GEOGRAPHY AND TOURISM, Vol. 7, No. 2 (2019), 103-113, Semi-Annual Journal
eISSN 2449-9706, ISSN 2353-4524, DOI: 10.36122/GAT20190717

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An Attempt to Assess the Potential of Geotourism Development in Selected Communes of Lower Silesian Voivodship (Poland)

Abstract: The article discusses the potential and perspectives of geotourist functions development in three selected communes of the Lower Silesian Voivodship (Świerzawa, Ząbkowice Śląskie, Stronie Śląskie). These regions already possess a number of geotourist objects which attract tourist traffic, and whose presence creates further prospects for the development of tourism in this direction. Based on the conducted indoor studies and field reconnaissance, the author proposed and analysed prospective geostations, which may create a coherent network of objects, and thus, increase the development potential of this particular form of tourism. The presented assessment was predicated on a point-based evaluation method utilizing predetermined criteria for geostation valorisation. At the same time, the article draws attention to the difficulties pertaining to straightforward synthetic interpretation of the value assessment of individual structures. It is also shown that the existing nationwide database of geosites proves to be lacking in terms of both the potential assessment as well as the needs for planning of geotourism development at a local level.

Keywords: geotourism, geotourism potential, geosites, geodiversity

1. Introduction

Geotourism is defined as a form of tourism that focuses specifically on landscape and geology. It is associated with exploring natural heritage, such as geological structures (including rocks, minerals, fossils) or specific landforms (Newsome and Dowling, 2010; Migoń, 2012).

The development of geotourism relies largely on the presence of accessible objects, such as interesting morphological and rock formations, artificial or natural geological outcrops, r, minerals or fossils of either fauna or flora (Kondej, 2011; Migoń, 2012).

Furthermore, the basic geotourist objects include geosites, that is places of special importance for gaining better understanding of Earth's history, which are of scientific, cognitive, aesthetic, cultural and historical significance (Migoń, 2012). The occurrence of intriguing and accessible objects of this kind should be considered a leading factor determining the potential for the growth of this form of tourism.

When it comes to recognition of geotourist potential in the entire country, the Polish Central Register of Geosites (PCRG), established by the Polish Geological Institute – National Research Institute, should be considered the most complete as of today. Covering a total of 3593 geosites, it is the largest database encompassing this type of objects in Poland, which can be taken as a general basis for planning activities in the field of geotourism development. Then again, said database does not include a sufficient number of elements that would be attractive enough to be of importance at a local level, let alone to become a major tourist attraction. For this reason, there is a need to undertake further inventory work aimed at detailed identification of both the occurrence and the character of such objects (Cwojdziński et. al., 2011; Migoń, 2012), as well as their comprehensive valorisation.

This applies to the area of Lower Silesia voivodship in particular, as it is distinguished by a great diversity of geological structure concentrated on a small area of rock occurrence, originating from various sources and geological periods (Aleksandrowiski and Mazur, 2002; Mazur et al., 2010).

2. Area descriptions, methods, and studied material

The study area is located in the southern part of the Lower Silesian Voivodship, in a belt comprising units of physiographic division that belong to both the Sudetes sub-region and Przedgórze Sudeckie (Sudeten Foreland) (Solon et. al., 2018).

According to the data in the current PCRG database, there are 330 geosites that can be found in this voivodship (9.2% of the total number of geosites in Poland), which makes it rank 6th in the whole country. As a matter of fact, Lower Silesian voivodeship stands out clearly in relation to its neighbouring regions (Lubuskie, Wielkopolskie, Opolskie), where the number of objects registered in the database does not exceed 100. The largest number of geosites in the voivodeship's area was recorded in Sudetes, to a smaller extent in the Sudeten Foreland and further north – in the lowland belt (Fig. 1). It should be mentioned that there are no recorded forms of this type in as many as 66 communes located mainly in the central and northern part of the voivodeship.

This paper analyses the geotourist potential of 3 selected communes of Lower Silesian voivodeship, which represent diverse physiographic macro-regions (Solon et. al., 2018). The communes in question are (Fig. 1):

– Świerzawa (Western Sudeten Foothills),
– Ząbkowice Śląskie (Sudeten Foreland),
– Stronie Śląskie (Eastern Sudetes).

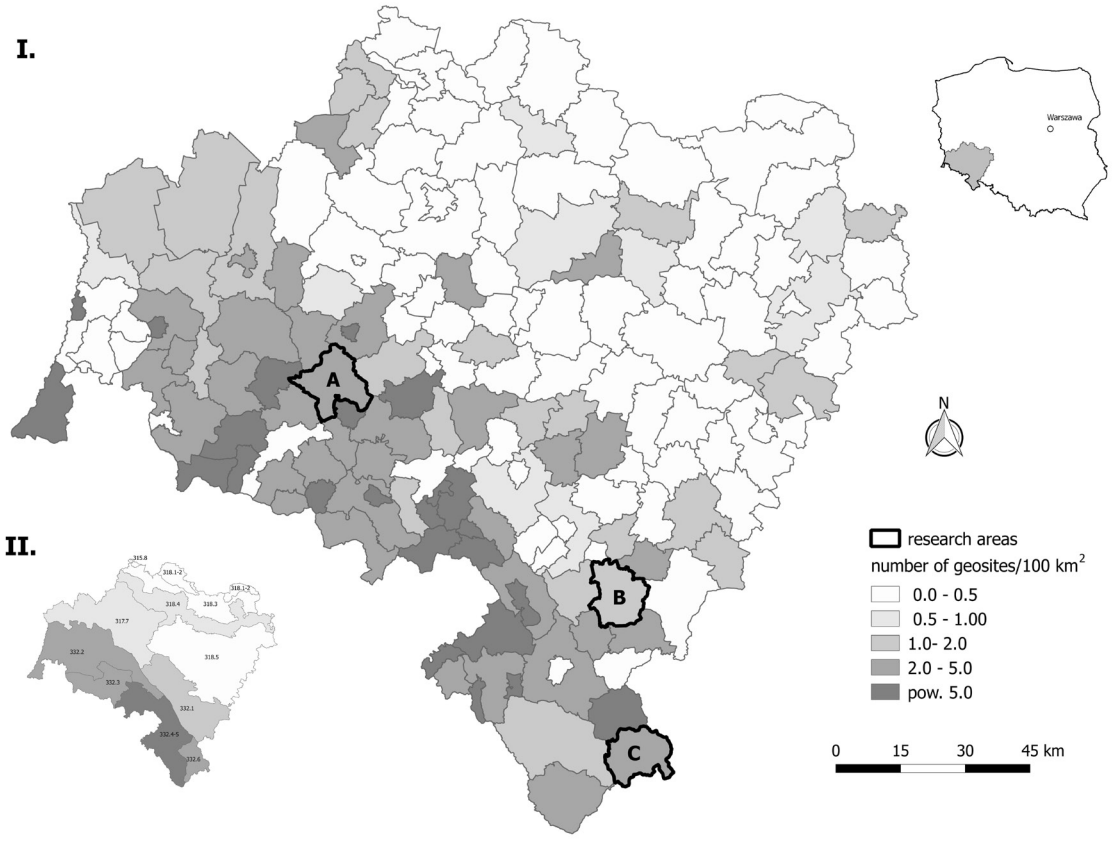

Figure 1. Research areas (A - Świerzawa commune, B - Ząbkowice Śląskie, C - Stronie Śląskie) against the background of differences in the number of geosites per 100 km² of area in the communes of Lower Silesian voivodship and within the boundaries of physiographic macro-regions (Authors' own study based on the Polish Central Register of Geosites - Centralny Rejestr Geostanowisk Polski)

As far as criteria for the unit selection are concerned, the area should feature already existing and developed geotourist facilities. In the Świerzawa commune, the Sudetic Educational Centre "Zagroda Sudecka" in Dobków constitutes one of such objects. In the commune of Ząbkowice Śląskie, on the other hand, there are the remnants of the Robert Adit nickel mine, a geotourist object open to the public. As for Stronie Śląskie, such functions are performed by two objects located in the village of Kletno: Bear Cave and the underground tourist route in a uranium mine drift (Fijałkowska-Lichwa, 2011).

Moreover, each selected area features interesting mineralogical sites (Lis and Sylwestrzak 1986; Janeczek et al., 1991; Bogdański, 2001; Łobos, 2007, 2010), which affects the potential and true development of the geotourist product.

With this in mind, detailed recognition of geotourist values was focused on the areas with functioning geotourist objects, interesting geological sites, and expositions of either cognitive or collector's value.

As a consequence, the following regions were covered by detailed research:
- the northern and central part of the Świerzawa commune – the Kaczawa valley and its surroundings,
- the northern part of the Ząbkowice Śląskie commune – including the Szklary Massif and its surroundings,
- the south-western part of the Stronie Śląskie commune.

The study utilised both stationary and field research methods. Part of the stationary works involved collecting and analysing the data sourced from the current version of PCRG, as well as other databases listing geosites, along with available literature data from geological guides and publications (Lis and Sylwestrzak, 1986; Janeczek et al., 1991; Bogdański, 2001; Łobos, 2007, 2010).

The following works were carried out within the scope of the field work:
- verification of the location and character of geosites registered in the PCRG database, together with geological sites indicated in literature and other databases;
- field mapping of new potential geotourist objects.

While carrying out this work, 5 basic characteristics of each site were assessed:
- representativeness and attractiveness in terms of geological values,
- state of preservation,
- the possibility of collecting samples and specimens of rocks or minerals,
- attractiveness of the landscape,
- field accessibility.

A point-based evaluation scale ranging from 0 (no value) to 5 (very high) was applied for the assessment of the above-mentioned criteria. As for the underground objects (adits, caves) in regard to landscape category, the attractiveness of forms and the exposition of the underground landscape was evaluated.

The values of individual criteria were determined in accordance with the following indications (for the highest and lowest rating):
- representativeness and attractiveness – the highest rating (5 points): sites described in the literature, featuring interesting and often unique phenomena and processes; lowest rating (0 points): little known or unknown sites with low scientific, study and didactic importance.
- state of preservation – the highest rating (5 points): well-preserved objects without soil and vegetation cover, enabling direct observation of phenomena; lowest rating (0 points): heavily overgrown sites with rock rubble and soil cover.
- the possibility of collecting samples and specimens of rocks or minerals – the highest rating (5 points): samples and specimens of rocks and minerals of high collector's value that can also be easily found and collected; lowest rating (0 points): collection either prohibited or impossible due to dangerous conditions.
- attractiveness of the landscape – the highest rating (5 points): clearly visible exposed formations, unique landscape value; lowest rating (0 points): hardly visible, unexposed objects or formations.
- field accessibility - the highest value (5 points): objects with good access via a paved road, by car, and a parking place nearby; lowest rating (0 points): inaccessible objects / accessibility using climbing or cave techniques.

The obtained point values for individual objects were then summed up. Subsequently, the valorisation indices were calculated by dividing the sum of points (SN) by the maximum possible total value (Nmax = 25). The resulting index values were classified into 4 categories (I–IV) based on the quartile division for the whole range of index variability (0–1). In this way, the assessed objects were classified into 4 categories of significance and relevance for the development of geotourism:

I - of key importance and high level of usefulness (0.76–1.0),
II - of high potential (0.51–0.75),
III - of average value (0.26–0.50),
IV - of low and very low utility (0–0.25).

3. Results and analyses

In general, the geotourist potential of the communes covered by the study can be presented by means of indicators based on data pertaining to the absolute number of geosites (n) and their density (n/100 km^2). In terms of the absolute number of geosites registered in the PCRG database, said communes show values from 2 to 7 (Table 1). In comparison with other administrative units of the voivodship, the values are either on par with the commune or even exceeding them (the average for the study areas amounting to 1.95). Apparently, the number of geosites per 100 km^2 (Fig. 1) constitutes the most reliable indicator for the overall assessment of geotourist potential. In the case of the analysed units, the values of this indicator are slightly above (Świerzawa, Stronie Śląskie) or below the average (Ząbkowice Śląskie), the average for the commune in the voivodship being 2.63. However, the values of both indices for all three areas are considerably lower than the maximum values recorded in the communes of Lower Silesia Voivodeship (17 geosites – the Mieroszów and Wałbrzych communes as well as 47.4 objects/100 km^2 – the Szczawno Zdrój commune – cf. Fig. 1).

Table 1. Diversification of basic indicators regarding geotourist potential of the investigated communes based on the number of geosites registered and indicated in the study (Authors' own study based on the Polish Central Register of Geosites - Centralny Rejestr Geostanowisk Polski)

Commune	Number of geosites according to PCRG		Number of selected geosites	
	[n]	[n/100 km^2]	[n]	[n/100 km^2]
Świerzawa	6	3.8	11	6.9
Ząbkowice Śląskie	2	1.4	9	6.2
Stronie Śląskie	7	4.8	10	6.9

Within the framework of the works carried out in all the analysed communes, further interesting objects meeting the geosite criteria were distinguished. In total, 30 facilities of great importance for the preservation of geodiversity were identified, verified and evaluated. Most of them are sites that may draw one's attention due to the presence of rocks and minerals. It should also be noted that, according to the assumptions of the research, this number was limited only to sites that form a coherent spatial wholeness with the functioning geotourist profile. Having said that, it certainly does not exhaust the full inventory of geosites within the boundaries of the analysed communes. After taking the selected objects into account, very similar indicators of geotourist potential, based on the number of objects and their density, were obtained for the investigated communes (Table 1).

A total of 11 geotourist sites have been identified in the Świerzawa commune. Most of them are connected with traces of volcanic activity from the Permian period (Kryza and Niśkiewicz, 1973; Milewicz, 1985). In their majority, they are grouped in the northern and central parts (Fig. 2), mainly along the valley of the Kaczawa River. This region is known among geologists and mineral collectors, above all, for its agate sites, along with its copper-bearing mineralization and traces of copper ore mining (Kryza and Niśkiewicz, 1973; Lis and Sylwestrzak, 1986; Janeczek et al., 1991; Bogdański, 2001). The occurrence of agates also com-

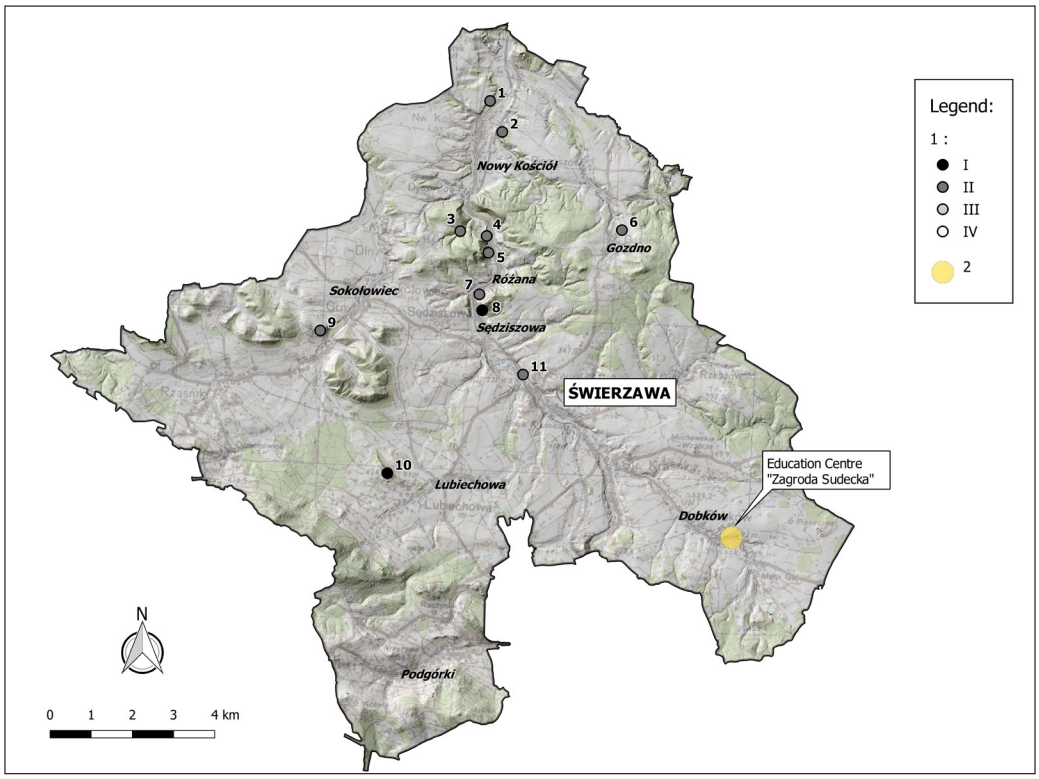

Figure 2. Assessed geotourist objects (geosites) in the Świerzawa commune. Explanations: 1 - geosites with evaluation of object attractiveness: I-IV (categories based on total score), 2 - objects developed for tourism. Numbering of objects according to Table 2 (Authors' own study)

Table 2. Valorisation of selected geotourist objects in the Świerzawa commune (Authors' own study)

No.	Locality	Object	Repr.	State	Coll. Sign.	Land.	Access	Overall assess.	Index	Cat.
1	Nowy Kościół	exposure of Permian mudstones with septaria	4	4	4	2	4	18	0.72	II
2	Gozdno	porphyry outcrops (quartz rhyolites) with quartz druses and agates	2	3	4	2	2***	13	0.52	II
3	Nowy Kościół – Lena	exposure of Permian marls (Zechstein) with copper-bearing mineralization	4	4	3	3	3	17	0.68	II
4	Nowy Kościół *	porphyries and porphyry tuffs with agates and quartz geodes	4	3	5	3	3	18	0.72	II
5	Różana – Wołek kamieniołom	melaphyres and quartz porphyries with agates and quartz geodes	4	2	3	3	3	15	0.6	II
6	Różana	melaphyre outcrops with agate almonds	3	3	5	2	4	17	0.68	II
7	Sokołowiec Górny	exposure of melaphyres with agates	4	3	4	3	3	17	0.68	II
8	Sędziszowa *	Wielisławskie organs (porphyry columns)	5	5	0	5	4	19	0.76	I
9	Lubiechowa *	melaphyre quarry with agates	5	4	4	4	4	21	0.84	I
10	Sędziszowa *	siliceous shale/old gold exploration adits	3	3	2	3	2	13	0.52	II
11	Świerzawa	exposure of the Rotliegend	3	3	2	3	4	15	0.6	II

prises a vital factor in attracting tourists into the region, as is the case with Nowy Kościół, Sokołowiec, and Lubiechowa. Such places facilitate independent acquisition of specimens which are different in terms of concentration, colour and size, depending on the location. In addition, there are land cluster formations of the Permian period, forming a complex of the so-called red beds (Milewicz, 1985). Among them, locally, there are layers containing septarian concretions. Comprehensive assessment of selected geosites in the Świerzawa commune is presented in Table 2.

The evaluation of the above-mentioned objects showed that the most valuable group (category I) features (Table 2):
– the quarry in Lubiechowa,
– the Wielisławskie organs in Sędziszowa.

The sites of agates in Sokołowiec, Różana, and Nowy Kościół are also highly rated (category II). Their overall total score is lower due to low scores in the criteria of landscape attractiveness and terrain accessibility. This, however, does not change the fact that these sites are valued by mineral prospectors and collectors.

In the Ząbkowice Śląskie commune, a total of 9 objects were indicated (Fig. 3). The main geotourist values are related to the serpentine Szklary Massif (northern part of the area). What is more, there is a geosite which is included in the PCRG list prepared by the Polish Geological Institute, namely the Szklary Nickel Mine. The area is so vast that it comprises, in fact, a series of sites exhibiting various phenomena, signs of mineralization, or traces of a mining past.

Geosites in this region were deemed to be of high value taking into consideration the following factors:
– occurrence of a silicate nickel ore deposit - the only site of this kind in Poland, and one of the few in the world (Sachanbiński, 1979; Dubińska et al., 2000);
– chalcedony-opal mineralization with classic occurrence of chrysoprase – one of the most precious ornamental stones in Poland (Sachanbiński, 1979; Niśkiewicz, 1982; Łobos, 2010);
– traces of a nearly 100-year-old mining activity (adits, surface excavations, slag heaps from the nickel smelter).

The most valuable objects (category I) in the overall assessment (Table 3) of the study area in terms of the total score include:
– Robert adit (existing underground tourist route),
– 3 artificial exposures and serpentine rocks occurring in the area of the former opencast nickel mine in Szklary.

It should be noted, however, that a site in Siodłowice, covering the area of former chrysoprase mining in the 19th century, shows a small potential (category III).

As far as the Stronie Śląskie commune is concerned, the existing geotourist objects, as well as those indicated in the conducted research, are grouped in its western part – including the regions of Kletno and Stronie Śląskie (Fig. 4). The existing, developed objects of great tourist and cognitive importance involve the Bear Cave, which is not only referenced in other geotourist databases (Słomka, 2012), but is also under reserve protection. The Old Uranium Mine – an underground tourist route – has also been operating here since 2003. The analysis of available data and field research allowed the author to indicate 6 more geosites in this region. Together with the objects already registered in the CRGP database, which can be found in the area, the analysis involved 10 objects.

The most important features that make this area highly geodiverse include:
– traces of old mining operations, particularly fragments of medieval sidewalks from the 16th century (Ciężkowski et al., 1996);
– occurrence of various karst forms;
– field exposures and post-mining heaps with the occurrence of numerous minerals (Lis and Sylwestrzak, 1986; Janeczek et al., 1991);
– groundwater saturated with radon in „Marianne's Well"
– marble quarry "Biała Marianna" – a valuable building material used in many historical objects of the region (Łobos, 2010).

Table 3. Valorisation of selected geotourist objects in the Ząbkowice Śląskie commune (Authors' own study)

No.	Locality	Object	Repr.	State	Coll. Sign.	Land.	Access	Overall assess.	Index	Cat.
1	Szklary	serpentinite rock with magnesite veins / opal occurrences / pegmatite	5	3	4	4	4	20	0.8	I
2	Szklary *	exposures of opal and chalcedony-chrysoprase veins	5	3	5	3	3	19	0.76	I
3	Szklary	Student adit	4	3	4	3	1	15	0.6	II
4	Szklary	heap of nickel smelter	4	3	1	3	4	15	0.6	II
5	Szklary **	Robert adit	5	5	0	5	5	20	0.8	I
6	Siodłowice	historic place of chrysoprase exploitation (18th century)	2	2	3	1	3	11	0.44	III
7	Szklary	serpentine rock with magnesite veins and nickel silicates	5	4	4	4	3	20	0.8	I
8	Siodłowice	serpentinite quarry with mineralization of nickel ores	2	2	3	2	3	12	0.48	III
9	Brodziszów	siliceous slate with wavellite	3	2	3	4	3	15	0.6	II

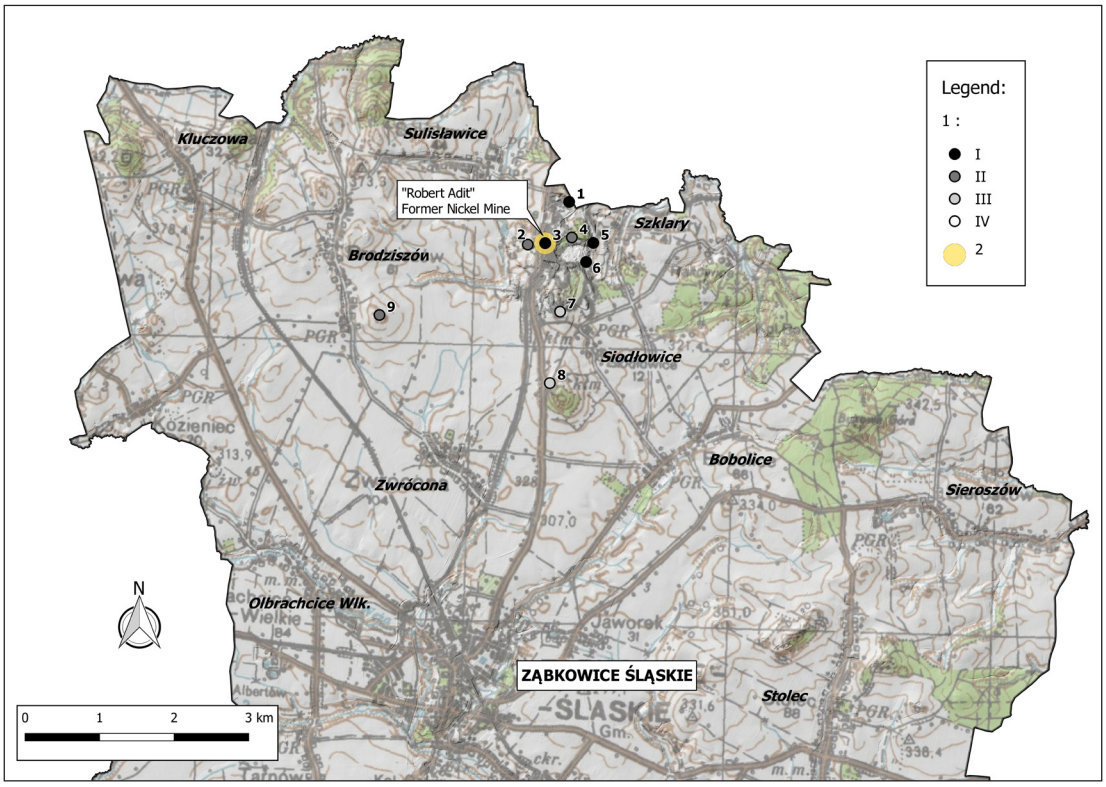

Figure 3. Assessed geotourist objects (geosites) in the Ząbkowice Śląskie commune – a region of the Szklary Massif. Explanations as in Fig. 2. Numbering of objects according to Table 3 (Authors' own study)

As can be concluded from the total synthetic assessment, the most valuable objects (category I) in the commune include (Table 4):

– the Bear Cave and Old Uranium Mine adit (Uranium Mine) - existing, developed underground routes;

Table 4. Valorisation of selected geotourist objects in the commune of Stronie Śląskie (Authors' own study)

No.	Locality	Object	Repr.	State	Coll. Sign.	Land.	Access	Overall assess.	Index	Cat.
1	Stronie Śląskie *	marble quarry "Biała Marianna"	4	4	4	3	1 ***	16	0.64	II
2	Stronie Śląskie *	marble quarry „Krzyżnik"	4	4	3	4	3	18	0.72	II
3	Sienna	residues of mining waste heaps	4	2	4	2	3	15	0.6	II
4	Kletno **	tourist adit no.18 (Uranium Mine)	5	5	0	5	5	20	0.8	I
5	Kletno	adit no. 17	5	4	5	4	2	20	0.8	I
6	Kletno	St. Paul's adit / exposure of quartz-fluorite veins	5	2	5	4	1	17	0.68	II
7	Kletno	residues of mining waste heaps	3	4	5	3	5	20	0.8	I
8	Kletno	marble quarry	3	3	3	4	4	17	0.68	II
9	Kletno	Marianna Spring - a borehole with radon water	3	4	0	1	5	13	0.52	II
10	Kletno *, **	Bear Cave	5	5	0	5	5	20	0.8	I

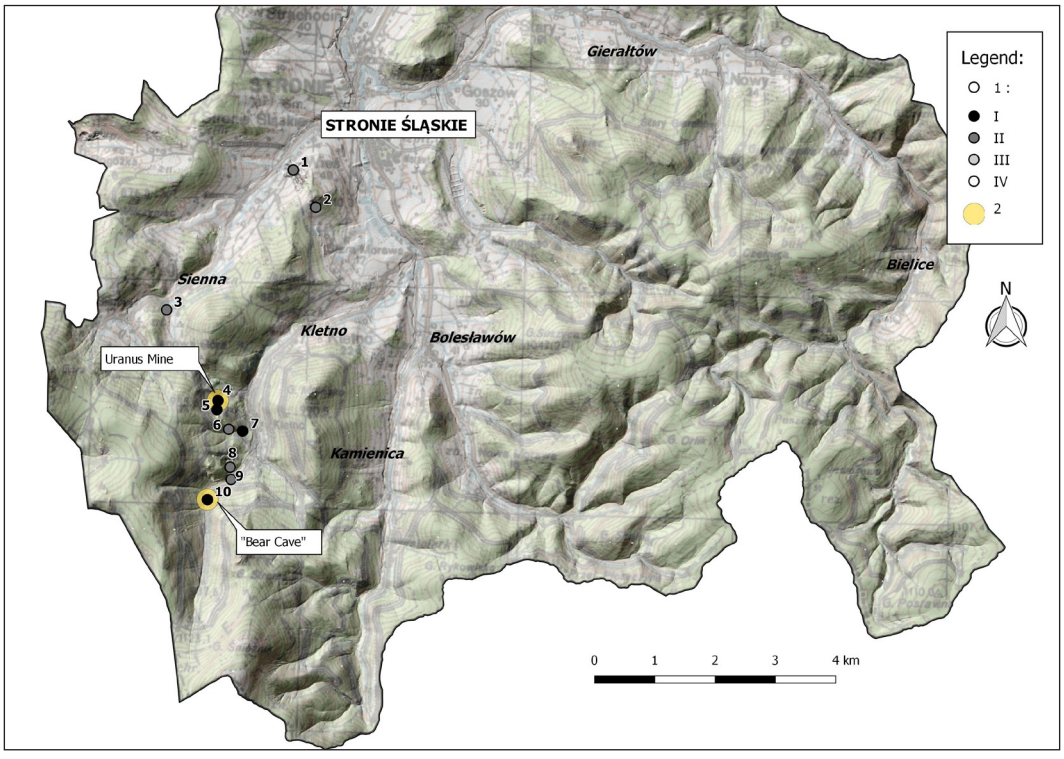

Figure 4. Assessed geotourist objects (geosites) in the commune of Stronie Śląskie –Stronie Śląskie–Kletno region. Explanations as in Fig. 2. Numbering of objects according to Table 4 (Authors' own study)

– remnants of mining heaps in Kletno (near the car park);
– other undeveloped underground excavations – adit no. 17.

Objects of high potential include adit no. 7 (the historic St. Paul's adit) with karst corridors and well-preserved, hand-forged sidewalks from the 16th century. Due to limited accessibility of the object, its overall rating is low.

Generally speaking, the total sum of points obtained from the evaluation of the values of geosites located in the analysed communes is as follows:
– Świerzawa - 183 points,
– Stronie Śląskie - 176 points,
– Ząbkowice Śląskie - 147 points.

These results can be considered as a comprehensive, synthetic assessment of the geotourist potential demonstrated by the surveyed areas. However, owing to the varied terrain of the regions found in the detailed object examination, their full representativeness and comparability – relative to the area of the entire communes – is not fulfilled. In order to ensure full measurability of the results, it is necessary to include the results of the full inventory and valorisation of objects within the boundaries of said administrative units as well.

4. Summary and conclusions

The presented results of the geosites' valorisation reveal diversified and mostly high values of the indicated objects. In most cases, the assessment confirmed the gravity of their role in geotourism development. Moreover, the analyses results also allow for the selection of sites with the highest potential, which is important for the planning of activities related to the long-term growth of these areas and their use in the context of tourism.

It is worth noting that as far as overall assessment is concerned, high – although not the highest – scores are awarded to tourist facilities of outstanding cognitive value, which are also main tourist attractions, i.e. the Bear Cave and Uranium adit in Kletno (the commune of Stronie Śląskie), as well as Robert adit in Szklary (the commune of Ząbkowice Śląskie). This results from the adopted assessment criteria – the aforementioned objects constitute underground tourist facilities and their state may not be altered. Unlike other objects, they do not offer the possibility to obtain rocks and minerals, which had an impact on the overall assessment of their value.

The same applies to the number of representative and attractive geotourist sites, whose total assessment was lowered, for example, due to difficult accessibility. In many cases, this factor can be changed through appropriate management and organisational activities.

The obtained results of the assessment regarding individual geosites can lead to a conclusion that performing a comprehensive, synthetic assessment of the geotourist values on individual objects may pose a challenge. In fact, when evaluating certain sites, constituent criteria should also be taken into consideration. It seems that in practice, when planning development of geotourism, the complementarity of the main values of individual objects constitutes one of the important features. Said elements may be very diverse (natural and artificial formations, surface and underground formations, diversity of relief, rocks and minerals), which renders them difficult to evaluate and classify unequivocally.

The valorisation method applied for the purposes of this article facilitates a synthetic, comprehensive assessment of the geotourist potential of administrative units, as well as any reference fields. Then again, in this situation, it is necessary to undertake methodologically homogeneous inventory works covering the entire area.

All three studied communes may exhibit a high potential for geotourism development. The existing values comprise an important basis for activities aimed at establishing national geoparks in accordance with the main principles of their delimitation (Kondej, 2011; Migoń 2012). As a matter of fact, such efforts have already been undertaken in the case of

areas covering the communes of Świerzawa (planned geopark "Land of Extinguished Volcanoes") and Ząbkowice Śląskie (planned geopark "Przedgórze Sudeckie") (Migoń and Pijet-Migoń, 2010; Tarka, 2012; Rogowski, 2016).

At the same time, the analysis shows that the number of interesting and accessible geological objects is substantially higher than the number of the geosites included in the national PCRG database. Despite the updates, this database does not allow for a sufficient assessment of both the potential and needs for geotourism development planning at the local, inter-communal, or county level.

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