found in all three locations and because here was chosen an assessment 0.0 points.

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 that 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.

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 available more than 1,000 meters from the nearest car park. For this reason, the criterion 3b reached the score 0.0 points. The criterion 3c infrastructure reached 1.0 point on Mt. Myslivna because you can borrow right on the top a cottage from the state enterprise: “Forest of the Czech Republic”. This criterion reached 0.5 points on Mt. Kamenec and Mt. Jelení because the nearest infrastructure is more distant than 5,000 metres.

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 criterion prevailed. Criterion 3f, the existence of commercial products presenting the site and propaganda, reached the value 0.5 points on Mt. Kamenec and Mt. Myslivna. The area is shown in tourist guides of the Novohradské Mountains The tourist information offices in the neighbouring towns, especially in Nové Hradý offer leaflets aimed at the promotion of tourist routes and bike routes. This area is shown on various website. This criterion reached 0.0 points on Mt. Jelení because this area is not shown on commercial products presenting of the Novohradské Mountains.

The criterion 3g reached the value 1.0 points on Mt. Kamenec and Mt. Myslivna because localities are well accessible by walk or by car. This criterion reached value 0.5 points on Mt. Jelení because locality is not well accessible by walk or by car as on Mt. Kamenec and Mt. Myslivna. Similarly, the criterion 3h – the possibilities of the use reached the score 1.0 points on Mt. Kamenec and Mt. Myslivna because there are lot of possibilities for the use in this area – tourism, biking, cross-country skiing during the winter, there are some objects of geocaching. This criterion reached the value 0.5 points on Mt. Jelení where the possibilities of the use are not great as on Mt. Kamenec and Mt. Myslivna.

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. Kamenec. Protected beech woods in the area of Natural Monument Myslivna on the slope of Mt. Myslivna and Natural Monument Ulrichov on the slope of Mt. Jelení are injured, hence the criterion of the existence of nature hazards reached the score of 1 points on Mt. Myslivna and Mt. Jelení..

The criterion 4b, Existence of the anthropogenic threats leading to the devaluation of the site is significant today. Especially in the area of Mt. Kamenec where is the most intensive tourism from all three locations. For this reason, this criterion in case of Mt. Kamenec achieved only 0.5 points. In case of Mt. Myslivna and Mt. Jelení where no remarks of anthropogenic activity are visible, this criterion reached 1.0 points.

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 Natural Monument Myslivna on the slope of Mt. Myslivna and the Natural Monument Ulrichov on the slope of Mt. Jelení. There 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.

5. Discussion And Conclusions

When we compare geoheritage values for localities of north - eastern part of Novohradské Mountains (Mt. Vysoká, Mt. Kraví and Mt. Kunií) (Rypl et al. 2019) and for localities of southern part of Novohradské Mountains (Mt. Kamenec, Mt. Myslivna, Mt. Jelení) (Table 3). We will find out, that geoheritage values are very similar except locality Mt. Jelení. There are a well preserved of frost – weathering landforms in all localities. All localities have been declared as geomorphologically significant localities. The difference of scientific values is primarily in the uniqueness of the site. The relief of Mt. Vysoká, Mt. Kraví and Mt. Kunií is very similar, and it reduces scientific values while the relief of Mt. Kamenec, Mt. Myslivna and Mt. Jelení is unique and it increases scientific values. Additional values and potential for the use are better rated at Mt. Vysoká, Mt. Kraví and Mt. Kunií this is due to better facilities and infrastructures close to the sites. The same reason increases threats and vulnerability values for these sites. Lower total values of Mt. Jelení is given above all by its remoteness and poor accessibility.

Table 3

Geoheritage values of Mt. Vysoká, Mt. Kraví, Mt. Kuní, Mt. Kamenec, Mt. Myslivna and Mt. Jelení.

(source: Authors).

Locality	Scientific values	Additional values	Potential for the use	Threats and vulnerability	Total values
Mt. Vysoká	6.25	4.75	5.50	2.00	18.50
Mt. Kraví	6.25	4.25	5.50	3.00	19.00
Mt. Kuní	6.25	4.25	5.50	3.00	19.00
Mt. Kamenec	7.50	4.00	4.50	2.50	18.50
Mt. Myslivna	7.25	3.50	5.00	2.50	18.25
Mt. Jelení	6.25	3.50	3.00	2.50	15.25

Generally, the sites have a relatively high scientific value (especially thanks to high conservation value, presence of meso- and micro-forms and palaeogeographic importance), which represent a good basis for the geoeducational and geotourism purposes (Rypl et al. 2021). 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) (Rypl et al. 2019). The guided walks would be organised by e.g. the tourist office of Nové Hrady 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.

Declarations

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection, analysis, writing - review and editing were performed by Jiří Rypl and Karel Kirchner. Preparation, creation and/or presentation of the published work, specifically visualization/data presentation performed by Stanislav Karft and Vojtěch Blažek. The first draft of the manuscript was written by Jiří Rypl and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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Figures

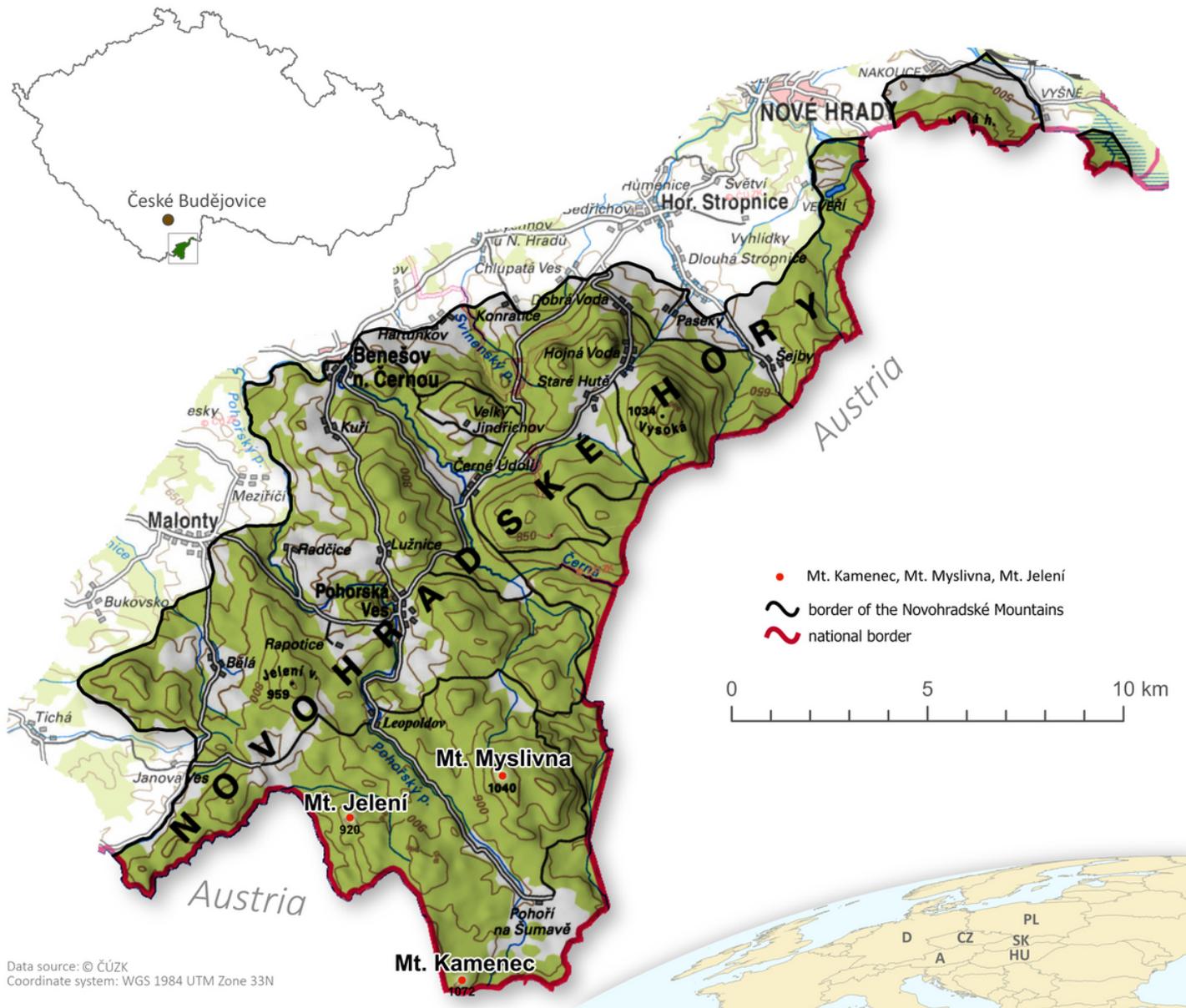


Figure 1

Location of the Novohradské Mountains within the scope of the Czech Republic (source: Authors).

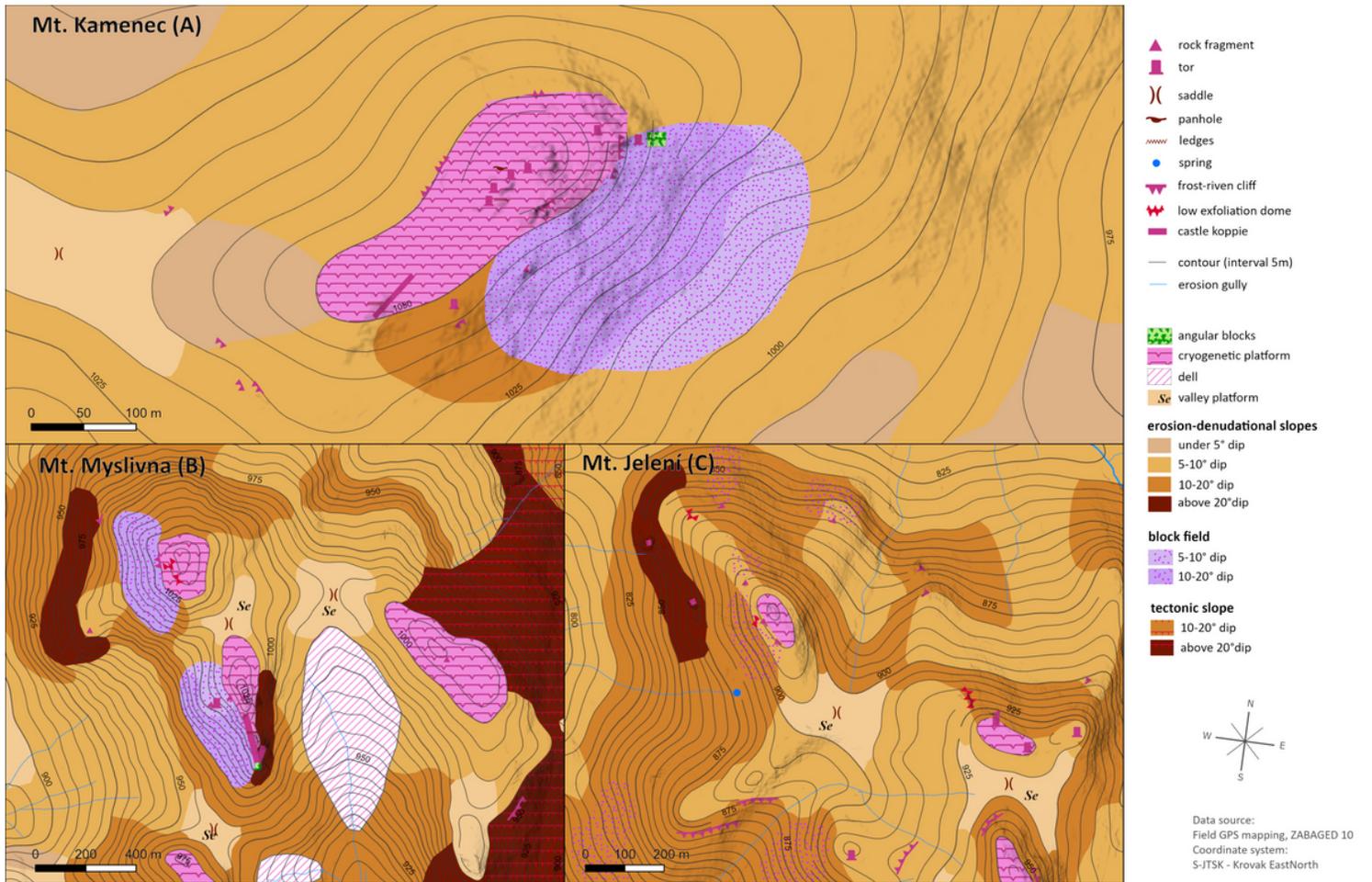


Figure 2

The geomorphological map of Mt. Kameneč(A), Mt. Myslivna (B), Mt. Jelení (C). (Rypl 2014, 2016,2022).