

GEOSITES IN ORAVA, LIPTOV AND SPIŠ (N SLOVAKIA) – EVALUATION, ACCESSIBILITY AND GEOTOURISTIC POTENTIAL

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ABSTRACT: The Sub-Tatra region, which includes Orava, Liptov, and Spiš regions, is an area with high geodiversity and biodiversity. This diversity is manifested, among others, by the occurrence of geosites of special cognitive, educational, and tourist value. This article aimed to list out such sites and their expert assessment using point valuation and triangulation methods. The authors described and assessed a total of 44 geosites, which were rock outcrops, including travertine outcrops, fragments of river valleys, lakes, caves, waterfalls, mineral water springs, peat bogs, landslides, viewpoints, and others. Of all the assessed geosites, the best values of the final valuation coefficient were obtained by the Oravské hradné bralo outcrop, the Dreveník outcrop, the Strednica viewpoint, and the Spišský hradný vrch outcrop. The authors believe that the promotion of geotourism and geosites in the Sub-Tatra region can contribute to greater dispersion of tourists and minimise the phenomenon of overtourism in the High Tatra Mts.

KEYWORDS: geotourism, geodiversity, geosites, assessment method, Sub-Tatra Region

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Introduction

Geotourism is a form of outdoor and sight-seeing tourism. The objective of geotourism is to discover and learn about the elements of abiotic nature and the processes that shape them (Hose 1995, 2000, 2008, 2011, Stueve et al. 2002, Słomka, Kicińska-Świdarska 2004, Joyce 2006, Newsome, Dowling 2006, 2010, Migoń 2012). The purpose of geotourism trips is to visit and become familiar with objects of abiotic nature that were formed as

a result of various geological and geomorphological processes (Słomka, Kicińska-Świdarska 2004, Kurek 2008). Currently, geotourism is most developed in mountainous areas, deserts, coastal areas and river valleys, as evidenced by the numerous publications describing such attractions (Borówka, Nowak 2005, Žaba 2005, Dmytrowski, Kicińska-Świdarska 2006, Łodziński 2007, Strzeboński, Słomka 2007, Mateos et al. 2011, Hlavňová, Pavolová 2013, Krzeszowska 2013, Farsani et al. 2014, Bąk et al. 2016, Rogowski 2016). In addition

to natural areas, geotourism is also promoted in anthropogenic facilities related to the exploitation of natural resources, that is, former mines, historical technological objects or hydrotechnical facilities (Baláž et al. 2008, Kowol, Różycki 2008, Kurek 2008, Rybár, Carvajal 2014). Also interesting is the educational approach to geosites that require special climbing equipment for exploration (Bollati et al. 2018, 2024, Knight, Bollati 2024). Travelling and exploring places of interest from the point of view of abiotic nature may require special qualifications, such as those related to climbing and underground exploration. Geotourism can also take the form of business tourism when it involves professionals (especially natural scientists) attending various types of scientific conferences (Migoń 2012). Currently, the development of geotourism is mainly influenced by scientific centres that promote natural heritage, education in the field of natural sciences and the preparation of popular educational publications and maps. It is mainly promoted by geologists and geographers, as well as lovers of abiotic nature (Kurek 2008).

Objects of abiotic nature that are the subject of geotourism are defined as geosites or geomorphosites. They are places where it is possible to learn about and obtain information on various forms and processes related to abiotic nature (Reynard 2004, Słomka, Kicińska-Świdorska 2004, Dmytrowski, Kicińska 2011, Migoń 2012). They fulfil scientific, educational, tourist, and conservation functions (Kožma 2008).

Orava, Liptov, and Spiš are ethnographic regions surrounding the Tatra Mountains (from the west, south and east). These areas have very well-developed tourist facilities and are well-connected. In addition, they are characterised by a rich culture, which is visible in the architecture, regional folk clothes and all sorts of traditions; this undoubtedly confirms this area as one of the most popular tourist areas in Slovakia (Kollár 1999a, b, Lacika 1999a, b).

This article aims to identify the most attractive geosites, inventory them and perform expert evaluation. This is based on several elements, including: (i) the representativeness of observable features, rocks and landforms and the geological, hydrogeological and geomorphological processes that led to their formation, (ii) the degree of uniqueness of the selected sites, presented on a regional and national scale, (iii) the degree of

landscape diversity and (iv) the scientific value of geosites demonstrated by domestic and international scientific publications. The assessment of the cognitive and educational value of geosites was complemented by an analysis of selected tourism criteria, that is: (i) the accessibility of the site and the degree of its degradation, (ii) the scenic value, including the viewpoint extent, (iii) the level of promotion of the geosite, (iv) the legal status of the area where the geosite is located and (v) an assessment of its location in relation to accommodation and complementary services, and other tourist attractions.

Literature review

Among the publications related to geotourism, there are only a few works concerning the region of Orava, Liptov and Spiš. Some authors emphasised the geotouristic values of the Podhale flysch (e.g. Ptaszek 2005, 2007, Krobicki, Golonka 2008b, Chrobak 2015, 2016, 2018, Chrobak, Bąk 2019). Many geotourism publications refer to the Pieniny Mountains and have been indirectly influenced by the idea of creating a cross-border Pieniny Geopark (Birkenmajer 1962, 1979, 2014, Alexandrowicz et al. 1997, Golonka, Krobicki 2007, Krobicki, Golonka 2008a, Golonka et al. 2014a, b, Jacko et al. 2014). Geosites are presented in the Slovak Paradise (Slovenský raj) National Park (Lukáč et al. 2010, Janočková et al. 2012, Janočková, Janočko 2013), the Dobšinská ľadová jaskyňa Cave (Gasinec et al. 2013) and selected areas of the Spiš region (Rybár, Compťová 2013, Štrba et al. 2022, Čech et al. 2025).

A detailed inventory of geological localities in the area of Podhale, Orava, Liptov and Spiš was created as part of the doctoral thesis of the first author of this article and subsequently published in the form of a monograph (Chrobak, Bąk 2019). Objects of outstanding geological value are also described in the central register of geosites administered by the State Geological Institute of Dionýz Štúr (Liščák et al. 2012).

Methods

All methods of geosite assessment described in the scientific literature are based on point

valuation. According to this method, different weights are assigned to defined criteria. Among the many assessment methods described so far, relating to different areas of mountain and foothill relief (Alexandrowicz et al. 1992, Serrano, González-Trueba 2005, Panizza, Mennella 2007, Reynard et al. 2007, Zouros 2007, Koźma 2008, Pereira, Pereira 2010, Rodrigues, Fonseca 2010, Rybár 2010, Bruschi et al. 2011, Coratza et al. 2011, Dmytrowski, Kicińska 2011, Fassoulas et al. 2012, Brilha, 2016), in this article, two methods were used: those presented by Pereira and Pereira (2010) and Fassoulas et al. (2012). According to the authors of these papers, these methods comprehensively evaluate geological sites of mountain and foothill relief; the first one was used for the Montesinho Mountain Park in Portugal and the second for the Psiloritis Geopark and the Lasithi Mountains on Crete. The criteria used in these two papers were the basis for the introduction of a modified assessment method of the geosites in the Sub-Tatra region (Chrobak 2018, 2021, Chrobak, Bąk 2019) that also belongs to the group of point valuation methods.

The assessment method used in this paper assumes that geosites are evaluated according to two sets of criteria: cognitive-educational and tourist criteria. The criteria for assessing cognitive and educational value were based on those presented in Pereira and Pereira (2010), while the tourist criteria were based on those presented in Pereira and Pereira (2010) and Fassoulas et al. (2012) (Table 1).

The sums of the values related to each criterion were then divided by the maximum sum that could be obtained for each criterion so that all values were in the range 0–1. On this basis, four groups were distinguished (Table 2). The boundaries between them were adopted on the basis of the proposals presented in Warszyńska (1970).

The final indexation coefficient of a given geosite (W_k), which was calculated according to the following formula (Chrobak, Bąk 2019):

$$W_k = 0.7W_E + 0.3W_T$$

where:

- W_E is the cognitive and educational value,
- W_T is the tourist value.

The weighted average values for calculating the index coefficient of the geosite at the level of

0.7 for W_E and 0.3 for W_T represent the greater importance of cognitive and educational value over tourist value, which, according to the authors, is key in this assessment (Chrobak, Bąk 2019). The elements that make up tourist value can change at any time and very quickly, either positively or negatively. Changing the ratio (e.g., 60% and 40% or 80% and 20%) does not change the values of the resulting ratings, and the distribution of geosites into categories I–III remains essentially the same.

The assessment method presented is subjective and based on the knowledge and experience of the experts who implement the assessment. In order to reduce the subjectivity of the assessment values obtained, the educational and cognitive criteria were assessed independently by three experts, and then an arithmetic average was calculated from their scores in accordance with the basics of the triangulation method (Flick 2011).

The experts who took part in the valuation of geosites are people who are both scientifically and sentimentally connected with the studied area. The first expert is a physical geographer who scientifically deals with the concepts of geodiversity, geoheritage, inventory, and valuation of geosites and their promotion. She was raised in the study area and knows the assessed geosites very well. The second expert is a regional geographer who, like the first expert, comes from the studied area. In his research, he deals with the important problems of transport, tourism, and cross-border development. The third expert is a physical geographer, a geomorphologist who deals with fluvial processes, tectonics, and morphostructures, and part of his research also takes place in the Tatra region.

Study area

The region surrounding the Tatra Mountains can be defined on the basis of various criteria. Ethnographically, it represents four historical cultural regions – Orava, Liptov, Spiš and Podhale (Fig. 1). Administratively, it covers the territory of three regions in Slovakia: Žilina (districts of Dolný Kubín – DK, Tvrdošín – TS, Námestovo – NO, Ružomberok – RK and Liptovský Mikuláš – LM), Prešov (districts of Poprad – PP, Kežmarok – KK, Levoča – LE and Stará Ľubovňa – SL), and

Table 1. Point values of elements valorising geosites.

E	Cognitive – Educational criteria
U	The uniqueness of the site in relation to the Sub-Tatra region
0	More than five examples of similar geosites in the region
2.5	Three to five examples of similar geosites in the region
5	Two to three examples of similar geosites in the region
7.5	Geosite is very special
10	The only such geosite in the region
Z	Degree of degradation (destruction) of the site
0	The site is damaged by human activity
2.5	The site is destroyed due to natural processes
5	The site is damaged, but has retained its basic geological and geomorphological features
7.5	The site is slightly damaged but still retains important geological and geomorphological features
10	The site is not damaged
R	Representativeness of geological, hydrogeological, hydrological and geomorphological processes and their educational value
0	Low representativeness and lack of educational value
3.3	Medium representativeness and low educational value
6.7	Geosite is a good example of natural processes, but recognition and interpretation are difficult for non-scientists
10	Geosite is a good example of natural processes and has a high educational value
Zk	Degree of landscape diversity
0	Lack of diversity (1 type of geomorphological process that forms the landscape)
3.3	Low diversity (2 types of geomorphological processes that form the landscape)
6.7	Average diversity (3 types of geomorphological processes that form the landscape)
10	High diversity (4 or more types of geomorphological processes that form the landscape)
Wg	Other features related to abiotic nature within the site and in its immediate vicinity
0	No other elements
3.3	Other elements of inanimate nature, but not related to geographical location
6.7	Other elements of inanimate nature related to geosite
10	Occurrence of other geosites within 2 km
L	Scientific value of geosite as expressed in scientific literature
0	There is no scientific literature describing this geosite
5	Geosite described in the national scientific literature
10	Geosite described in the international scientific literature
SK	Uniqueness of the geosite in comparison with other similar sites in Slovakia
0	More than five examples of similar geosites
3.3	Three to five examples of similar geosites
6.7	Two examples of similar geosites
10	There are no similar geosites
T	Tourist criteria
W	Scenic values
0	Difficult observation of the object or the object is not visible at all
2	The object can only be observed using special equipment
4	Visibility is limited by trees or lower vegetation
6	Good visibility, but you have to move around for full observation
8	Good visibility for all elements (partially grass-covered object)
10	Perfect visibility for all components
Pw	Visibility range
0	No view
2.5	Limited view with a range of 90°
5	Semi-circular view with 180°
7.5	View to three sides (270°)
10	Unlimited circular view (360°)

D	Object accessibility
0	Difficult to access object; only with the use of special equipment
2	Accessible on foot; parking more than 2000 m away
4	Object is accessible by car and/or bicycle; parking more than 1000 m away
6	Object is accessible by car and/or bicycle; parking at a distance of 500–1000 m
8	Object is accessible by car and/or bicycle; parking within 500 m
10	The object is accessible by car and local means of transport; bus stop within 500 m, parking within 100 m
Ot	Current form of accessibility as a tourist attraction
0	The site is not known in tourist literature, is not a tourist attraction and is not promoted
3.3	The site is known in tourist literature, but it is not used as a tourist attraction or promoted
6.7	The site is known in tourist literature, it is promoted, but it is not used as a tourist attraction
10	The site is well known in tourist literature, it is promoted and used as a tourist attraction
O	Legal status of geosite protection
0	Strict security measures, no access to the object
3.3	Partial protection with precise instructions for object accessibility
6.7	No protection with full access to the object
10	Partial protection without additional restrictions related to the accessibility of the object
Ud	Facilities and additional services (gastronomy, souvenir shops)
0	Accommodation and additional services more than 5 km away
2.5	Accommodation and additional services 2–5 km
5	Accommodation and additional services 500 m to 2 km
7.5	Accommodation and additional services between 100 m and 500 m
10	Accommodation and additional services within 100 m
It	Presence of other tourist attractions
0	There are no other tourist attractions within a radius of more than 5 km
2.5	The nearest tourist attraction is 2–5 km away
5	The nearest tourist attraction is 500 m to 2 km away
7.5	The nearest tourist attraction is 100–500 m away
10	The nearest tourist attraction is less than 100 m away

Košice (district of Spišská Nová Ves – SN). In Poland, it covers the Lesser Poland Voivodeship (districts of Tatra – TT and Nowy Targ – NT).

From the physical-geographical point of view (Mazúr, Lukniš 1978, Balon et al. 2015), this region includes the mountain ranges (Tatra Mountains, Kozie chrbty Mountains, Chočské vrchy Mountains) and interior mountain basins (Podtatranská kotlina Basin, Hornádska kotlina Basin) of the Fatra-Tatra Area within the Inner Western Carpathians, as well as the units of the Podhale-Magura Area (Podtatranská brázda Trench, Skorušinské vrchy Mountains (continued within Poland as the Pogórza Przedtatrzańskie Mountains), Oravská kotlina Basin (continued within Poland as the Kotlina Orawsko-Nowotarska Basin), Spišská Magura Mountains (also extend into Poland as the Magura Spiska Mountains)), the Central section of the Western Beskids (Oravská vrchovina Mountains, Oravská Magura Mountains) and the Eastern section of the Western Beskids (Pieniny Mountains) within the Outer Western Carpathians (Fig. 2).

In the varied geological structure of the territory (e.g. Bezák et al. 2008), several basic units of the Western Carpathians are represented, from the Tatric units (mainly Palaeozoic crystalline core – granites, granodiorites, metamorphites) and the Sub-Tatric Mesozoic nappes (Fatrikum, Hronikum – limestones, dolomites, marls), through the layers of the Inner Carpathian Palaeogene (sandstones, claystones, siltstones), up to the Mesozoic (limestones, marls) units of the Pieniny Klippen Belt and the flysch formations (Palaeogene – sandstones, claystones). The

Table 2. Geosite classification based on the results of the valorisation.

Group	Point value	Definition
I	>0.7	Object with special cognitive, educational/tourist values
II	0.4–0.7	Object of high cognitive, educational/tourist value
III	0.2–0.4	Object of average cognitive, educational/tourist value
IV	<0.2	Object of low cognitive, educational/tourist value

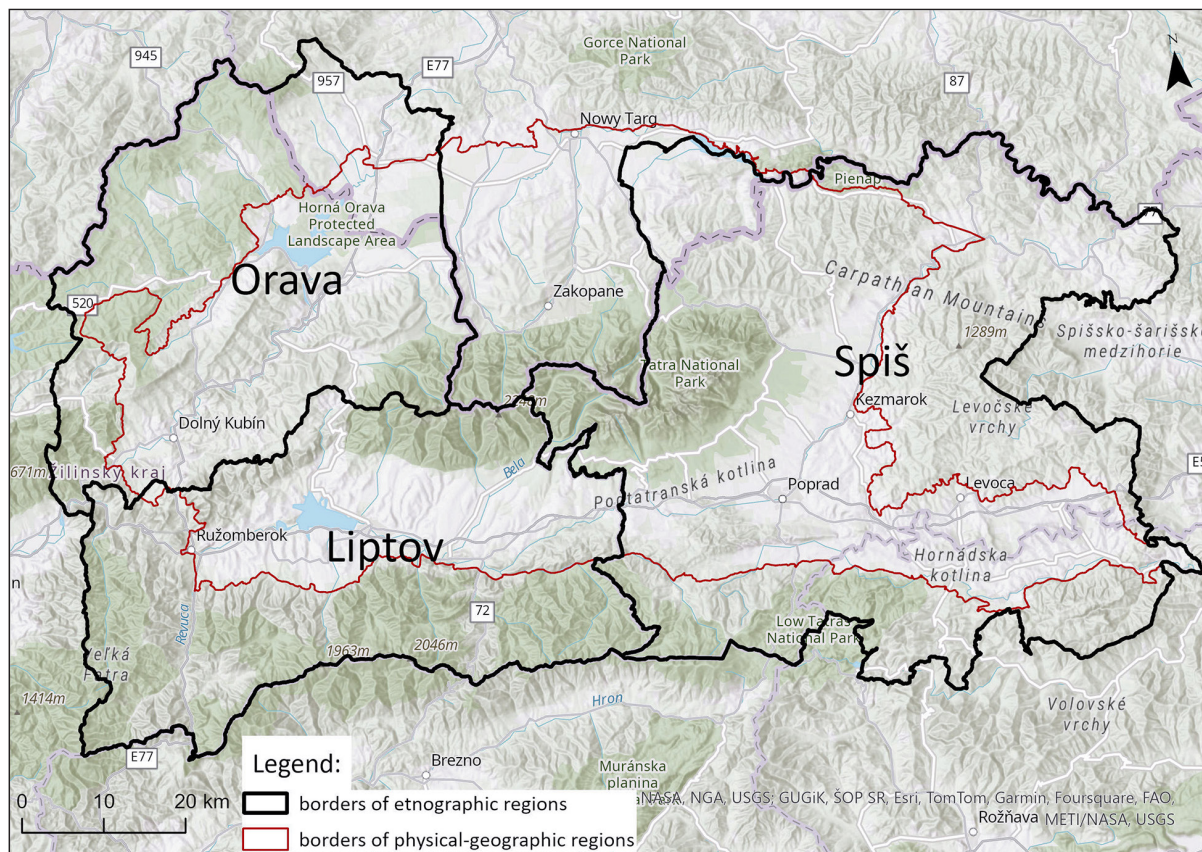


Fig. 1. Location of Sub-Tatra region (based on the administrative map of Slovakia available online at www.geoportal.sk).

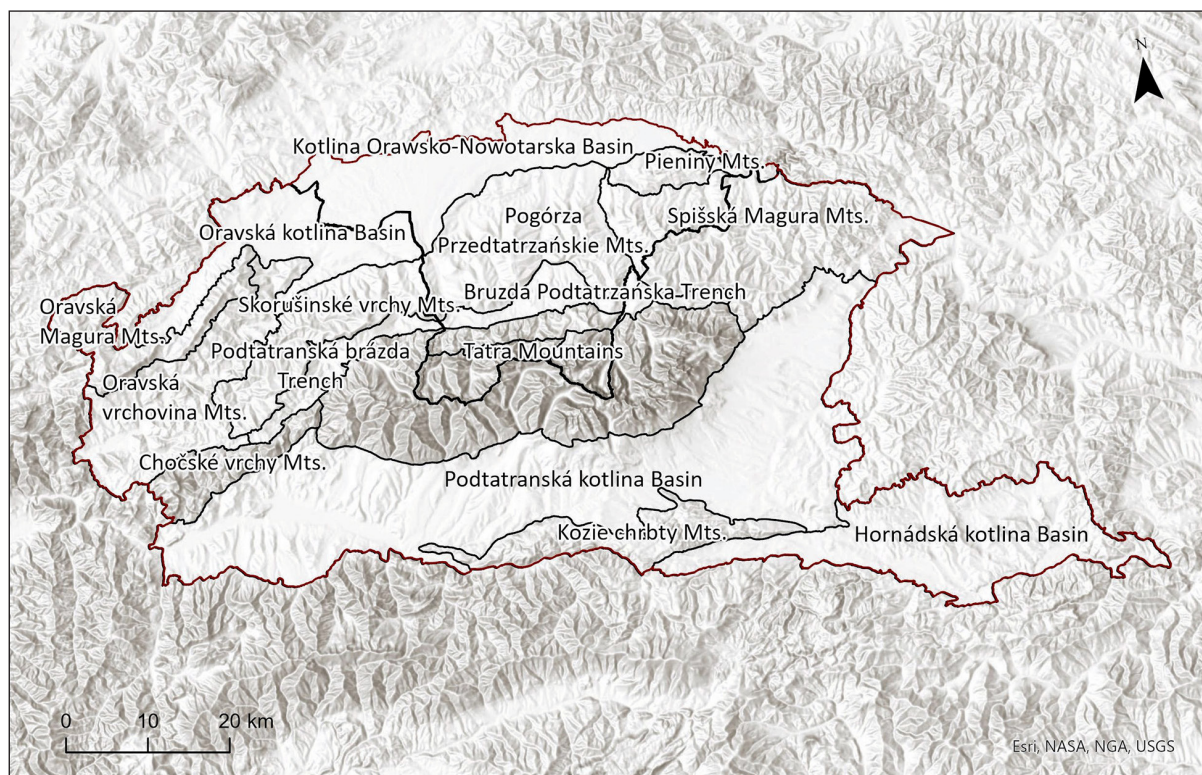
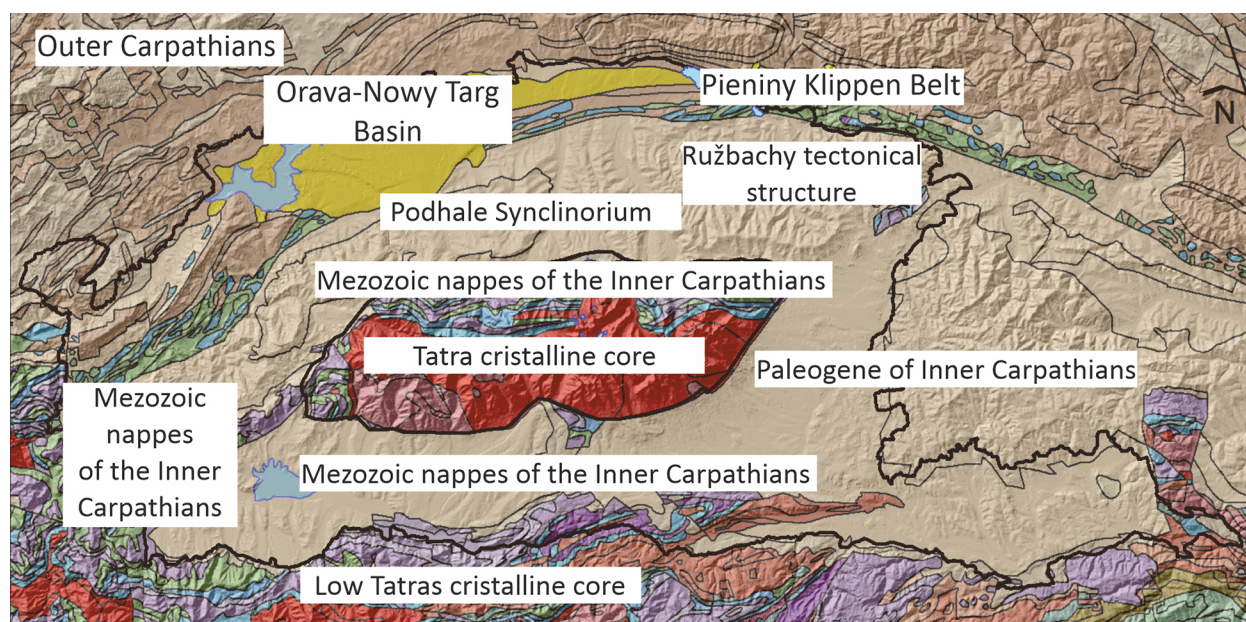


Fig. 2. The physical-geographical mesoregions of the study area (based on Urbánek et al. 2009 and Balon et al. 2015).



The age of the rocks occurring in the Tatra Mountains, in the Podtatrze region and in the neighboring regions

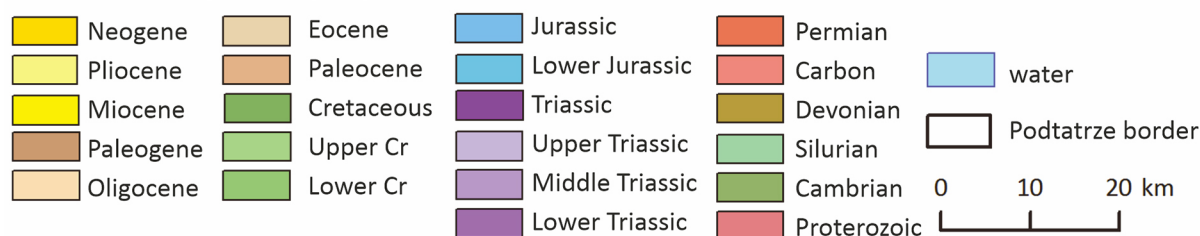


Fig. 3. The geology of the studied area (based on the geological map of Lexa et al. 2000).

youngest units are the Neogene filling of the Oravská kotlina Basin (clays, dusts, coals, sands, gravels) and Quaternary sediments (fluvial, glacial, glacifluvial). Travertines are a special example of Quaternary rocks that are very numerous. They are formed by chemical precipitation from mineral springs, and their occurrence is mainly linked to the tectonic lines bordering the Podtatranská kotlina Basin and the Hornádska kotlina Basin (Fig. 3).

The nature of the relief in the region under study varies in accordance with the varied geological structure (e.g. Lukniš 1972, Lehotský, Boltižiar 2022). The basic geomorphological units have been individualised as a result of neotectonic movements (e.g. Minár et al. 2011). The highest elevated mountain ranges (Tatra Mountains, Nízke Tatry Mountains) were shaped by mountain glaciers in the Pleistocene, and many fossil forms of glacial relief (glacial valleys, glacial cirques, glacial lakes) can be found there

(e.g. Lukniš 1973). Their present-day rocky and mountainous relief is the result of a combination of frost weathering processes and gravitational processes in the periglacial morphoclimatic zone and different geological structures (e.g. Boltižiar 2022). Karst relief on limestones and dolomites (caves, abysses, rock formations) is a special phenomenon. Fluvial and slope processes dominate in the lower mountain ranges, with the flysch mountains in particular being significantly affected by the occurrence of landslides.

From the hydrological point of view, the study area is located on the Main European watershed. It converges southwards via the Váh River to the Danube River and the Black Sea, and northwards via the Dunajec River to the Vistula River and the Baltic Sea. The most important tributaries of the Váh River within the study area are the Orava River and the Belá River, while the tributaries of the Dunajec River include the Poprad River and the Biálka River. Most of the lakes are located in

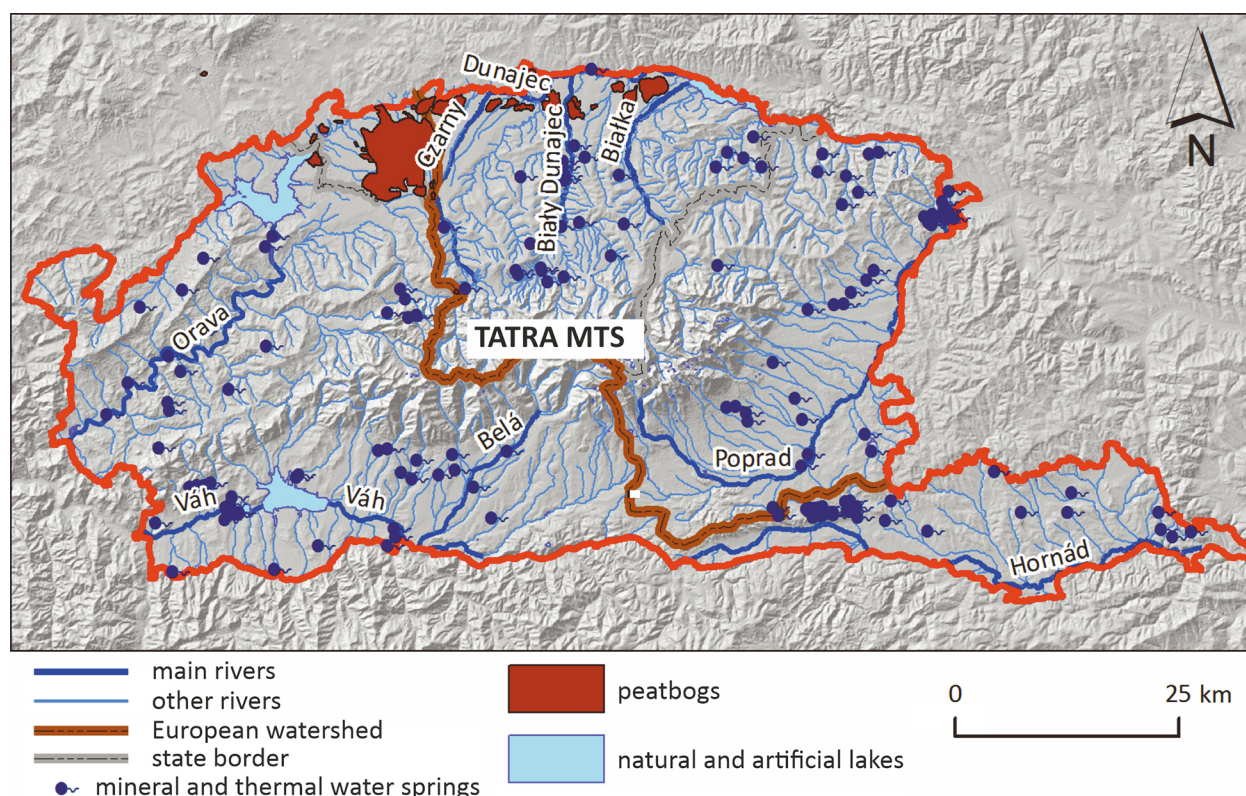


Fig. 4. Hydrology of the study area (based on the hydrological map of Turbek (1980), the hydrogeological maps of Chowaniec and Witek (1997a, b), Skąpski and Garbacz (1997), Małecka et al. (2002a, b), and the map of the hydrographic division of Poland available online at www.kzgw.gov.pl).

the Tatra Mountains and are of glacial origin. In the Spišská Magura Mountains, we can find several smaller landslide-dammed lakes (Fig. 4).

Geosites

In the study area, 44 geosites were inventoried and then subjected to valorisation (Fig. 5). They were finally selected through several steps. First, a library search was conducted, consisting of a review of both scientific and popular science literature describing the Sub-Tatra region in search of descriptions of geographically interesting places. Here, guides to conference field sessions (e.g., Gradziński, Mrozińska-Broda 2004, Gradziński et al. 2015) proved very useful. The next step was to identify these objects in the field and check their availability and the possibility of observing forms and explaining the phenomena that led to their creation. Finally, from over 200 inventoried geosites in the entire Sub-Tatra region (on both the Slovak and Polish sides), the 44 best preserved objects in Slovakia were selected and subjected to

expert valuation. These consist of rock outcrops, including travertines and quarries, viewpoints, peat bogs, lakes, fragments of river valleys, waterfalls, caves, springs, landslides, and the ruins of buildings related to the local culture and built using local rock materials. Full descriptions of all geosites have been published (Chrobak, Bąk 2019), while their most important features have been published online (Chrobak-Žuffová et al. 2025) as a [supplementary file](#) to this article.

Assessment of the geosites

The cognitive and educational assessment of the geosites

The cognitive and educational assessment of the geosites was performed by three experts by the principles of expert triangulation. According to Expert 1, the best-rated geosites in terms of cognitive and educational value are the Červená skala outcrop, the Oravské hradné bralo outcrop, the Pucovské zlepenie outcrop, the

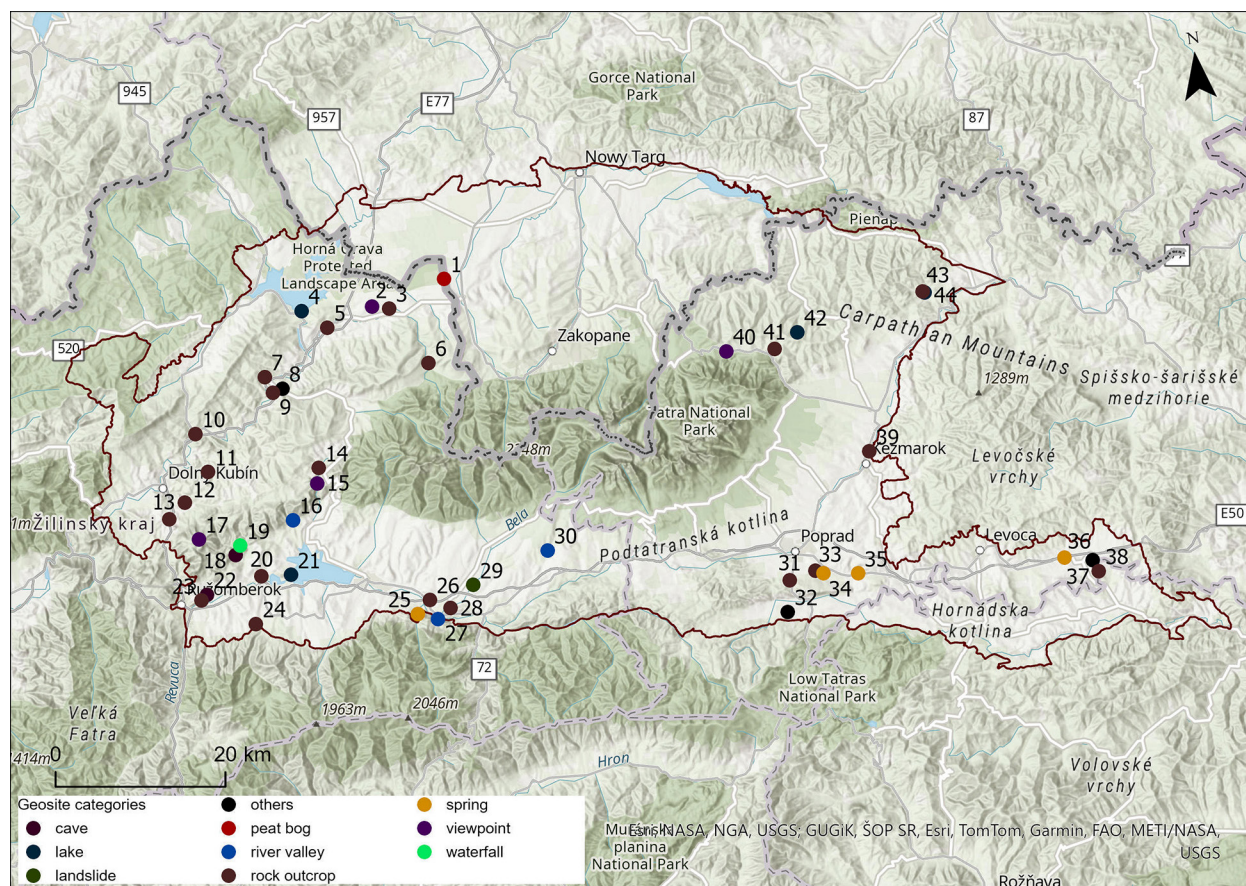


Fig. 5. Locations of geosites.

Lúčanské travertíny outcrop, the Lúčanský vodopád waterfall, the Bešeňovské travertíny outcrop, the Liskovská jaskyňa Cave, the Vavrišovo landslide, the Gánovské travertíny outcrop, the Spišský hradný vrch outcrop, the Dreveník outcrop, the Smrtná jama crater, and the Ružbašské travertíny outcrop. They were included in the first group of geosites with exceptional cognitive and educational value (Table 3). The lowest scores were given to the Jasenová outcrop and the Výhľad na Kozie chrbty viewpoint. These are objects in the last group (group IV) of geosites with low cognitive and educational value (Table 3).

According to Expert 2, the best assessed geosites in terms of cognitive and educational value are the Oravská priehrada viewpoint, the Oravské hradné bralo outcrop, the Veľký Choč viewpoint, the Sivá brada outcrop, the Dreveník outcrop and the Strednica viewpoint; they are in the first group of geosites with exceptional cognitive and educational value (Table 3). The lowest assessed geosites were the Liptovský Hrádok

outcrop and the Skalná (Jánošíkova) päsť outcrop. They are in group IV, which contains geosites with low cognitive and educational value (Table 3).

According to Expert 3, the best-rated geosites in terms of cognitive and educational value are the Sivá brada outcrop, the Rašelinisko Przybojce/Rudné peatbog, the Gánovské slaniská outcrop, the Pucovské zlepenice outcrop, the Strednica viewpoint, Jezersko Lake, the Červená skala outcrop, the Oravské hradné bralo outcrop, the Gánovské travertíny outcrop, the Ružbašské travertíny outcrop, the Spišský hradný vrch outcrop, and the Dreveník outcrop. They were included in the first group of geosites with exceptional cognitive and educational value (Table 3). The lowest rated geosites were the Jasenová outcrop, the Sliačske travertíny outcrop, the Skalná (Jánošíkova) päsť outcrop, and the Vavrišovo landslide. These are objects in the last group (group IV) of geosites with low cognitive and educational value (Table 3). From the expert triangulation, the best-rated geosites are

Table 3. Assessment of geosites according to cognitive and educational criteria.

No.	Name of the geosite	Expert 1			Expert 2			Expert 3			Expert triangulation		
		Sum	Warszyńska indicator	Group	Sum	Warszyńska indicator	Group	Sum	Warszyńska indicator	Group	Average	Warszyńska indicator	Group
1	Rašelinisko Przybojec/Rudné Peatbog	47.6	0.68	II	35.8	0.51	II	51.8	0.74	I	45.07	0.64	II
2	Viewpoint over the Oravská kotlina Basin and Tatra Mountains	29.2	0.42	II	34.2	0.49	II	30.0	0.43	II	31.13	0.44	II
3	Čimhovské vrstvy layers	27.5	0.39	III	42.5	0.61	II	27.5	0.39	III	32.50	0.46	II
4	Oravská priehrada Dam viewpoint	40.0	0.57	II	56.7	0.81	I	38.3	0.55	II	45.00	0.64	II
5	Halečková outcrop	23.4	0.33	III	15.8	0.23	III	23.4	0.33	III	20.87	0.30	III
6	Oravice outcrop	17.5	0.25	III	20.8	0.30	III	17.5	0.25	III	18.60	0.27	III
7	Červená skala outcrop	56.7	0.81	I	45.8	0.65	II	60.9	0.87	I	54.47	0.78	I
8	Františkova huta ironworks	22.5	0.32	III	40.0	0.57	II	25.0	0.36	III	29.17	0.42	II
9	Biela skala outcrop	42.5	0.61	II	27.5	0.39	III	43.4	0.62	II	37.80	0.54	II
10	Oravské hradné bralo outcrop	57.5	0.82	I	56.6	0.81	I	64.2	0.92	I	59.43	0.85	I
11	Pucovské zlepenice outcrop	54.2	0.77	I	42.5	0.61	II	56.7	0.81	I	51.13	0.73	I
12	Ostrá skala a Tupá skala outcrop	41.7	0.60	II	37.4	0.53	II	45.9	0.66	II	41.67	0.60	II
13	Jasenová outcrop	7.5	0.11	IV	15.8	0.23	III	8.3	0.12	IV	10.53	0.15	IV
14	Hutianske súvrstvie outcrop	24.1	0.34	III	30.8	0.44	II	22.5	0.32	III	25.80	0.37	III
15	Kvačianska dolina Valley	41.6	0.59	II	45.9	0.66	II	20.0	0.29	III	35.83	0.51	II
16	Prosiecka dolina Valley	40.0	0.57	II	35.9	0.51	II	28.3	0.40	II	34.73	0.50	II
17	Viewpoint from the Veľký Choč Mt.	33.3	0.48	II	52.5	0.75	I	23.3	0.33	III	36.37	0.52	II
18	Lúčanské travertíny outcrop	50.9	0.73	I	31.7	0.45	II	18.3	0.26	III	33.63	0.48	II
19	Lúčanský vodopád waterfall	57.6	0.82	I	31.7	0.45	II	31.7	0.45	II	40.33	0.58	II
20	Bešeňovské travertíny outcrop	54.3	0.78	I	43.3	0.62	II	25.0	0.36	III	40.87	0.58	II
21	Viewpoint of the Liptovská Mara Dam	22.5	0.32	III	36.6	0.52	II	20.0	0.29	III	26.37	0.38	III
22	Liskovská jaskyňa Cave	55.1	0.79	I	35.0	0.50	II	15.0	0.21	III	35.03	0.50	II
23	Skalná (Jánošíkova) päť outcrop	32.6	0.47	II	13.3	0.19	IV	13.3	0.19	IV	19.73	0.28	III
24	Sliačske travertíny outcrop	38.4	0.55	II	36.6	0.52	II	11.6	0.17	IV	28.87	0.41	II
25	Termálny prameň Kaďa spring	30.9	0.44	II	16.7	0.24	III	25.0	0.36	III	24.20	0.35	III
26	Velínok outcrop	27.5	0.39	III	38.4	0.55	II	47.5	0.68	II	37.80	0.54	II
27	Belá and Váh riverbed	40.0	0.57	II	44.1	0.63	II	33.4	0.48	II	39.17	0.56	II
28	Liptovský Hrádok outcrop	30.9	0.44	II	9.9	0.14	IV	40.0	0.57	II	26.93	0.38	III
29	Vavrišovo landslide	55.0	0.79	I	35.0	0.50	II	13.4	0.19	IV	34.47	0.49	II
30	Hybická tiesňava gorge	47.6	0.68	II	16.6	0.24	III	23.4	0.33	III	29.20	0.42	II
31	Kvetnica outcrop	44.1	0.63	II	32.5	0.46	II	42.5	0.61	II	39.70	0.57	II
32	Kozie chrbty viewpoint	13.3	0.19	IV	45.0	0.64	II	28.3	0.40	II	28.87	0.41	II
33	Gánovské travertíny outcrop	63.4	0.91	I	29.1	0.42	II	64.2	0.92	I	52.23	0.75	I
34	Gánovské slaniská springs	40.0	0.57	II	45.8	0.65	II	52.5	0.75	I	46.10	0.66	II
35	Ondrej mineral spring	32.5	0.46	II	20.7	0.30	III	47.6	0.68	II	33.60	0.48	II
36	Sivá brada outcrop	30.0	0.43	II	58.4	0.83	I	50.0	0.71	I	46.13	0.66	II
37	Spišský hradný vrch outcrop	57.5	0.82	I	39.9	0.57	II	67.5	0.96	I	54.97	0.79	I
38	Dreveník outcrop	64.2	0.92	I	54.1	0.77	I	67.5	0.96	I	61.93	0.88	I
39	Kežmarské vrstvy outcrop	32.4	0.46	II	44.2	0.63	II	30.8	0.44	II	35.80	0.51	II
40	Strednica viewpoint	42.5	0.61	II	62.5	0.89	I	58.3	0.83	I	54.43	0.78	I
41	Bachledova dolina outcrop	31.6	0.45	II	34.2	0.49	II	35.8	0.51	II	33.87	0.48	II
42	Jezersko Lake	34.2	0.49	II	39.2	0.56	II	59.2	0.85	I	44.20	0.63	II
43	Smrtná jama outcrop	60.9	0.87	I	30.0	0.43	II	45.9	0.66	II	45.60	0.65	II
44	Ružbašské travertíny outcrop	55.0	0.79	I	39.2	0.56	II	66.7	0.95	I	53.63	0.77	I

the Pucovské zlepenice outcrop, the Gánovské travertíny outcrop, the Ružbašské travertíny outcrop, the Strednica viewpoint, the Červená skala outcrop, the Spišský hradný vrch outcrop, the Oravské hradné bralo outcrop, and the Dreveník outcrop. They were placed in the first group of geosites with exceptional cognitive and educational value (Table 3). The Jasenová outcrop was rated the worst. It is an object in the last group (group IV) of geosites with low cognitive and educational value (Table 3).

The experts were more unanimous in their assessment of the representativeness of geological, hydrogeological, hydrological, and relief-forming processes and their educational value, as well as in assessing the degree of landscape diversity and degree of degradation (destruction) of the site. On the contrary, a lower level of agreement in the evaluation was reached in terms of the uniqueness of each site compared to other similar sites in Slovakia and the uniqueness of each site in relation to the Sub-Tatra region, as well as from the point of view of the scientific value of

each site expressed in scientific publications and other features related to abiotic nature near each site.

In terms of the geosite type, in the overall assessment, the experts differed the most in the assessment of caves, and there were also relatively large differences in the assessment of landslides and waterfalls. On the contrary, the expert assessments differed the least for rock outcrops and peatlands.

In terms of the assessment of the uniqueness of each site in relation to the Sub-Tatra region, the experts differed the most in the assessment of peatlands and the least in the assessment of sites associated with the history of mining and metallurgy, springs, and waterfalls. Conversely, when assessing the degree of degradation, the assessments of the sites associated with the history of mining and metallurgy diverged the most (the assessments of the travertines and viewpoints diverged the least). In the assessment of the representativeness of geological, hydrogeological, hydrological, and relief-forming

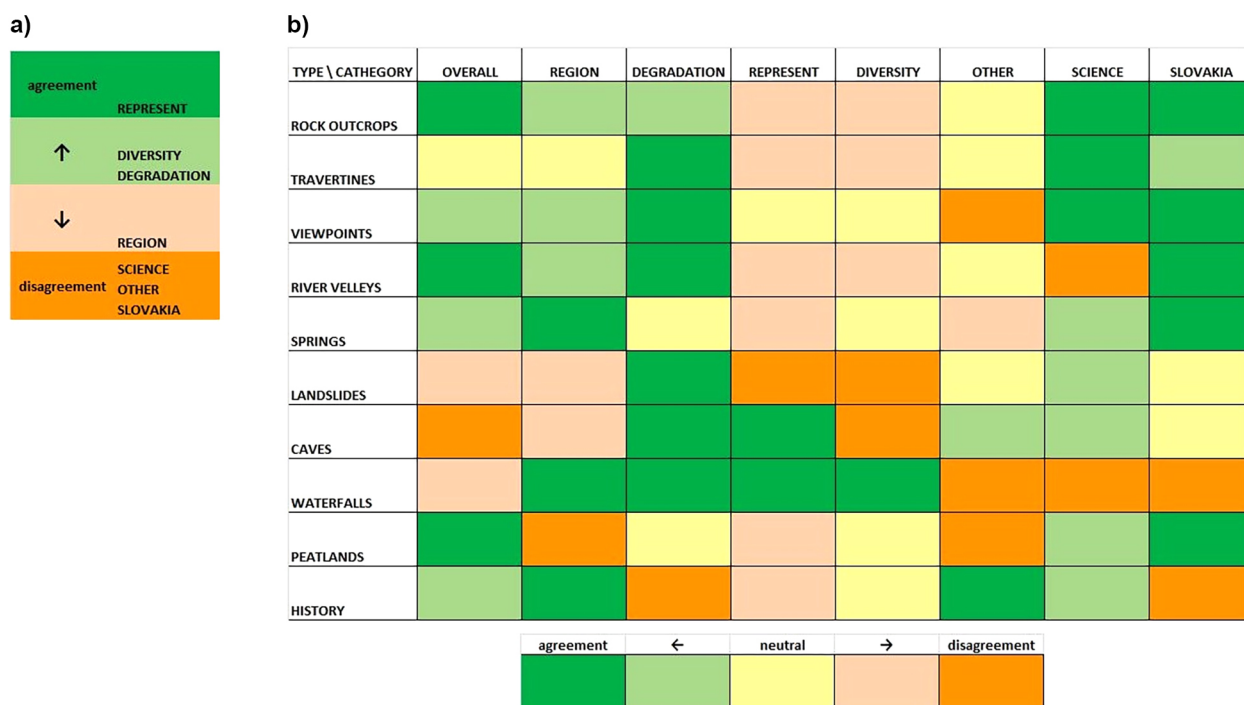


Fig. 6. Expert assessment agreement level. A – Agreement level within each evaluation category. B – Agreement level for the different types of geosites. REGION – The uniqueness of the site in relation to the Sub-Tatra region, DEGRADATION – The degree of degradation (destruction) of the site, REPRESENT – The representativeness of geological, hydrogeological, hydrological and relief-forming processes and their educational value, DIVERSITY – The degree of landscape diversity, OTHER – Other features related to abiotic nature in the immediate vicinity of the site, SCIENCE – The scientific value of the site expressed in scientific publications, SLOVAKIA – The uniqueness of the site compared to other similar sites in Slovakia.

Table 4. Assessment of geosites in terms of tourist criteria.

No.	Name of the geosite	Scenic values	Width of the viewing angle from the point of view	Accessibility of the site	Current form of accessibility as a tourist attraction	Legal protection status of geosite	Equipment and additional services (gastronomy, souvenir shops)	Presence of other tourist attractions	Sum	Warszynska indicator	Group
10	Oravské hradné bralo outcrop	8	10.0	8	10.0	6.7	7.5	10.0	60.2	0.86	I
40	Strednica viewpoint	10	2.5	10	10.0	6.7	5.0	10.0	54.2	0.77	I
25	Termálny prameň Kaďa spring	8	2.5	10	10.0	3.3	7.5	10.0	51.3	0.73	I
37	Spišský hradný vrch outcrop	8	10.0	8	10.0	0.0	5.0	10.0	51.0	0.73	I
28	Liptovský Hrádok outcrop	6	5.0	10	10.0	6.7	5.0	7.5	50.2	0.72	I
19	Lúčanský vodopád waterfall	10	2.5	10	10.0	3.3	7.5	5.0	48.3	0.69	II
21	Viewpoint of the Liptovská Mara Dam	6	7.5	8	10.0	6.7	2.5	7.5	48.2	0.69	II
44	Ružbašské travertíny outcrop	10	2.5	8	10.0	0.0	7.5	7.5	45.5	0.65	II
7	Červená skala outcrop	8	5.0	6	6.7	6.7	7.5	5.0	44.9	0.64	II
36	Sivá brada outcrop	10	7.5	8	10.0	0.0	2.5	5.0	43.0	0.61	II
16	Prosiecka dolina Valley	6	10.0	6	10.0	3.3	2.5	5.0	42.8	0.61	II
8	Františkova huta ironworks	8	2.5	8	10.0	6.7	2.5	5.0	42.7	0.61	II
4	Oravská priehrada Dam viewpoint	6	2.5	2	10.0	6.7	5.0	10.0	42.2	0.60	II
38	Dreveník outcrop	6	10.0	8	10.0	0.0	2.5	5.0	41.5	0.59	II
26	Velínok outcrop	10	2.5	8	3.3	6.7	5.0	5.0	40.5	0.58	II
17	Viewpoint from the Veľký Choč Mt.	10	10.0	2	10.0	3.3	2.5	2.5	40.3	0.58	II
6	Oravice outcrop	8	2.5	8	0.0	6.7	7.5	7.5	40.2	0.57	II
33	Gánovské travertíny outcrop	10	5.0	10	10.0	0.0	2.5	2.5	40.0	0.57	II
15	Kvačianska dolina Valley	10	2.5	4	10.0	3.3	5.0	5.0	39.8	0.57	II
2	Viewpoint over the Oravská kotlina Basin and Tatra Moutnains	8	2.5	4	10.0	6.7	5.0	2.5	38.7	0.55	II
9	Biela skala outcrop	8	5.0	8	0.0	6.7	5.0	5.0	37.7	0.54	II
18	Lúčanské travertíny outcrop	8	2.5	8	0.0	6.7	7.5	5.0	37.7	0.54	II
13	Jasenová outcrop	8	2.5	10	0.0	6.7	7.5	2.5	37.2	0.53	II
42	Jezersko Lake	6	5.0	2	10.0	6.7	2.5	5.0	37.2	0.53	II
5	Halečková outcrop	6	2.5	8	0.0	6.7	5.0	7.5	35.7	0.51	II
14	Hutianske súvrstvie outcrop	8	2.5	8	0.0	6.7	5.0	5.0	35.2	0.50	II
39	Kežmarské vrstvy outcrop	8	2.5	8	0.0	6.7	5.0	5.0	35.2	0.50	II
41	Bachledova dolina outcrop	8	2.5	8	0.0	6.7	2.5	7.5	35.2	0.50	II
43	Smrtná jama outcrop	4	2.5	8	0.0	3.3	7.5	7.5	32.8	0.47	II
24	Sliačske travertíny outcrop	8	2.5	8	3.3	0.0	5.0	5.0	31.8	0.45	II
20	Bešeňovské travertíny outcrop	6	2.5	6	6.7	0.0	5.0	5.0	31.2	0.45	II
27	Belá and Váh riverbed	6	2.5	6	0.0	6.7	7.5	2.5	31.2	0.45	II
29	Vavrišovo landslide	6	2.5	8	0.0	6.7	5.0	2.5	30.7	0.44	II
31	Kvetnica outcrop	8	2.5	8	0.0	6.7	2.5	2.5	30.2	0.43	II
11	Pucovské zlepenice outcrop	8	2.5	8	0.0	3.3	5.0	2.5	29.3	0.42	II
12	Ostrá skala a Tupá skala outcrop	6	5.0	4	0.0	6.7	5.0	2.5	29.2	0.42	II
3	Čimhovské vrstvy layers	6	2.5	6	0.0	6.7	5.0	2.5	28.7	0.41	II
34	Gánovské slanská springs	10	2.5	4	0.0	6.7	2.5	2.5	28.2	0.40	II
23	Skalná (Jánošíkova) päsť outcrop	8	2.5	8	0.0	0.0	5.0	2.5	26.0	0.37	III
35	Ondrej mineral spring	8	2.5	8	0.0	0.0	5.0	2.5	26.0	0.37	III
32	Kozie chrby viewpoint	6	5.0	2	0.0	6.7	2.5	2.5	24.7	0.35	III
22	Liskovská jaskyňa Cave	6	2.5	8	0.0	0.0	5.0	2.5	24.0	0.34	III
1	Rašelinisko Przybojec/Rudné Peatbog	6	2.5	2	0.0	3.3	2.5	2.5	18.8	0.27	III
30	Hybická tiesňava gorge	4	2.5	2	0.0	0.0	2.5	0.0	11.0	0.16	IV

Table 5. Final assessment of geosites.

No.	Name of the geosite	Average	Warszynska indicator	Group	Sum	Warszynska indicator	Group	Total Assessment	Warszynska indicator	Group
10	Oravské hradné bralo	59.43	0.85	I	60.20	0.86	I	59.66	0.85	I
38	Dreveník	61.93	0.88	I	41.50	0.59	II	55.80	0.80	I
40	Strednica	54.43	0.78	I	54.20	0.77	I	54.36	0.78	I
37	Spišský hradný vrch	54.97	0.79	I	51.00	0.73	I	53.78	0.77	I
7	Červená skala	54.47	0.78	I	44.90	0.64	II	51.60	0.74	I
44	Ružbašské travertíny	53.63	0.77	I	45.50	0.65	II	51.19	0.73	I
33	Gánovské travertíny	52.23	0.75	I	40.00	0.57	II	48.56	0.69	II
36	Sivá brada	46.13	0.66	II	43.00	0.61	II	45.19	0.65	II
11	Pucovské zlepence	51.13	0.73	I	29.30	0.42	II	44.58	0.64	II
4	Oravská priehrada	45.00	0.64	II	42.20	0.60	II	44.16	0.63	II
19	Lúčanský vodopád	40.33	0.58	II	48.30	0.69	II	42.72	0.61	II
42	Jezersko	44.20	0.63	II	37.20	0.53	II	42.10	0.60	II
43	Smrtná jama	45.60	0.65	II	32.80	0.47	II	41.76	0.60	II
34	Gánovské slaniská	46.10	0.66	II	28.20	0.40	II	40.73	0.58	II
26	Velínok	37.80	0.54	II	40.50	0.58	II	38.61	0.55	II
20	Bešeňovské travertíny	40.87	0.58	II	31.20	0.45	II	37.97	0.54	II
12	Ostrá skala a Tupá skala	41.67	0.60	II	29.20	0.42	II	37.93	0.54	II
9	Biela skala	37.80	0.54	II	37.70	0.54	II	37.77	0.54	II
17	Veľký Choč	36.37	0.52	II	40.30	0.58	II	37.55	0.54	II
1	Rašelinisko Przybojec/Rudné	45.07	0.64	II	18.80	0.27	III	37.19	0.53	II
16	Prosiecka dolina	34.73	0.50	II	42.80	0.61	II	37.15	0.53	II
15	Kvačianska dolina	35.83	0.51	II	39.80	0.57	II	37.02	0.53	II
31	Kvetnica	39.70	0.57	II	30.20	0.43	II	36.85	0.53	II
27	Ústie Belej do Váhu	39.17	0.56	II	31.20	0.45	II	36.78	0.53	II
39	Kežmarské vrstvy	35.80	0.51	II	35.20	0.50	II	35.62	0.51	II
18	Lúčanské travertíny	33.63	0.48	II	37.70	0.54	II	34.85	0.50	II
41	Bachledova dolina	33.87	0.48	II	35.20	0.50	II	34.27	0.49	II
28	Liptovský Hrádok	26.93	0.38	III	50.20	0.72	I	33.91	0.48	II
2	Výhľad na Oravskú kotlinu a Tatry	31.13	0.44	II	38.70	0.55	II	33.40	0.48	II
29	Vavrišovo	34.47	0.49	II	30.70	0.44	II	33.34	0.48	II
8	Františkova huta	29.17	0.42	II	42.70	0.61	II	33.23	0.47	II
21	Liptovská Mara	26.37	0.38	III	48.20	0.69	II	32.92	0.47	II
25	Termálny prameň Kaďa	24.20	0.35	III	51.30	0.73	I	32.33	0.46	II
22	Liskovská jaskyňa	35.03	0.50	II	24.00	0.34	III	31.72	0.45	II
3	Čimhovské vrstvy	32.50	0.46	II	28.70	0.41	II	31.36	0.45	II
35	Minerálny prameň Ondrej	33.60	0.48	II	26.00	0.37	III	31.32	0.45	II
24	Sliačske travertíny	28.87	0.41	II	31.80	0.45	II	29.75	0.42	II
14	Hutianske súvrstvie	25.80	0.37	III	35.20	0.50	II	28.62	0.41	II
32	Výhľad na Kozie chrbty	28.87	0.41	II	24.70	0.35	III	27.62	0.39	III
5	Halečková	20.87	0.30	III	35.70	0.51	II	25.32	0.36	III
6	Oravice	18.60	0.27	III	40.20	0.57	II	25.08	0.36	III
30	Hybická tiesňava	29.20	0.42	II	11.00	0.16	IV	23.74	0.34	III
23	Skalná (Jánošíkova) päsť	19.73	0.28	III	26.00	0.37	III	21.61	0.31	III
13	Jasenová	10.53	0.15	IV	37.20	0.53	II	18.53	0.26	III

processes and their educational value, the differences were largest for landslides and smallest for caves and waterfalls. When assessing the degree of landscape diversity, in turn, the differences were greatest in the case of caves (along with landslides), and the lowest differences again occurred in the assessment of sites with a waterfall. For other features related to abiotic nature in the immediate vicinity of each site, the assessments of peat lands and waterfalls differed the most, with the smallest differences in the assessment of sites associated with the history of mining and metallurgy. There was also a large dispersion in the assessment of the waterfalls in terms of the scientific value of each site expressed in scientific publications (the smallest differences were found in the assessment of the rock outcrops). Finally, in terms of evaluating the uniqueness of each site compared to other similar sites in Slovakia, the opinions of experts differed most for sites associated with the history of mining and metallurgy and least for springs, peatlands and rock outcrops (Fig. 6).

The assessment of geosites according to the tourist criteria

Geosites were assessed for tourism value based on previously conducted analyses of distance and accessibility (Chrobak, Bák 2019). The best assessed geosites in terms of the tourism criteria are the Oravské hradné bralo outcrop, the Strednica viewpoint, the Termálny prameň Kaďa spring, the Spišský hradný vrch outcrop and the Liptovský Hrádok outcrop. They were classified into the first group of sites with special tourist value. The worst assessed geosite in terms of the tourism criteria is the Hybická tiesňava gorge. It is the only geosite in group IV, consisting of geosites with low tourist value (Table 4).

Results of the final assessment

The best assessed geosites in terms of general valorisation are the Oravské hradné bralo outcrop, Dreveník outcrop, Strednica viewpoint, Spišský hradný vrch outcrop, Červená skala outcrop and Ružbašské travertíny outcrop. The lowest rated geosite is the Jasenová outcrop (Table 5).

Discussion

Assessment of the cognitive and educational value of geosites

Geosites with high cognitive and educational value are associated with rocks that rarely occur on the Earth's surface, such as travertines, and with the possibility of observing how these rocks are formed, as well as with the presence of artefacts in these rocks documenting the history of settlement in this region. This mainly concerns travertines located in Spiš and Liptov.

The dome in the ruins of the Spiš castle contains underground karst forms, and the Dreveník travertine dome is one of the largest in Europe (2 km × 1 km). Travertine craters of varying degrees of activity in Vyšné Ružbachy represent a place of gas exhalation. Carbonate floods formed in the vicinity of active springs in Lúčky, Vyšné Ružbachy and Bešeňová are examples of contemporary processes of calcareous tufa formation, while the dome in Gánovce is one of the most famous archaeological sites in Slovakia. From an educational point of view, the occurrence of travertines in these places can be additionally linked to the presence of mineral springs, and the mineralisation and outflows to the surface of these springs occurred in zones of deep fractures of the geological bedrock (e.g. Vlček 1969, Gross et al. 1999a, b, Mello et al. 2000a, b, Potočná 2007, Gradziński et al. 2008, 2014, Wróblewski et al. 2010, Sabol et al. 2017). The high cognitive and educational value of geosites located in the Pieniny Klippen Belt, which have the character of limestone outcrop rocks (Oravské hradné bralo outcrop – rock with a medieval castle, or Červená skala outcrop – Jurassic rock containing numerous fossils), results from the fact that they are very good places for interpretation: they include features of marine environments, which were recorded in various types of carbonate-siliceous rocks (shell rocks, micritic limestones, nodular limestones, siliceous limestones, radiolarites) and structural features related to the complicated history of the formation of this area. At the opposite end of the valuation coefficients of objects according to cognitive and educational criteria (fourth category of sites) is the exposure of carbonate rocks of a submarine landslide in the village of Jasenová. The low value results from the

high degree of destruction of the exposure and, consequently, the incompleteness of the record of rock features that can be observed and used to interpret the environment in which they formed.

Assessment of the degree of tourist development of geosites

Analyses of the distances of geosites from accommodation facilities, road and rail infrastructure and other additional tourist attractions confirm their very good transport accessibility. Most of the facilities are located close to roads and trails, next to which are parking spaces.

The best tourist development of the valorised facilities, expressed by the highest tourist value coefficients, is presented by the limestone rock of the Orava castle, the viewpoint in Ždiar-Strednica, the thermal spring in Liptovský Ján, the travertine dome of the Spiš castle and the Liptovský Hrádok outcrop. They were classified in category I, consisting of facilities distinguished by very good transport accessibility, close proximity to other (additional) tourist facilities or themselves being part of other tourist facilities. In addition, they are widely promoted as tourist facilities, and there is a large amount of accommodation in their vicinity.

On the other side, the least developed geosite, with the lowest tourist value, is the Hybická tiesňava gorge. It is in category IV, which contains geosites that are not listed in any databases (guidebooks) of tourist facilities, and accommodation and other possible tourist attractions are located a large distance away.

The proximity of larger towns for most geosites also guarantees the possibility of using other tourist services, that is accommodation, catering, guide services or additional tourist and recreational attractions, including visiting the monuments of this region, such as cultural monuments, museums or natural monuments (Chrobak, Bák 2019). An additional tourist advantage of the Sub-Tatra region is its elements of folk culture, such as dialectal phraseology, which was shaped in the conditions of the interpenetration of dialects, languages and cultures.

The ownership structure of the plots on which the geosites are located and the state of their legal protection are conducive to the expansion of tourist infrastructure, as most of them are located

in areas with a lower level of protection (active or landscape protection) or no protection.

Assessment of the value of geosites based on the final valuation coefficient

The characteristics of the physical and geographical elements and tourist assets presented for the 44 assessed geosites indicate that the Sub-Tatra region is characterised by, on the one hand, strong geodiversity, and on the other hand, good tourist development, which is reflected in the high values of the final valuation coefficients, based on which six described sites fall into the highest attractiveness category. At the same time, there are no sites in the lowest category. However, it should be emphasised here that the authors assumed that in the assessment of the final attractiveness of this type of geosite, the weight of the cognitive and educational criteria should be much higher than the weight of the tourist development criteria (WT) (Chrobak, Bák 2019). For this reason, the values of the educational and cognitive coefficient strongly correlate with the values of the final coefficient ($r = 0.94$). The highest final valuation coefficients for objects in the Sub-Tatra region showing particularly high geotourist value were obtained by the following geosites: limestone rock of the Oravský hrad castle, the travertine dome Dreveník, the travertine hill of the Spišský hrad castle, limestone rock with Jurassic fossils near the village of Podbiel and contemporary forms of sculpture associated with travertines in Vyšné Ružbachy. There were 32 geosites in category II (high geotourist value). These objects are characterised by high assessments of the main components, or they have one very high and one very low assessment. Six geosites represent objects in category III, that is sites with medium geotourist value. The valuation coefficients for individual components in these groups were medium and low, respectively, or very diverse, with low dominance. Taking into account the unequal weights of the final valuation coefficient components, their values should be considered primarily in the context of the distribution of the educational and cognitive valuation coefficients; this results primarily from the diverse geological structure of the studied area. The largest number of geosites is located at the junction of two or three physical and geographical units, in

most cases corresponding to the boundaries of geological units, that is the Podhale Basin with the Pieniny Klippen Belt, the Oravská vrchovina Foothills and the Liptovská kotlina Basin with the Chočské vrchy Mountains, the Malá Fatra Mountains and Veľká Fatra Mountains, and the Tatra Mountains. This results primarily from the contact of different rock series, characterised by varying degrees of resistance to weathering, and also from the proximity of fault zones and related outflows of waters supersaturated with CaCO_3 . Taking into account the values of the final valuation coefficient, attractive objects in the Sub-Tatra region also include fragments of valleys in the Chočské vrchy Mountains massif (Prosiecka dolina and Kvačianska dolina), waterfalls in Spiš, Liptov and Orava, and caves. They are distinguished on the one hand by morphological diversity, as exemplified by deep ravines with numerous forms of surface and underground karst in the Prosiecka dolina and Kvačianska dolina valleys or fragments of riverbeds with waterfalls of various shapes and origins, as well as by the uniqueness of their occurrence on a supra-regional scale, such as a small cylindrical cave in Lúčky. On the other hand, the distinction of some forms is influenced by the cultural values of the region associated with them, as is the case, for example, in the Liskovská jaskyňa Cave. They are associated with artefacts related to the history of settlement in the Liptov and Spiš regions (e.g. Kollár 1999a, Lacika 1999a). Although the values of the final valuation coefficients for hydrological objects are at an average level (within a wide range of values), many of them have special cognitive and educational significance, because they allow the observation of contemporary natural processes leading to the creation of new forms of relief or changes in the shape of existing relief elements. This applies to fragments of riverbeds and springs, which until now have rarely been the main goal in geotourism, but they could be. Places where it is possible to observe hydrological phenomena include strongly mineralised springs, around which calcium carbonate is precipitated on various surfaces, including herbaceous vegetation. They also include artesian outflows of water under pressure, resulting in a fountain effect. Observation spread over a slightly longer period of time, for example two visits over the course of 1 year, allows the understanding of the scale

of changes occurring in mountain stream beds, related to changes in the speed of gravel and sand transport during floods and during periods of hydrological drought. For this group of objects, an additional element of attraction may be the difficult-to-measure aesthetic values of such places, the importance of which may be highly variable, depending on the individual sensitivity of the assessor.

Conclusions

The analysis of the natural characteristics and scientific data of the Sub-Tatra region and verification in the field in terms of assessing the value of abiotic nature showed that this is an area with very high geotourism potential. Based on this and using the valuation method for selected geosites, based on a number of cognitive, educational and tourist criteria, 44 geosites were inventoried. Among them, objects related to various elements of the geological structure, various forms of relief and various hydrological elements predominate, but the places whose locations are related to the occurrence of travertines in the geological substrate stand out. They are located in the area of the Liptovská kotlina Basin, the Kozie chrbty Mountains and the tectonic structure of Ružbachy. The north-western part of the Oravská vrchovina Mountains, where the formations of the Pieniny Klippen Belt and the Chočské vrchy Mountains occur, has equally high geotourism potential. These places themselves can be the main destinations for tourism. These areas have a large lithological diversity of the substrate, a large number of microscale and mesoscale tectonic structures, and diverse, mainly karst, relief. They also include viewpoints, which, through the possibility of observing many types of landscapes, acquire a high educational value, especially in terms of regional aspects related to the observation of the relief of the Tatra Mountains, the Nízke Tatry Mountains and the Tatra Foothills (Skorušinské vrchy Mountains, Spišská Magura Mountains, and Pogórza Przedtatrzzańskie Mountains).

The locations of the geosites, most of which are grouped within short distances of each other, in regions with a high degree of geodiversity, make it possible to connect them using roads or tourist trails, which is an additional factor that

led to the high geotourism values in the assessment of this region.

The Sub-Tatra region has long traditions related to tourism; this is documented by the results of analyses of various tourist indicators based on data on the number of tourists and accommodation facilities in this region. They indicate that the best-developed administrative units are those that include the Tatra Mountains or the Nízke Tatry Mountains.

The analysis of the geotourism potential of the Sub-Tatra region presented in this work conveys a message to individuals and local government units about the possible additional tourist promotion of various parts of Spiš, Orava and Liptov. The method of promoting the geosites selected in this work could take various forms that are currently used in marketing for this type of tourist product, such as information panels in appropriate places, descriptions of geosites in various types of mobile applications, tourist guides or geological and tourist maps for the Sub-Tatra region. Enriching the tourist offerings of the Sub-Tatra region with geoattractions could, even if only to a small extent, contribute to 'moving' some of the tourist traffic out of the crowded Tatra Mountains. This will be influenced primarily by guides, teachers, and organisers of tourist trips.

However, the results of expert assessment represent only part of the assessment of the geotourism potential of this region. These studies will probably be complemented by studies of tourist preferences, which have already been partially done and indicated specific types of geosites as the most attractive ones, that is viewpoints, river gorges and travertine outcrops (Chrobak-Žuffová 2023). The authors of this article plan to conduct further studies and public consultations to be able to select the most attractive geosites possible.

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Author's contribution

ACH-Ž, JN: conceptualisation, resources, formal analysis, validation, roles/Writing – original draft, writing – review & editing, ACh-Ž, JN, DM: data curation, ACh-Ž: methodology, project administration, supervision, visualisation.

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