ASSESSMENT OF THE EDUCATIONAL VALUES OF GEOMORPHOSITES BASED ON THE EXPERT METHOD, CASE STUDY: THE BIAŁKA AND SKAWA RIVERS, THE POLISH CARPATHIANS

Anna Chrobak, Karol Witkowski, Jacek Szmańda

Institute of Geography, Pedagogical University of Krakow, Poland

Manuscript received: October 2, 2019
Revised version: December 12, 2019

Chrobak A., Witkowski K., Szmańda J., 2020. Assessment of the educational values of geomorphosites based on the expert method, case study: the Białka and Skawa rivers, the Polish Carpathians. *Quaestiones Geographicae* 39(1), Bogucki Wydawnictwo Naukowe, Poznań, pp. 45–57. 8 figs, 3 tables.

Abstract: Geotourism is a type of qualified tourism promoting geosites related to the geological outcrops and relief elements, such as river channels. Examples of these landforms with high educational values can be seen in the Białka and Skawa riverbeds. However, an important element in the description of such geosites (geomorphosites) is their educational values, which make it possible to clearly determine their suitability and possible use in geotourism. The assessment methods are the only methods of evaluating these values. But they are subjective, and the results of the analyses carried out on them largely depend on the knowledge and experience of the evaluator. In this paper, four geomorphosites have been assessed using the triangulation expert method. All described geomorphosites have received a high educational value, and the highest had the Białka Gorge.

Key words: Białka and Skawa rivers, geomorphosites, Polish Carpathians, expert method, geo-education

Corresponding author: Anna Chrobak, anna.chrobak@up.krakow.pl

Introduction

Geotourism is a form of a qualified and thematic tourism and its goal is to describe abiotic processes and their significance for education (Hose 1995, 2000, 2008, 2011, Joyce 2006, Newsome, Dowling 2006, 2010, Ólafsdóttir 2019). The first definition of geotourism was formulated in the 90s of the 20th century. However, the idea of travelling to places of natural interest dates back to the 15th and 16th centuries, when Europeans began to discover new lands (Kurek, 2008). The best places for developing geotourism are in mountain areas, deserts, coasts, river valleys and canyons, as evidenced by numerous publications describing this type of attraction (e.g. Golonka, Krobicki 2007, Krobicki, Golonka 2008, Hlavňová, Pavolová 2013, Golonka et al. 2014, Jacko et al. 2014, Chrobak 2016, Rogowski 2016, Zgłobicki et al. 2019). The study area covers two catchments in the Polish Carpathians – the Białka and Skawa rivers.

Among publications in the field of geotourism, there are a few works concerned with this study area. Some authors, for example, Krobicki and Golonka (2008), Ptaszek (2005, 2007) and Chrobak (2015, 2016), emphasised the geotouristic qualities of the Podhale flysch. In addition,

doi: 10.2478/quageo-2020-0004
ISSN 0137-477X, eISSN 2081-6383

there are a number of publications on the Pieniny Klippen Belt including Białka Gorge (Birkenmajer 1958, 1962, 1979, 2014, Alexandrowicz et al. 1997, Golonka, Krobicki 2007, Krobicki, Golonka 2008, Golonka et al. 2014, Jacko et al. 2014, Hełdak 2016). These sites are also described in the Central Register of Polish Geosites (PGI-PIB 2019). The geotouristic values of the Skawa valley have not been described so far.

In the contemporary era of the development of geotourism, apart from typical objects promoting the geological heritage – geosites (e.g. Alexandrowicz, Alexandrowicz 2002, Reynard 2004, Dowling 2011), there are also places where the effects of geomorphological processes can be observed and promoted – geomorphosites (Reynard, Panizza 2005, Reynard 2009). There is a wide range of methods for assessing the geosites and geomorphosites (e.g. Kubalíková 2013, Brilha 2016, Reynard et al. 2016, Mucivuna et al. 2019). Several methods have also been described for the assessment of Carpathian geosites (e.g. Alexandrowicz et al. 1992, Rybár 2010, Kubalíková 2019, Overeiu et al. 2019). The assessment methods were created to assess the scientific, educational, touristic and additional values of geosites and to determine which types of them are the most valuable and can be used as tourist attractions. These methods can be classified into one of the following five groups (Mucivuna et al., 2019):

1. based on previous methods,
2. creation of new methods,
3. application of previous methods combined with new methods,
4. comparison of methods and
5. methods without descriptions.

All the assessment methods presented in the scientific literature are based on the point bonitation method, according to the different weights, which are assigned to the defined criteria. However, of the assessment methods described so far, especially referring to various areas of mountain and foothill relief, many are based only on more or less precisely formulated assessment criteria, causing a high degree of subjectivity of the assessment of objects depending on the knowledge and experience of the evaluator. The main purpose of this article is to assess the geomorphosites using the expert assessing method based on triangulation method (Flick 2011), which makes it possible to use less subjectivity in evaluating these sites.

The high geodiversity which characterises the Polish Carpathians (Alexandrowicz, Margielewski 2010, Zwoliński 2009, 2010) gives a high probability that valuable geomorphosites may be found in many Carpathian river valleys. The rivers Białka and Skawa are good examples of places where the educational values of the effects of geomorphological processes are particularly high.

Geographic context

Two river catchments were selected for this study: Białka and Skawa. The Białka river catchment is located in the Inner Carpathians (Fig. 1). Its area is 230 km^2. The source of the Białka river is located in the High Tatras, whereas the estuary is located in a dam reservoir built on the Dunajec river called the Czorsztyn Lake. The length of the river is 41 km. The Skawa river catchment is located in the Outer Carpathians (Fig. 1). Its area is 1160 km^2. The source of the Skawa river is located in the Beskid Żywiecki Range and the estuary is in the Vistula river. The length of the river is 103 km. Both the rivers are mountainous rivers with braided channels.

The braided channel of the Białka river is well known in the scientific literature (Baumgart-Kotarba 1983, Krąż, Balon 2010, Gorczyca et al. 2011, Krąż 2012). Białka drains the High Tatras (Białka, Biała Woda and Jaworowa Valley) and Belianske Tatras (over 60% of the catchment area) as well as the eastern part of the Sub-Tatra Depression and Fore-Tatra Foothills (Fig. 1). The greater part of the catchment is composed of igneous rocks – granitoids and sedimentary rocks – limestones, dolomites, conglomerates and marls (Kotański 1971, Bac-Moszaszwili, Jurewicz 2010). The remaining part of the catchment is composed of alternating layers of sandstones and shales, called the Podhale flysch (Gołąb 1954, Watycha 1959) (Fig. 2). In the lower reaches, the Białka river passes through the limestone rocks belonging to the Pieniny Klippen Belt, creating a river gorge (Birkenmajer 1958, 1979). The Białka river channel and its tributaries in the upper part of the river stream are straight and winding, sometimes bounded by moraines (Baumgart-Kotarba

1983). It is a rock bed or rock-alluvial channel. On the other hand, the middle and lower channel of the river (from the connection from Białka to Jaworowy Stream, up to the estuary) is braided, and the riverbed is alluvial (Baumgart-Kotarba 1983). The contemporary hydrological regime of the Białka river is determined by the hydrology of the upper part of the catchment area in the Tatra Mountains. The catchment can produce two flood states in a year. The first occurs in March and April and is associated with the thaw, and the second occurring in June and July is associated with heavy rains. The Białka hydrological regime is typical for high-mountainous rivers; but when the Białka river flows into the area of the Orawa-Nowy Targ Basin, it quickly loses this character (Dobija 1981).

Due to the positioning of the river in two geologically different parts of the catchment, Skawa has an upper and a lower course. In the upper course, the Skawa drains the ranges of Beskid Żywiecki, Wyspowy, Makowski and Mały (Kondracki 2011, Solon et al. 2018). The lower course begins at the dam in Świnna Poręba. The Lower Skawa passes through the Silesian and Wieliczka Foothills and through the Oświęcim Basin (Kondracki 2011, Solon et al. 2018) (Fig. 1). The dam in Świnna Poręba creates a reservoir Mucharskie Lake with a total capacity of 160 million m^3. This water reservoir protects Krakow against floods; it also has an energetic activity and a recreational function. The Skawa catchment is composed of Carpathian flysch – the napes: Magura, Silesia, Subsilesia and Skole. The Oświęcim Basin is located in the Carpathian Fellowship and it is filled with molasses Neogene deposits (Fig. 2). Before the regulation, at the beginning of the 20th century, in the Skawa riverbed, there were a few sections with braided channels in the lower course and in the Maków Basin and other extensions of the mountain valley. In the lower course, there were also two anabranching

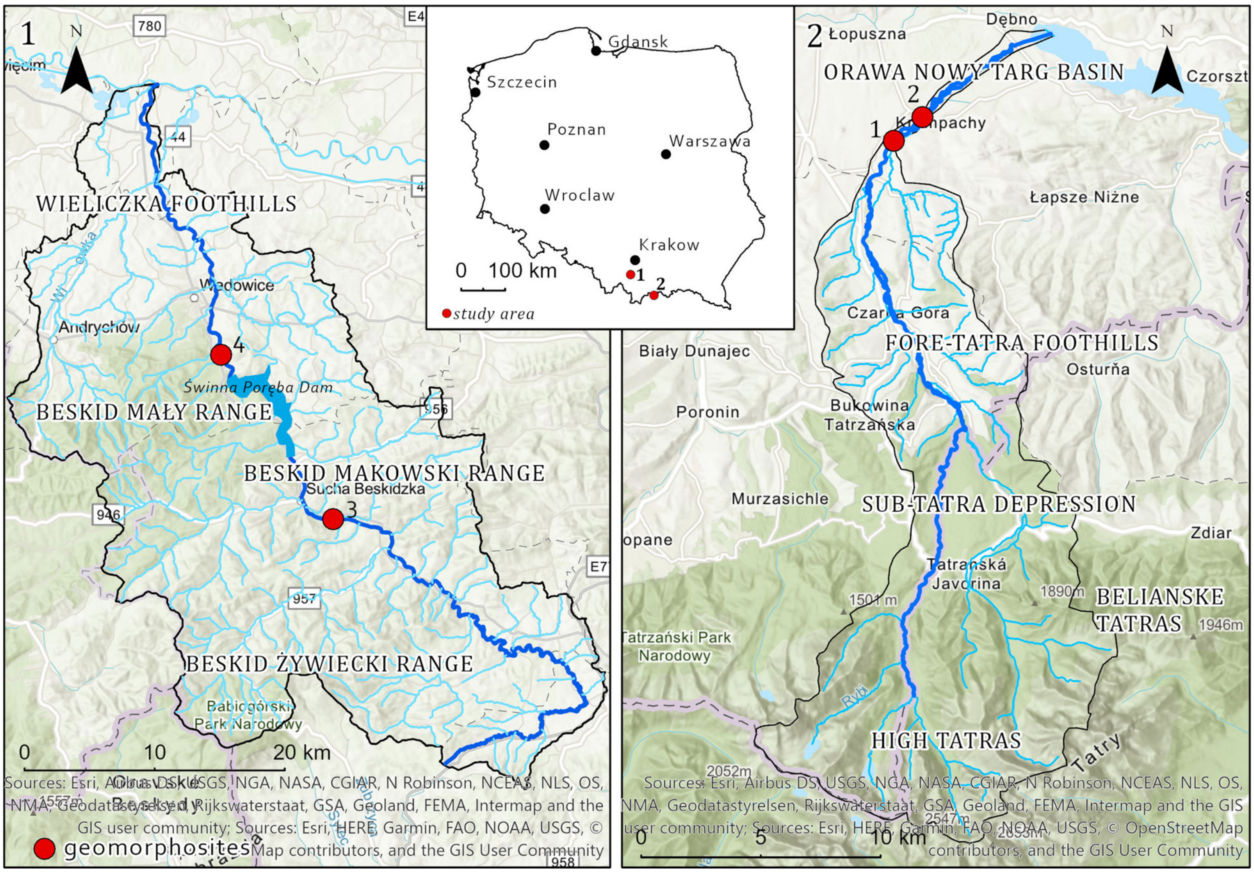

Fig. 1. The Skawa (1) and Białka (2) rivers' catchments with the location of the geomorphosites. Based on the Hydrographical Map of Poland, available online: GUGiK 2019.
1 – Białka Gorge through the Pieniny Klippen Belt, 2 – Białka Valley at the Spisz Region, 3 – rocky and braided channel in Maków Podhalański, 4 – fragment of the river channel in Jaroszowice).

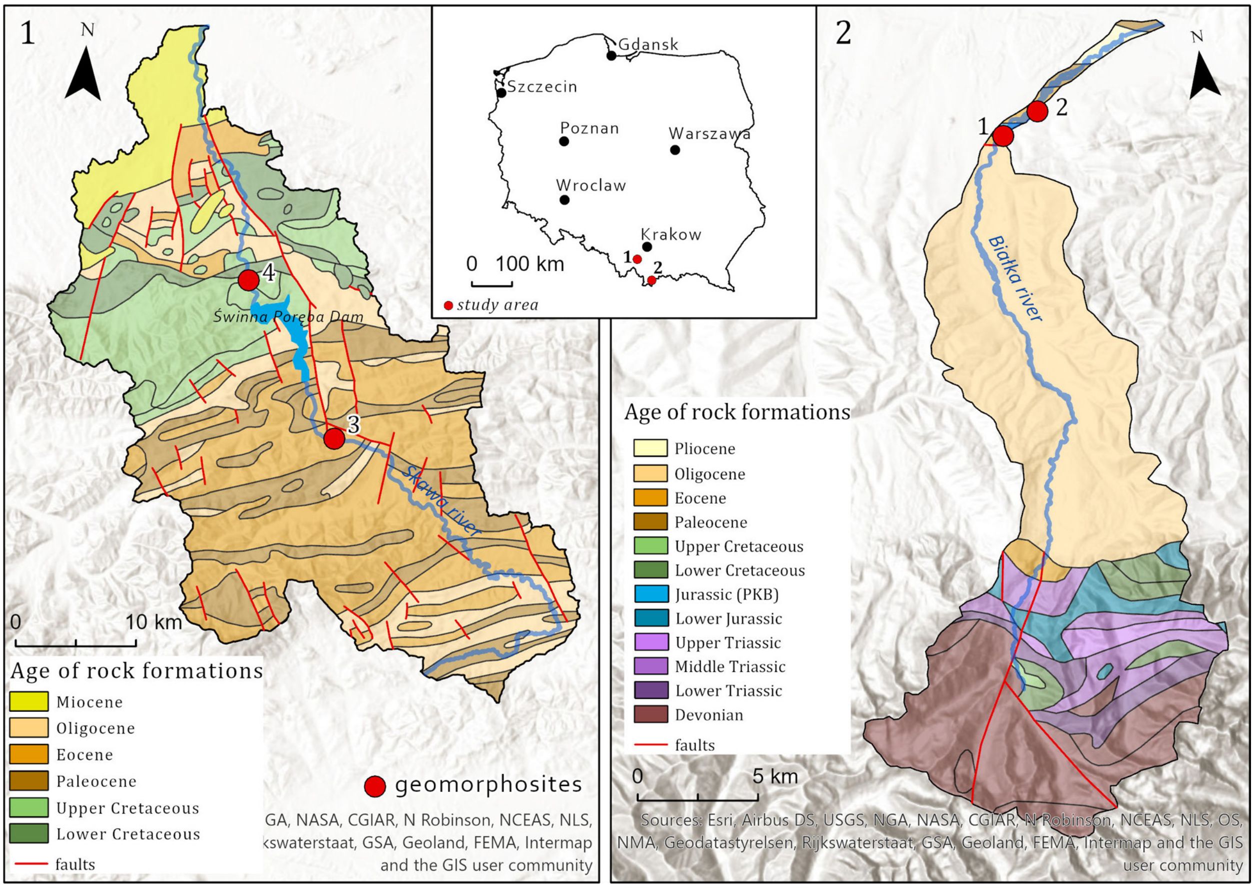

Fig. 2. Geology of the Skawa (1) and Białka (2) riverbeds with the location of geomorphosites. Based on Lexa et al. 2000.
1 – Białka river Gorge through the Pieniny Klippen Belt, 2 – Białka Valley at the Spisz Region, 3 – rocky and braided channel in Maków Podhalański, 4 – fragment of the river channel in Jaroszowice); PKB – Pieniny Klippen Belt.

sections(Witkowski, Wysmołek 2015). The contemporary Skawa riverbed is mostly regulated. In sections with destroyed ripraps, braided channels are currently being developed (Wyżga et al. 2016, Wojkowski et al. 2019).

Geomorphosites description

Four geomorphosites were selected for the assessment (Figs 1, 2):

1. the Białka Gorge through the Pieniny Klippen Belt,
2. the Białka Valley at the Spisz Region,
3. the rocky and braided channel in Maków Podhalański, and
4. the fragment of the river channel in Jaroszowice.

For these geomorphosites, descriptions containing basic information on the location and affiliation of the regional geosources and characteristics along with the drawings, with particular emphasis on their educational values, have been made.

GEOSITE NO. 1: The Białka Gorge through the Pieniny Klippen Belt (Fig. 3) is located in the Nowa Biała village (Nowy Targ community, nowotarski district, Lesser Poland Voivodeship). This geosite is a part of the protected area (The Białka Gorge Reserve). Geologically, it is a part of the Pieniny Klippen Belt. According to physico-geographical division (Solon et al. 2018), it is a part of the Magura Spiska and Pieniny.

This geosite has multiple educational aspects. It is a place that makes it possible to explain the size, causes and consequences of the hydrological processes taking place in a mountain riverbed from which the waters drain the surface area of the High Tatras (230 km²). The bottom of the Białka Valley narrows in the described geomorphosite several times to a width of about 100 m,

Fig. 3. The Białka Gorge. View from the Obłazowa Rock. Photo: A. Chrobak.

in the region where the outcrops of the Czorsztyn succession belonging to the Pieniny Klippen Belt appear on the surface, forming rock formations. This short (around 100 m) gorge between the Obłazowa Rock and the Kramnica Rock (Fig. 3) was created at different stages of the development of this area, where the system of the river network was also changed. These changes resulted from the tectonic zone to the diversified geological structure of the Pieniny Klippen Belt, with a lithologically contrasting series of carbonate (limestone) and siliceous (radiolarite) rocks and a series of rocks dominated by fine grains (clay and marly shales, mudstones and sandstones) (Birkenmajer 1963).

The Obłazowa Rock (high at 670 m a.s.l.) located on the western side of the Białka Gorge can also be used for educational purposes to explain the conditions for the formation of limestone containing rare carbonate fossils belonging to the crinoids (Birkenmajer 1958). The main mass of the rocks is formed by crinoid limestone with fragments of stems of daylilies visible on weathered surfaces (Głuchowski 1986, 1987).

The last educational element related to this geomorphosite is the result of an archaeological research carried out in the Obłazowa Cave created in the stone part of the red boulder limestone (Czorsztyn limestone formation). This cave (length 9 m) is an archaeological site in which traces of settlements from the Stone Age, Neolithic, Bronze Age and Middle Ages were found, and among others, a boomerang from a mammoth hit dated to about 30,000 BC was found here. The cave in Obłazowa Rock was a place of worship (Valde-Nowak et al. 1987, 1995, Valde-Nowak 1991, 2008, Łanczont et al. 2019).

GEOSITE NO. 2: The Białka Valley at the Spisz Region is also located in the Nowa Biała village (Nowy Targ community, nowotarski district, Lesser Poland Voivodeship). According to the physico-geographical division (Kondracki 2011, Solon et al. 2018), it is a part of the Orawa-Nowy Targ Basin.

The educational values of this geosite are focused on the characteristics of the braided river type (Fig. 4). From its junction with the Jaworowy Stream, the Białka river takes a characteristic braided channel, which can be observed from the bridge between the villages of Nowa Biała and Krempachy. The Białka river channel in this section is alluvial, and the material which is visible both at its bottom and in the fills came mainly from the Tatra Mountains (Baumgart-Kotarba 1983, Gorczyca et al. 2011). According to Gorczyca et al. (2011), the observed section of Białka was classified as type B, which forms a river flowing through a wide valley, cutting through layers of gravels with an upper layer of alluvial deposits. Its arrangement is braided with meandering sections. The processes of the bottom and lateral erosion, accumulation and redeposition

Fig. 4. The Białka river channel at the Spisz Region. Photo: A. Chrobak.

Fig. 5. The braided channel of the Białka river near Nowa Biała village. Photo: A. Chrobak.

primarily shape it (Fig. 5). During freshets in the channel, there is intense bottom erosion, which results in deep cuts, uncovered rock thresholds and dry side channels visible in the period after a flood. Fluvial processes can operate here without any significant restrictions since the width of the trough reaches up to 200 m. The regulatory work is visible in the described place, where edges have been reinforced with sandstone blocks. The river regulation and shore reinforcement were carried out in the 1960s (Baumgart-Kotarba 1983).

Compared with other mountain rivers flowing from the Tatras (e.g. Czarny and Biały Dunajec), the Białka riverbed is the least regulated and, as the only river channel of this type in the Polish Western Carpathians, it should be protected against all types of hydrotechnical control (Krąż, Balon 2010, Gorczyca et al. 2011, Hełdak 2016).

GEOSITE NO. 3: The Skawa riverbed in Maków Podhalański is located in the Maków Podhalański community, Suski district, Lesser Poland Voivodeship. According to the physico-geographical division (Kondracki 2011), it is a part of the Beskid Makowski Range. The educational values of this geosite are focused on the characteristics of the rocky and braided channel (Fig. 6). The distinguishing feature of the fragment of the Skawa river valley in Maków Podhalański is the rock outcrops located in the course of the alluvial riverbed. The braided river sections develop during the floods. In the period after the floods, the braided channel is transformed into a straight river, spontaneously or as a result of human activities. The geosite makes it possible to show the processes of the formation and functioning of the rock and braided channel due to anthropopression. The Skawa river channel in Maków Podhalański is located in the Skawa River Fault Zone (Żytko 1981). The valley gained the highest slope in the places where less resistant rocks occur (Grzybowski 1999). The Skawa valley was a place of intense neotectonic movements, the last phase of which lasts for 15,000 years (Zuchiewicz 1995, 2011). Geological conditions are responsible for the increase in the longitudinal slope of the valley, starting from Jordanów (about 30 km of the river's course from the source) to Mucharz (about 70 km). The geosite is located in the section below Osielec (about 40 km), where the decrease in slope is noticeably larger (Fig. 6).

Fig. 6. The fragment of the rocky channel in the Skawa river. Photo: K. Witkowski.

The intensification of anthropopressure from the second half of the 19th century – cutting down the forests, gravel mining from the rivers and their regulation – led to vanishing of the braided channel and its deepening until the bedrock was exposed. The construction of a bridge with pillars with foundations on the riverbed also favoured deep erosion. The contemporary renaturalisation of the braided channel is the result of the supply of sediments from the mountain tributaries (Skawica and Żarnowianka) and the availability of gravels downstream of the rock channel in the widening of the valley in Maków Basin (Witkowski, Wysmołek 2015). Spontaneous restoration of the Skawa river towards the braided system was possible due to the occurrence of the record of high water flows in 2001 and very high flows in 2010 and 2014 (Gorczyca 2016).

GEOSITE NO. 4: The fragment of the river channel in Jaroszowice (Fig. 7) is located in the Jaroszowice village (Wadowice community, Wadowice district, Lesser Poland Voivodeship). According to the physico-geographical division (Kondracki 2011), it is a part of the Beskid Mały Range. The educational value of the Skawa river channel in Jaroszowice is functioning of the multi-channel system in the immediate vicinity of the Świnna Poręba dam. The riverbank was transformed into a cut bank during the flood in 2001. This flood had a record-breaking discharge in the 20th and 21st centuries in the Skawa valley (Witkowski 2017). The right bank, almost a rectilinear channel, was then significantly shifted

Fig. 7. The section of the Skawa river near Jaroszowice village. Photo: K. Witkowski.

and in the extended bottom, a central form was created. The lack of reaction of the stream administrator allowed for the consolidation of the form and the development of the braided channel.

Fine-grained material was deposited on the surface of the bar during the next floods. The main central form evaluated towards the inter-channel area (Fig. 8) (Teisseyre 1991). The beginning of water damming in the Świnna Poręba reservoir resulted in regulating the flow downstream of the dam and maintaining long-lasting high flows, necessary due to emptying the reservoir after floods. The fine-grained material was washed out of the surface of the form (Witkowski

Table 1. The criteria of a scientific-educational assessment. Based on Pereira, Pereira (2010) and Brilha (2016).

SEV	SCIENTIFIC-EDUCATIONAL VALUE
Ra	Rareness in relation to the study area
0	It is not one of the most important 5
2,5	One of the most 5 important examples in the study area to illustrate elements or processes
5	One of the most 3 important examples in the study area to illustrate elements or processes
7,5	Good example in the study area to illustrate elements or processes
10	The best example in the study area to illustrate elements or processes
In	Integrity/Intactness
0	Highly damaged as a result of human activities
2,5	Damaged as a result of natural processes
5	Damaged, but preserving essential geomorphological features
7,5	Slightly damaged, but still maintaining the essential geomorphological features/other geomorphological features were created as a result of human activity and/or natural processes
10	All geological and geomorphological features are very well preserve
Rp	Representativeness of geomorphological processes and pedagogical interest
0	Low representativeness and without pedagogical interest
3,3	With some representativeness, but with a low pedagogical interest
6,7	The good example of processes, but hard to explain to non-experts
10	The good example of processes and/or good pedagogical resource
Dv	Number of interesting geomorphological features (diversity)
0	1
3,3	2
6,7	3
10	More than 3
Ge	Other geological features with heritage value
0	The absence of other geological features
3,3	Other geological features, but without relation to geosite
6,7	Other geological features with relation to geosite
10	The occurrence of other geological features with a degree higher than geomorphological features
Kn	Scientific knowledge on geomorphological issues
0	None
5	Medium: presentations, national papers
10	High: international papers, thesis
Av	Additional values (historical, cultural, archeological)
0	No other scientific or educational values
3,3	One scientific or educational value which could be related to the geomorphosite
6,7	2-5 scientific or educational values which could be related to the geomorphosite
10	Existence more than 5 scientific or educational values which could be related to the geomorphosite

Fig. 8. Satellite images of the Skawa river near Jaroszewice in 2012 and 2018 (Google Earth, downloaded on August 16, 2018).

2018). Due to the size, durability and well-vegetated main form, it can be classified as an inter-channel area.

The functioning of the braided channels on both sides of the main form makes it possible to classify this section of the channel as an anabranch with laterally active gravel beds (Nanson, Knighton 1996).

Data and methods

To assess the scientific–educational values of selected fragments of the Białka and Skawa rivers, the authors applied the valorisation method of geomorphosites based on the criteria proposed by Pereira and Pereira (2010) and Brilha (2016), which, according to the authors, are the most

Table 2. Definitions of division into valorization groups. Based on Warszyńska (1970).

Group	Point value	Definition
I	0.7–1.0	An object with very high scientific-educational values
II	0.4–0.7	An object with high scientific-educational values
III	0.2–0.4	An object with medium scientific-educational values
IV	0.0–0.2	An object with low scientific-educational values

relevant to describe the research area. The assessment was supplemented with the Warszyńska method (1970) and the expert triangulation method (Flick 2011).

The geomorphosites were assessed according to 7 seven scientific–educational criteria: the rareness in relation to the study area, integrity/intactness, representativeness of geomorphological processes and a pedagogical interest, a number of interesting geomorphological features, a scientific knowledge on geomorphological issues and additional values – defined on a scale from 0 to 10 (Table 1).

Authors applied a simple algorithm to determine whether the geosite has a high or low educational value. The sum of points obtained from the assessment of the geomorphosite was divided by the maximum sum of points possible to reach 70 points (Warszyńska 1970). The obtained result allowed classifying the geosite into one of four groups, with a very high, high, medium or low scientific-educational value (Table 2).

The last methodical element used by the authors was an attempt to objectify the valorisation results with an expert triangulation method. Three experts (authors of this paper) independently evaluated each geomorphosite according to the same assessment criteria. The mean of these three evaluations gave the definitive assessment index.

Results

All geomorphosites described above have a high or a very high scientific–educational value. Geosite no. 1 – the Białka Gorge through the Pieniny Klippen Belt – is the highest rated geomorphosite and received 68.9 points. Two experts rated it even for the maximum number of points (70) (Table 3). The very high value of the assessment index received by the Białka Gorge results from the multitude of visible elements that are the effects of many geomorphological processes. The Białka Gorge (between two limestone rocks) is geologically and geomorphologically unique in the range of the Polish Carpathians (Birkenmajer 1958), with an additional advantage of the archaeological finds discovered in the Obłazowa Cave (Valde-Nowak et al. 1987, 1995, Valde-Nowak 1991, 2008, Łanczont et al. 2019). In the 90s, attention was paid to its unique educational and cognitive values and the idea of protecting this area was proposed (Alexandrowicz et al. 1997).

Geomorphosite no. 4, the fragment of the river channel in Jaroszowice (54.5 points), and geosite no. 2, the Białka Valley at the Spisz Region (53.1 points), were also highly rated. The high grades of the geomorphosite located in Jaroszowice result from the unique relief of this section of the Skawa river, where a large central form was

Table 3. Results of the assessment of selected geomorphosites.

Criteria	GEOSITE NO. 1				GEOSITE NO. 2				GEOSITE NO. 3				GEOSITE NO. 4			
	E1	E2	E3	Av	E1	E2	E3	Av	E1	E2	E3	Av	E1	E2	E3	Av
Ra	10.0	10.0	10.0	10.0	7.5	7.5	10.0	8.3	7.5	7.5	10.0	8.3	10.0	10.0	10.0	10.0
In	10.0	10.0	10.0	10.0	10.0	10.0	7.5	9.2	10.0	10.0	10.0	10.0	7.5	10.0	7.5	8.3
Rp	10.0	10.0	10.0	10.0	6.7	10.0	10.0	8.9	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Dv	10.0	10.0	10.0	10.0	6.7	10.0	10.0	8.9	3.3	3.3	3.3	3.3	10.0	10.0	10.0	10.0
Ge	10.0	6.7	10.0	8.9	0.0	0.0	0.0	0.0	6.7	6.7	6.7	6.7	0.0	6.7	6.7	4.5
Kn	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Av	10.0	10.0	10.0	10.0	6.7	6.7	10.0	5.8	0.0	0.0	0.0	0.0	10.0	10.0	10.0	10.0
SUM	70.0	66.7	70.0	68.9	47.6	54.2	57.5	53.1	39.2	39.2	41.7	40.0	49.2	58.4	55.9	54.5
P.value	1.00	0.95	1.00	0.98	0.68	0.77	0.82	0.75	0.56	0.56	0.60	0.57	0.70	0.83	0.80	0.78
GROUP	I	I	I	I	II	I	I	I	II	II	II	II	I	I	I	I

P.value – point value; the quotient of the sum of points obtained from the valorization of the geosite by the maximum sum of points possible to reach by the geosite; GROUP – based on Warszyńska (1970).

created in the channel after the flood in 2001, which then stabilised (Witkowski 2018). The current shape of the riverbed, where the river flows from both sides of the present central form, forms of an anabranching section found nowhere else in the Carpathians. Geomorphosite no. 2 in Nowa Biala, which also received high bonitation scores, is a very famous place where tourists admire a river with a typical braided layout (Baumgart-Kotarba 1983, Gorczyca et al. 2011). Especially interesting are the observations before, during and after high water levels caused mainly by heavy showers, when the river can change its current several times a year.

Geomorphosite no. 3, the rocky and braided channel in Maków Podhalański (40 points), received the lowest rank. It was in the second group of objects with high educational values (Table 3). It is also interesting because in the most-alluvial channel, it suddenly reveals rocky ground. This is due to the presence of the fault zone, which, probably, Skawa used in the observed episode (Żytko 1981, Zuchiewicz 1995, 2011).

The greatest disproportions in the conducted bonitation were noted in the assessment of geosite no 2, where the difference between the lowest and the highest sum of points reached 9.9 points.

Discussion

Presented types of geomorphosites are described and assessed in the world literature in mountainous areas, primarily in the Alps (Ilieş, Josan 2009, Jaskulska et al. 2013, Reynard, Coratza 2016, Reynard et al. 2016a, b, Cocean, Cocean 2017, Clivaz, Reynard 2018). Some of them are tourist attractions and some are completely unknown. The examples of selected geomorphosites in the valleys of the Białka and Skawa rivers show that both very well-known places (the Białka Gorge) and those which are less known (Jaroszowice) have very high scientific and educational potential. The expert triangulation method makes possible less subjectivity of the scientific–educational index, which is presented in Table 3. An example of this is the assessment of geosite No. 2, which was qualified to the second group of objects with high scientific–educational values by one of the experts in the second group. However, according to the other two experts, this geomorphosite received very high assessment and the mean of these three assessments ultimately classified this geomorphosite into first group with very high educational values.

The differences in individual expert assessments resulted from the knowledge and experience of the authors assessing individual geomorphosites. The largest disproportions (3.3 points) were due to:

1. different interpretation of the uniqueness of a chosen geomorphosite against the geological background of the catchment,
2. the degree of its degradation,
3. its representativeness, and
4. the number of geological and geomorphological features that can be described in the geomorphosite.

The authors were almost 100% consistent in assessing the description of a given place in the literature and its additional values.

Comparing the assessment results of the four describing geomorphosites with the results obtained from the assessment of similar types of geomorphosites, it can be said that river gorges (like Białka Gorge) are interesting morphological objects that can increase the geotourism potential of a region (Cocean, Cocean 2017).

Creating educational aids describing the relief and geological features, which could be used by geography teachers in schools, also should be preceded by assessment and specification of the describing geomorphosites. Geography teachers could use such prepared materials during their lessons, or even take their students on the trip to see the geomorphosites and explain to them the features of:

1. the braided river,
2. a geological specification and its impact on the formation of river gorges, or
3. how the construction of a dam can affect the riverbed and material transport.

Describing geomorphosites are good viewing points in the local landscapes, and developing educational activities on environmental issues like that due to natural hazards like floods or human impact on sensitive environmental sites is a very important issue (Reynard, Coratza 2016). The geomorphosites could be also a good example of artistic inspiration (especially wedding photography and making movies), which also increases their additional value (Ilies, Josan

2009). Described geomorphosites are also in close proximity to other valuable abiotic nature objects that have already been described (e.g. Hełdak 2016, Chrobak 2018, PGI-PIB 2019). It is possible to create an educational path with a description of various forms and processes within the Białka (Chrobak 2016, 2018) and Skawa catchments.

Conducting the qualitative research of assessment of the geomorphosites allows to less subjectively select the geomorphosites in the mountain river valleys, which can actually be used later in creating a new (geo)tourist product. However, it should be remembered that the use of the potential of the geomorphosites also depends on the preferences of tourists who want to visit such places (Comănescu, Nedelea 2015, Martins, Pereira 2018, Štrba 2019).

Conclusions

Presented assessment methods and the proposed use of them in the study of the scientific–educational values of interesting natural objects are a good solution to objective evaluation of geomorphosites. The authors think that all describing geomorphosites should be promoted in (geo) tourism like the Białka Gorge which is widely known, accessible to the tourists and promoted. These geomorphosites should be promoted by creating:

1. educational boards and
2. guidebooks describing the natural and cultural micro-regions.

On a local scale, schools should be a target for such promotional activities. The lectures for teachers will allow them to understand what educational opportunities geomorphosites provide. The educational trips to the geomorphosites will help students in understanding the processes forming the landscape. In addition, such activities will promote the nearest neighbourhood among students.

Acknowledgements

The research was financed by the statutory research for Young Scientists of the Pedagogical University in Krakow (2018 and 2019) and the statutory research of the Pedagogical University in Krakow, No. BS/452/G/2018. The authors are very grateful to four anonymous reviewers for their thorough reviews and constructive comments.

Authors' contribution

ACh – 40% – conducting research, research methodology and data analysis, preparation of the discussion chapter, making figures, study area description; KW – 40% – conducting research, research methodology and data analysis, preparation of the discussion chapter, making figures, study area description; JSz – 20% – conducting research, data analysis, preparation of the discussion chapter.

References

Alexandrowicz Z., Alexandrowicz W.P., 2002. Geoturystyka a promocja dziedzictwa geologicznego. *Użytkowanie Turystyczne Parków Narodowych. Ruch Turystyczny–Zagospodarowanie–Konflikty–Zagrożenia* 91–97.

Alexandrowicz Z., Krobicki M., Gonera M., Alexandrowicz W.P., 1997. Projekt powiększenia i dydaktycznego uprzystępnienia rezerwatu przyrody „Skałka Rogoźnicka" na Podhalu. *Chrońmy Przyrodę Ojczystą 53*(4): 58–73.

Alexandrowicz Z., Kućmierz A., Urban J., Otęska-Budzyn J., 1992. *Waloryzacja przyrody nieożywionej obszarów i obiektów chronionych w Polsce*. Warszawa: Wydawnictwo Państwowego Instytutu Geologicznego.

Alexandrowicz Z., Margielewski W., 2010. Impact of mass movements on geo- and biodiversity in the Polish Outer (Flysch) Carpathians. *Geomorphology 123*(3–4): 290–304. DOI: 10.1016/j.geomorph.2010.07.020.

Bac-Moszaszwili M., Jurewicz E., 2010. *Wycieczki geologiczne w Tatry*. Zakopane: TPN.

Baumgart-Kotarba M., 1983. Kształtowanie koryt i teras rzecznych w warunkach zróżnicowanych ruchów tektonicznych (na przykładzie wschodniego Podhala). *Prace Geograficzne* 145: 7–133.

Birkenmajer K., 1958. *Przewodnik geologiczny po Pienińskim Pasie Skałkowym, t.I–IV*. Warszawa: Wydawnictwa Geologiczne.

Birkenmajer K., 1962. Forma geologiczna andezytów Wżaru. *Acta Geologica Polonica* 12: 201–213.

Birkenmajer K., 1963. Stratygrafia i paleogeografia serii czorsztyńskiej Pienińskiego Pasa Skałkowego Polski. *Studia Geologica Polonica* 9: 1–380.

Birkenmajer K., 1979. *Przewodnik geologiczny po Pienińskim Pasie Skałkowym*. Warszawa: Wydawnictwa Geologiczne.

Birkenmajer K., 2014. Mapy geologiczne pienińskiego pasa skałkowego. *Pieniny – Przyroda i Człowiek* 8: 3–8.

Brilha J., 2016. Inventory and quantitative assesment of geosites and geodiversity sites: a review. *Geoheritage* 8(2): 119–134.

Chrobak A., 2015. Geotourism potential in the Podhale, Orava, Liptov and Spiš regions (Southern Poland/Northern Slovakia). *Acta Geoturistica* 6(2): 1–10.

Chrobak A., 2016. Valorisation and categorisation of the geosites in the Podtatrze area (Southern Poland). *Geotourism* 46–47(3–4): 3–26.

Chrobak A., 2018. Analiza i ocena potencjału geoturystycznego Podtatrza. PhD Thesis. Uniwersytet Pedagogiczny w Krakowie.

Clivaz M., Reynard E., 2018. How to Integrate Invisible Geomorphosites in an Inventory: a Case Study in the Rhone River Valley (Switzerland). *Geoheritage* 10(4): 527–541. DOI: 10.1007/s12371-017-0222-7.

Cocean G., Cocean P., 2017. An Assessment of Gorges for Purposes of Identifying Geomorphosites of Geotourism Value in the Apuseni Mountains (Romania). *Geoheritage* 9(1): 71–81. DOI: 10.1007/s12371-016-0180-5.

Comănescu L., Nedelea A., 2015. Public perception of the hazards affecting geomorphological heritage – case study: the central area of Bucegi Mts. (Southern Carpathians, Romania). *Environmental Earth Sciences* 73(12): 8487–8497. DOI: 10.1007/s12665-014-4007-x.

Dobija A., 1981. Sezonowa zmienność odpływu w zlewni górnej Wisły (po Zawichost). *Zeszyty Naukowe UJ, Prace Geograficzne* 53: 51–112.

Dowling R.K., 2011. Geotourism's Global Growth. *Geoheritage* 3(1): 1–13. DOI: 10.1007/s12371-010-0024-7.

Flick U., 2011. *Jakość w badaniach jakościowych*. Warszawa: Wydawnictwo Naukowe PWN.

Głuchowski E., 1986. Liliowce (*Crinoidea, Articulata*) jury i dolnej kredy pienińskiego pasa skałkowego Polski. *Przegląd Geologiczny* 34(6): 304–309.

Głuchowski E., 1987. Jurassic and Early Cretaceous Articulate Crinoidea from the Pieniny Klippen Belt and Tatra Mts. *Studia Geologica Polonica* 94: 1–102.

Golonka J., Doktor M., Miśkiewicz K., Krobicki M., Słomka T., 2014. Selected geosites within a proposed new trans-border Pieniny Geopark (Polish-Slovakian). *Acta Geoturistica* 5(2): 46–63.

Golonka J., Krobicki M., 2007. The Dunajec River rafting – one of the most interesting geotouristic excursions in the future trans-border PIENINY Geopark. *Geoturystyka* 10(3): 29–44.

Gołąb J., 1954. *Flisz Podhala na zachód od Białego Dunajca*. Kraków: Archiwum Państwowego Instytutu Geologicznego. Oddział Karpacki.

Gorczyca E., 2016. *Rozwój górskich żwirodennych koryt rzecznych w warunkach antropopresji*. Instytut Geografii i Gospodarki Przestrzennej UJ, Kraków.

Gorczyca E., Krzemień K., Łyp M., 2011. Contemprorary trends in the Białka river channel development in the Western Carpathians. *Geographia Polonica* 84 (Sp. Iss. 2): 39–53. DOI: 10.7163/GPol.2011.S2.3.

Grzybowski K., 1999. Wpływ litologii i tektoniki serii fliszowych oraz młodoczwartorzędowych ruchów tektonicznych na ukształtowanie doliny Skawy (zachodnie Karpaty zewnętrzne). *Przegląd Geologiczny* 47(9): 846–850.

GUGiK, 2019. Hydrographical Map of Poland. Online: https://mapy.geoportal.gov.pl/imap/Imgp_2.html?gpmap=gp0 (accessed 30 November 2019).

Hełdak D., 2016. The geotourist potential of the Bialka River valley (in the Podhale Basin) – a project of a geotourist trail. *Geotourism* 44–45(1–2): 19–26.

Hlavňová B., Pavolová H., 2013. Evaluation of the geotourism development potential in Malá Fatra mountain range. *Acta Geoturistica* 4(2): 21–30.

Hose T.A., 1995. Selling the story of Britain's stone. *Environ Interpretation* 10(2): 16–17.

Hose T.A., 2000. European geotourism – geological interpretation and geoconservation promotion for tourists. In: D.Barretino, W.A.P.Wimbledon, E.Gallego (Eds.), *Geological Heritage: Its Conservation and Management* Madrid: Instituto Tecnologico GeoMinero de Espana: 127–146.

Hose T.A., 2008. Towards a history of geotourism: definitions, antecedents and the future. *Geological Society, London, Special Publications* 300(1): 37–60. DOI: 10.1144/SP300.5.

Hose T.A., 2011. The genesis of geotourism and its management implications. In T.Słomka (Ed.), *Geotourism a Variety of Aspects*. Akademia Górniczo-Hutnicza, Kraków: 23–38.

Ilieş D.C., Josan N., 2009. Geosites-geomorphosites and relief. *GeoJournal of Tourism and Geosites* 3(1): 78–86.

Jacko S., Janočko J., Kondela J., Prekopová M., Zakršmídová B., 2014. Geological research results utilization for tourism development in the Pieniny and Zamagurie region (north-eastern Slovakia). *Acta Geoturistica* 5(1): 18–23.

Jaskulska A., Reynard E., Zwoliński Zb., 2013. Geodiversity assessment for environmental management of geomorphosites: Derborence and Illgraben, Swiss Alps. *Geophysical Research Abstracts* 15, 1.

Joyce B., 2006. *Geomorphological sites and the new geotourism in Australia*. Geological Society of Australia, Melbourne.

Kondracki J., 2011. *Geografia regionalna Polski*. Wydawnictwo Naukowe PWN, Warszawa.

Kotański Z., 1971. *Przewodnik geologiczny po Tatrach*. Wydawnictwa Geologiczne, Warszawa.

Krąż P., 2012. Antropogeniczne zagrożenia środowiska przyrodniczego Doliny Białki. *Prace Geograficzne UJ* 128: 45–54.

Krąż P., Balon J., 2010. Przemiany środowiska przyrodniczego zlewni Białki na Podtatrzu. In: A.Kotarba (Ed.), *Przyroda Tatrzańskiego Parku Narodowego a Człowiek*. TPN, Zakopane: 77–82.

Krobicki M., Golonka J., 2008. Geotouristical values of the Pieniny Klippen Belt and Tatra Mountains regions (Poland). *Przegląd Geologiczny* 56(8/1): 670–711.

Kubalíková L., 2013. Geomorphosite assessment for geotourism purposes. *Czech Journal of Tourism* 2(2): 80–104. DOI: 10.2478/cjot-2013-0005.

Kubalíková L., 2019. Assessing geotourism resources on a local level: a case study from Southern Moravia (Czech Republic). *Resources* 8(3): 150–170.

Kurek W., 2008. *Turystyka*. Wydawnictwo Naukowe PWN, Warszawa.

Lexa J., Bezák M., Elečko M., Mello J., Polák M., Potfaj M., Vozár J. 2000. *Geological map of Western Carpathians and adjacent areas,* 1:500 000. Geological Survey of Slovak Republic, Bratislava.

Łanczont M., Madeyska T., Hołub B., Komar M., Mroczek P., Standzikowski K., Valde-Nowak P., Kraszewska A., Cieśla M., Skłucki, J., 2019. Late Glacial environment and human settlement of the Central Western Carpathians: A case study of the Nowa Biała 1 open-air site (Podhale Region, southern Poland). *Quaternary International* 512: 113–132. DOI: 10.1016/j.quaint.2019.02.036.

Martins B., Pereira A., 2018. Residents' perception and assessment of geomorphosites of the Alvão-Chaves Region. *Geosciences* 8(10): 381–395.

Migoń P., 2012. *Geoturystyka*. Wydawnictwo Naukowe PWN, Warszawa.

Mucivuna V.C., Reynard E., Garcia M. da G.M., 2019. Geomorphosites Assessment Methods: Comparative Analysis and Typology. *Geoheritage*. DOI: 10.1007/s12371-019-00394-x.

Nanson G.C., Knighton D.A., 1996. Anabranching rivers: Their cause, character and classification. *Earth Surface Processes and Landforms* 21(3): 217–239.

Newsome D., Dowling R.K., 2006. The scope and nature of geotourism. *Geotourism* 3–25. DOI: 10.1016/B978-0-7506-6215-4.50009-9.

Newsome D., Dowling R.K., 2010. *Geotourism. The tourism of Geology and Landscape*. Goodfellow Publishers Limited, Oxford.

Ovreiu A.-B., Comănescu L., Bărsoianu I-A., Nedelea A., 2019. Evaluating Geomorphosites and the Geomorphological Hazards that Impact them: Case Study – Cozia Massif (Southern Carpathians, Romania). *Geoheritage* 11(3): 1067–1087. DOI: 10.1007/s12371-019-00352-7.

Ólafsdóttir R., 2019. Geotourism. *Geosciences*. 9(1): 48–55. DOI: 10.3390/geosciences9010048.

Panizza V., Mennella M., 2007. Assessing geomorphosites used for rock climbing. The example of Monteleone Rocca Doria (Sardinia, Italy). *Geographica Helvetica* 62(3): 181–191.

Pereira P., Pereira D., 2010. Methodological guidelines for geomorphosite assessment. *Géomorphologie: Relief, Processus, Environnement* 2: 215–222.

PGI-PIB, 2019. Central Register of Polish Geosites. Online: http://geoportal.pgi.gov.pl/portal/page/portal/geostanowiska/ (accessed 30 November 2019)

Ptaszek A., 2005. Wodospady w potoku Kacwinianka jako obiekty geoturystyczne. *Geoturystyka* 2(1): 25–31.

Ptaszek A., 2007. Geoturystyczne atrakcje Pogórza Spisko-Gubałowskiego – uwarunkowania geologiczne i możliwości zagospodarowania. *Studia Nad Turystyką. Prace Geograficzne i Regionalne* 2: 231–239.

Radwanek-Bąk B., 2008. Selected geosites and geotourist objects in Colca Canyon and its vicinity (Southern Peru). *Geoturystyka* 15(4): 3–12.

Reynard E., 2004. Geosite. In: A.Goudie (ed.), *Encyclopedia of Geomorphology, vol. 1*. Routledge, 440.

Reynard E., 2009. The assessment of geomorphosites. In: E.Reynard, P.Coratza, G.Regolini-Bissig (Eds.), *Geomorphosites. Assessment, mapping and management*. Pfeil Verlag, München: 63–72.

Reynard E., Coratza P., 2016. The importance of mountain geomorphosites for environmental education: Examples from the Italian dolomites and the swiss alps. *Acta Geographica Slovenica* 56(2): 291–303. DOI: 10.3986/AGS.1684.

Reynard E., Coratza P., Giusti C., 2011. Geomorphosites and Geotourism. *Geoheritage* 3(3): 129–130. DOI: 10.1007/s12371-011-0041-1.

Reynard E., Coratza P., Hobléa F., 2016a. Current Research on Geomorphosites. *Geoheritage* 8(1): 1–3. DOI: 10.1007/s12371-016-0174-3.

Reynard E., Panizza M., 2005. Geomorphosites: definition, assessment and mapping. An introduction. *Géomorphologie: relief, processus, environnement* 3: 177–180.

Reynard E., Perret A., Bussard J., Grangier L., Martin S., 2016b. Integrated Approach for the Inventory and Management of Geomorphological Heritage at the Regional Scale. *Geoheritage* 8(1): 43–60. DOI: 10.1007/s12371-015-0153-0.

Rogowski M., 2016. The potential of the Sudetes Mountains for the development of geotouristic products Geotouristic product. *Geotourism* 46–47(3–4): 59–80.

Rybár P., 2010. Assessment of attractiveness (value) of geotouristic objects. *Acta Geoturistica* 1(2): 13–21.

Solon J., Borzyszkowski J., Bidłasik M., Richling A., Badora K., Balon J., Brzezińska-Wójcik T., Chabudziński Ł., Dobrowolski R., Grzegorczyk I., Jodłowski M., Kistowski M., Kot R., Krąż P., Lechnio J., Macias A., Majchrowska A., Malinowska E., Migoń P., Myga-Piątek U., Nita J., Papińska E., Rodzik J., Strzyż M., Terpiłowski S., Ziaja W., 2018. Physico-geographical mesoregions of Poland: Verification and adjustment of boundaries on the basis of contemporary spatial data. *Geographia Polonica* 91(2): 143–170.

Štrba Ľ., 2019. Analysis of Criteria Affecting Geosite Visits by General Public: a Case of Slovak (Geo)Tourists. *Geoheritage* 11(2): 291–300. DOI: 10.1007/s12371-018-0283-2.

Teisseyre A.K., 1991. *Klasyfikacja rzek w świetle analizy systemu fluwialnego i geometrii hydraulicznej*. Wydawnictwo Uniwersytetu Wrocławskiego, Wrocław.

Valde-Nowak P., 1991. Studies in Pleistocene settement in the Polish Carpathians. *Antiquity* 65: 593–606.

Valde-Nowak P., 2008. Człowiek pierwotny w Jaskini w Obłazowej. *Pieniny – Przyroda i Człowiek* 10: 133–146.

Valde-Nowak P., Madeyska T., Nadachowski A., 1995. Jaskinia w Obłazowej. Osadnictwo, sedymentacja, fauna kopalna. *Pieniny – Przyroda i Człowiek* 4: 5–23.

Valde-Nowak P., Nadachowski A., Wolsan M., 1987. Upper Palaeolithic boomerang made of a mammoth tusk in southern Poland. *Nature* 329: 436–438.

Warszyńska J., 1970. Waloryzacja miejscowości z punktu widzenia atrakcyjności turystycznej (zarys metody). *Zeszyty Naukowe Uniwersytetu Jagiellońskiego. Prace Geograficzne* 27: 103–114.

Watycha L., 1959. Uwagi o geologii fliszu podhalańskiego we wschodniej części Podhala. *Przegląd Geologiczny* 7: 350–356.

Witkowski K., 2017. Transformacja układu korytowego dolnej Skawy. *Prace Geograficzne* 150: 41–59.

Witkowski K., 2018. Morfodynamika uregulowanego koryta rzeki górskiej. *Przegląd Geograficzny* 90(1): 137–155.

Witkowski K., Wysmołek G., 2015. Inicjalne stadium rozwoju koryta wielonurtowego Skawy w Makowie Podhalańskim. *Acta Scientiarum Polonorum Formatio Circumiectus* 14(1): 223–228.

Wojkowski J., Młyński D., Lepeška T., Wałęga A., Radecki-Pawlik A., 2019. Link between hydric potential and predictability of maximum flow for selected catchments in Western Carpathians. *Science of the Total Environment*, 683: 293–307. DOI: 10.1016/j.scitotenv.2019.05.159.

Wyżga B., Zawiejska J., Radecki-Pawlik A., 2016. Impact of channel incision on the hydraulics of flood flows: Examples from Polish Carpathian rivers. *Geomorphology* 272: 10–20. DOI: 10.1016/j.geomorph.2015.05.017.

Zgłobicki W., Poesen J., Cohen M., Del Monte M., García-Ruiz J. M., Ionita I., Niacsu L., Machová Z., Martín-Duque J. F., Nadal-Romero E., Pica A., Rey F., Solé-Benet A., Stankoviansky M., Stolz C., Torri D., Soms J., Vergari, F. (2019). The Potential of Permanent Gullies in Europe as Geomorphosites. *Geoheritage* 11(2): 217–239. DOI: 10.1007/s12371-017-0252-1.

Zuchiewicz W., 1995. Selected aspects of neotectonics of the Polish Carpathians. *Folia Quaternaria* 66: 145–204.

Zuchiewicz W., 2011. Pleistocene tectonic activity of the Polish Western Carpathians: insights from fluvial terraces. *Acta Geodynamica et Geomaterialia* 8(3): 197–224.

Zwoliński Zb., 2009. The routine of landform geodiversity map design for the Polish Carpathian Mts. *Landform Analysis* 11: 77–85.

Zwoliński Zb., 2010. Aspekty turystyczne georóżnorodności rzeźby Karpat. *Prace Komisji Krajobrazu Kulturowego* 14: 316–327.

Żytko K., 1981. Bloki i rozłamy skorupy ziemskiej. *Kwartalnik Geologiczny* 25: 428–428.