GeoJournal of Tourism and Geosites
ISSN 2065-1198, E-ISSN 2065-0817

Year XVII, vol. 52, no. 1, 2024, p.294-312
DOI 10.30892/gtg.52129-1206

THE GEOHERITAGE POTENTIAL OF THE SOUTH-EAST PAŁUKI (WESTERN POLAND) TO PROMOTE GEOTOURISM

Maria GÓRSKA-ZABIELSKA*
Jan Kochanowski University in Kielce, Institute of Geography and Environmental Sciences, Kielce, Poland, e-mail: maria.gorska-zabielska@ujk.edu.pl

Natalia BŁASZCZYK
Kielce, Poland, e-mail: nataliaj.blaszczyk@gmail.com

Izabela NOWAK
Pałucki Division of the Polish Tourist Country-Lovers Society in Żnin, Pl. Wolności, Żnin, Poland, e-mail: alpinus11@wp.pl

Citation: Górska-Zabielska, M., Błaszczyk, N., & Nowak, I. (2024). THE GEOHERITAGE POTENTIAL OF THE SOUTH-EAST PAŁUKI (WESTERN POLAND) TO PROMOTE GEOTOURISM. *GeoJournal of Tourism and Geosites*, 52(1), 294–312. https://doi.org/10.30892/gtg.52129-1206

Abstract: The aim of the work is to examine the possibilities of developing geotourism in the context of existing, but not yet recognised, geoheritage in the north-eastern Wielkopolska, western Poland. Pałuki is characterised by exceptional geodiversity, which has enormous potential for diversifying the present tourist offer. The valorisation method of selected 12 geosites was used, taking into account geomorphological, additional and utility categories. The results of the analytical part made it possible to identify the most valuable and geotouristically attractive geosites. They form two original geotourism trails under the common name of "Geodiversified Pałuki". In order to increase the possibilities of developing local geotourism, two proposals for thematic geotourism trail focusing on the most interesting, and highly rated, geosites in the research area are presented.

Key words: geoheritage, geodiversity, evaluation analysis, geotrail, geotourism, Pałuki, western Poland

* * * * * *

INTRODUCTION

Every society, every person has its own precious treasure, which is called heritage. Special emphasis is placed on cultural heritage, which is related to traditions, culture and art (Reynard and Giusti, 2018; Sisto et al., 2020; Vale Caetano and Corral Martins de Oliveira Ponciano, 2021; Pijet-Migoń and Migoń, 2022). There is no doubt that cultural heritage is extremely important for knowing and understanding our past. But we often forget what is with us every day, what has been with mankind since time immemorial. This is the geological heritage. It is a very specific kind of heritage that is difficult to perceive by the general public. It is hard for lay recipients to find texts about geoheritage in scientific literature. However, they can learn about it through oral transmission, such as storytelling (Wolniewicz, 2019). This is why the role of the expert, who is able to discover the secrets of the earth and pass them on skilfully, is so important.

Alexandrowicz (2007, cf. Urban et al., 2021) believes that geoheritage is "components of natural geodiversity that have significant value for people, scientific research, education, aesthetics, inspiration, cultural development and places that are important for social reasons". According to Carrión-Mero et al. (2018), "geological heritage is defined as a set of geological elements or geological sites (geosites) with outstanding scientific, cultural and educational values". According to Urban et al., 2020; Urban et al., 2021: "Geological heritage is the abiotic elements of nature - fragments of the Earth's crust, its relief and the processes that shape the Earth, which enable the scientific reconstruction of the history of the Earth and life on it, and the understanding of the processes that shape it, but also elements of significant importance for human culture and intellectual life". According to Ng (2022), "the terms geodiversity and related activities such as geoprotection, geotourism and geoeducation are new to most people. They are becoming more widely used as awareness of the protection of the abiotic elements of the environment has grown in recent decades, complementing a sustainable approach to environmental protection. There are many definitions of geodiversity in the literature (Zwoliński, 2004; Serrano and Ruiz-Flano, 2007; Gray, 2013, 2018), which were recently summarised by Ng (2022) into one: "the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, processes) and soil features, including their assemblages, relationships, properties, interpretations and systems. Geodiversity provides an abiotic environment and a foundation upon which biological, human and cultural activities can be carried out effectively".

Geodiversity is the result of presence within a limited area of genetically diverse abiotic resources. They are common, but only some of them - geosites - are unique and have exceptional aesthetic, scientific and educational values (Vujičić et al., 2011). If they are characterised by clear geomorphological features, they are called geomorphosites (Reynard, 2009; Carrión-Mero et al., 2020). Both have unique features for science, education and tourism. Brilha (2016) writes that they

* Corresponding author

occur *in situ* (e.g. glacial cirques, cliffs, deserts or erratic boulder) or *ex situ* (e.g. museums where geoheritage is collected, exhibited and preserved). Geosites can also be defined (Pasquaré-Mariotto et al., 2023) as "places where geological features or fragments of the geological environment are exposed on the earth's surface and can therefore be visited and studied". Gioncada et al. (2019) emphasise "the unique importance of outreach activities based on in-depth knowledge of the general and local geological significance of the proposed site".

Geosites can be as small as a single outcrop or as large and complex as the unique Dunajec gorge through the Pieniny Mountains. Fuertes-Gutiérrez and Fernández-Martínez (2010) divide them into five typological categories: point, section, area, complex area and viewpoint. Depending on their importance, they can be local, regional, national or global (Zorina and Silantiev, 2014). Geosites can also be distinguished according to their spatial appearance (Pasquaré-Mariotto et al., 2023): confined places (e.g. rock outcrops), linear features (e.g. faults), as well as features extending in the air (e.g. mountain peaks). A vantage point, a place from which one can enjoy a panoramic view of the surroundings, should not be missing from the last group. According to Migoń and Pijet-Migoń (2017) and Bruschi et al. (2005), this issue is neglected in geosite research.

Raising people's awareness of geoheritage enables them not only to understand the processes that have taken place and to anticipate those that will take place, but also to understand the relationship between man and nature, how he has affected the Earth and how Earth processes have affected man. This can lead to environmentally responsible attitudes/behaviours.

Cultural and geological heritage are often intertwined. An example related to the topic of this article are erratic boulders, sometimes named after deities (e.g. Trygław in Tychowo, the West Pomeranian Voivodeship), which were particularly worshipped in the past. Today, an educated and aware person is able to understand the world around her/him and appreciate the value of geoheritage. Unfortunately, it is impossible to recreate it on the scale of human life, which is why all initiatives aimed at preserving the geological heritage for future generations are so important.

Pałuki, known mainly as a region rich in archaeological (e.g., Pospieszny et al., 2017) and ethnographic objects, has a rich geoheritage. It is undoubtedly genetically linked to the presence and retreat of the last Scandinavian ice sheet in this area in the Upper Pleni Vistulian (Kozarski, 1995). The record of geomorphological processes and palaeoenvironmental conditions from this period, as seen by an expert in this region today, remains silent to the average tourist. However, there are numerous examples of interesting and scientifically valuable geological objects being made available to lay tourists in a simple, accessible and successful way (Mamoon, 2014; Miśkiewicz, 2016; Kubalikova et al., 2021; Zafeiropoulos et al., 2021; Evelpidou et al., 2022, Pasquaré-Mariotto et al., 2023). Also examples of Polish young glacial landforms and various forms of legally protected nature can be used for geoeducation and tourism in areas of natural value (e.g. Szyda and Karasiewicz, 2017; Górska-Zabielska and Kamieńska, 2017; Płoskonka, 2018; Górska-Zabielska, 2021).

Over time, they become geo-attractions, visited by masses of tourists who are not necessarily trained in the geosciences (e.g. the Niagara Falls in the USA and Canada, the Colorado River Canyon in the southwest of the USA or in Poland: the Pieniny Gorge of the Dunajec River or the Land of 1000 Lakes in Masuria). Geotourism is concerned with providing tourists with access to geological and geomorphological objects, combined with age-appropriate geoeducation and obligatory geoprotection (e.g. Hose, 2005, 2012; Dowling and Newsome, 2006; Górska-Zabielska, 2020, 2021, 2022, 2023; Górska-Zabielska et al., 2022). It reads the signs of the times and provides a new, diversified tourist offer. There are, e.g., examples in the literature of ecological reclamation of abandoned post-mining areas and their transformation into recreational areas (e.g. in the Upper Silesian Coal Basin in Poland – Gaidzik and Chmielewska, 2020), natural areas (e.g., in the German-Polish UNESCO Global Geopark Muskau Arch https://www.muskau-arch.eu/ - Koźma, 2011) geo-educational areas (e.g. Koźma, 2011; in the Sadowa Góra quarry area in southern Poland https://www.jaworzno.pl/osrodek-edukacji-ekologiczno-geologicznej-geosfera/ - Chećko et al., 2022) and geotourism (e.g. in the Świętokrzyskie Mountains in the central Poland – Pabian, 2015; in southern Ecuador - Carrión-Mero, 2021; on the Serifos Island in Greece – Vlachopoulos and Voudouris, 2022). The role of water reservoirs in urban areas should not be forgotten. According to Szafarczyk and Gawawałkiewicz (2023), the use of pits created after mineral extraction in urban areas as water reservoirs not only increases water retention, but also has a positive impact on the standard of living of urban dwellers by lowering the air temperature in the vicinity of the reservoir. An additional benefit of this solution is that it also reduces the cost of maintaining green spaces.

Geotourism offers tourists/recipients a range of activities, products, services and infrastructure aimed at promoting geosciences. An important element of geotourism is the educational function of georesources/tourist geoattractions (e.g. Wolniewicz, 2021; Kubalikova et al., 2021), as it satisfies the need to learn new things that characterise a geotourist. Dissemination and promotion of georesources is achieved through local governments or local action groups in widely accessible and free festivals, competitions, workshops, geowatching, orienteering walk, hiking/biking rally. There are well-known ideas for learning through play (e.g. Garofano, 2015; Rodrigues et al., 2015; Żbikowski, 2018). All of them may be an effective driving force for the sustainable development of local government units located mainly in peripheral tourist areas.

South-eastern Pałuki has facilities that would provide opportunities for the development of geotourism. It is worth knowing good models - examples of sustainable development of the region based on inanimate natural objects (e.g. Fassoulas et al., 2012; Boškov et al., 2015, Orłowska, 2017; Suzuki and Takagi, 2018; Górska-Zabielska, 2021b, 2023, Drinia et al., 2022 , Stolz and Megerle, 2022, Górska-Zabielska et al., 2022) - to make them more realistic also in Pałuki.

PURPOSE AND METHODS OF RESEARCH

Taking into account numerous examples from Poland and the world of tourist development of geological heritage objects, on the one hand, and the lack of awareness among the inhabitants and authorities of the study area that this can also be realised in the south-eastern part of the Pałuki region, on the other hand, the authors aimed to demonstrate that it is possible to diversify the tourist offer with abiotic objects of the area.

To this end, they investigated the potential of the geodiversity of the south-eastern part of Pałuki for the development of geotourism. In this article, they present the results of their field research and focus on analysing the valorisation of selected geosites for the sustainable development of the region, of which geotourism is a tool (e.g. Ehsan et al., 2013; Newsome and Dowling, 2018). According to Chrobak et al. (2021), a geodiversity assessment is the first step in identifying sites with geotourism potential. In response to the needs of geotourists to learn about the region's interesting geological past or to increase their knowledge of the region's geodiversity, the authors will use the highest-rated geosites to propose two new geotourism routes under the common name of "Geodiversfied Pałuki". The adopted objectives require the use of specific research methods. In the first stage, field research was carried out, which included:

- location (smartphone application "my GPS location") and inventory of geosites according to the adopted field protocol; special features that will be used in the valorisation analysis were recorded; in the case of an erratic boulder, the petrographic type and the type (leading or indicator) of the Scandinavian erratic were recorded (Meyer and Lüttig, 2007); the estimated volume of the boulders was calculated using Schulz's formula (1999): 0.523 × length × width × height and weight - assuming that 1 m3 = 2.75 t. At this stage, photographic archiving (Czubla and Petera-Zganiacz, 2019) and geowatching (Garofano, 2015) methods were used,

- records of geomorphological processes from the Upper Vistulian period and contemporary morphogenetic processes affecting the environment of the study area were identified,

- particular attention was paid to traces of subglacial impacts on the parent rock, subglacial and inglacial impacts on rock loading during glacial transport, and post-positional processes, i.e. modern morphogenetic processes modifying the silhouette of erratic boulders. In turn, within the framework of the chamber work, methods have been carried out and will be presented in this thesis, consisting of

- valorisation, using the point bonitation method, of 12 geosites representing natural environments (glacial, glacilimnic, glacifluvial and crenological) and 2 anthropogenic ones, but with a close link to the geoheritage; the categories and evaluation criteria (Table 1), although modelled on well-known and numerous sources (Coratza and Giusti, 2005; Serrano, González Trueba, 2005; Reynard et al., 2007; Bruschi and Cendrero, 2009; Pena dos Reis and Henriques, 2009; Pereira and Pereira, 2010; Fassoulas et al., 2012; Kubalíková, 2013; Štrba et al., 2015; Brilha, 2016; Bollati et al., 2016; Warowna et al., 2016; Carrión-Mero et al., 2021;), have been modified to suit the local context, mainly due to the nature of the young glacial relief, the rich cultural heritage and the good development of tourism infrastructure such as hotels and restaurants. The categories and evaluation criteria have been also adjusted to suit the purpose of this study.

Table 1. Criteria and categories of valuation analysis of selected geosites in south-eastern Pałuki

CATEGORIES		**CRITERIA**			
		Points			
		0	**0,25**	**0,5**	**1**
1	**Geomorphological values**				
1a	**Current state**	totally destryed	transformed by a man or/and by natural processes	transformed exclusively by natural processes	lack or low state of transformation
1b	**Educational value**	low	only relevant for experts	mean	high (e.g., several educational elements on a boulder)
1c	**Geomorphological representativeness**	invisible	low visible	visible	perfect example
2	**Added values**				
2a	**Aesthetic values**	-	low	mean	high
2b	**Cultural value**	lack		there are legends about the object; the boulder serves as a boundary	there are legends and are related to geological and geoarchaeological heritage
2c	**The vicinity of an object of animate nature protected by law**	lack	a monument of inanimate nature	NATURA 2000 area/natural and landscape complex/ protected landscape area	nature reserve
3	**Utility values**				
3a	**Availability**	lack	a hiking trail leading on an unpaved road, or only an unpaved road	paved road	paved road (asphalt)
3b	**Visibility**	invisible	limited by trees or other obstacles	visible only from a distance	possibility of close observation
3c	**Level of security**	strict security - no access	occurring in the cover of the form of protection	no protection	shaping appropriate pro-environmental attitudes
3d	**Hotel service within distance**	more than 25 km	25-10 km	10-5 km	less than 5 km
3e	**Restaurant service within distance**	more than 25 km	25-10 km	10-5 km	less than 5 km
3f	**Special offer**	Lack	local	leaflets	special offer in INTERNET

The maximum number of points to be obtained in this evaluation analysis was 12, while in individual categories it could be reached, taking into account: - Geomorphological values - 3 points, - Added value - 3 points, - Utility values - 6 points,

- dissemination of geological knowledge and promotion of geotourism by proposing new, unique in the research area, two geotourist trails under the common name of "Geodiversified Pałuki".

We intend to promote the most geotouristically attractive sites identified in the valorisation analysis by including them in the author's geotourist trail. The geoproduct can only fulfil its potential if it is properly and effectively publicised and integrated into the network of other local trails. They must be equipped with a well-designed, clear informative panel with a small amount of text, different levels of text and descriptive graphics (e.g. Kicińska-Świderska and Słomka, 2004; Stolz and Megerle, 2022). It is worth supplementing the board with a QR code, where the interested geotourist will receive an additional dose of knowledge. More traditional forms of knowledge transfer should not be forgotten either - tourists should have access to leaflets or brochures discussing the material, educational, environmental and cultural values of the geosite and its immediate surroundings. Upgrading the skills of local guides and teachers will make it possible to organise walks with a geo-interpreter, who, by providing experiential guided tours, will present the geological past of the region in a professional, engaging way that can be understood by the layman (see e.g. Tetik, 2016, Van Geert, 2019, Górska-Zabielska, 2023).

The social responsibility of science through its innovative popularisation is a very current trend in today's world. Attractive geo-objects, by conveying specialised knowledge (e.g. Macadam, 2018; Pasquaré-Mariotto et al., 2023), reveal the backstage of the geological past without destroying it and preserve it for future generations.

Criteria and categories of valuation analysis

An extremely important stage of the evaluation analysis is the selection of categories and criteria for assessing the geosites in the context of their current functioning and future participation in the development of geotourism. Therefore, categories and criteria for assessing the geotourism attractiveness of the previously presented geoheritage objects qualified for analysis have been established. At this point, the authors' contribution to the creation of a set of evaluation criteria should be clearly emphasised. The authoresses followed known examples from the literature (e.g. Pereira et al., 2007; Kubalíková, 2013; Brilha, 2016; Górska-Zabielska et al., 2019; Saurabh et al., 2021; Fancello et al., 2022; Marescotti et al., 2022). However, due to the specificity of the research area, they modified these parameters in relation to the characteristics and uniqueness of geosites in the young glacial relief which is abundant in the south-eastern part of Pałuki (see Sisto et al., 2020). Such modifications have been made in criteria 1b (educational value), 1c (geomorphological representativeness), 2b (cultural value; there are legends about the object; the area is rich in geoarchaeological heritage) and in criteria 3d and 3e (utility values; hotel and restaurant at a distance corresponding to the tourist infrastructure development of the study area).

These adjustments were made to suit the purpose of this study. The categories and criteria are listed in Table 1. The categories were divided into three groups according to geomorphological values (enabling knowledge transfer) and additional and utility values (meeting the needs of tourists). The evaluation criteria were described in detail along with the points that could be allocated. A geosite could receive between 0 and 1 point in each of the 12 categories. A maximum of 12 points could be awarded to each surveyed site in the overall analysis (Table 2).

Table 2. Assessing the Pałuki geosites according to their geotourism attractiveness
(Red font of digits indicates the highest score in a particular group of values)

	Geomorphological values				Added values				Utility values							
Object No.	1a	1b	1c	Σ	2a	2b	2c	Σ	3a	3b	3c	3d	3e	3f	Σ	sum
1	0,5	0,25	1	1,75	1	0	0	1	0	1	0,5	0,5	0,5	0	2,5	5,25
2	0,25	0,25	0,5	1	1	0	0	1	0,25	1	0,5	0,5	0,5	1	3,75	5,75
3	0,25	0,25	1	1,5	1	0	0	1	0,25	0,25	0	0,5	0,5	1	2,5	5
4	1	1	0,5	2,5	0,25	0	0,5	0,75	0,5	1	0,25	1	1	0	3,75	7
5	0,25	1	1	2,25	1	1	0,5	2,5	1	0,5	0,25	1	0,5	1	4,25	9
6	0,25	1	1	2,25	1	1	0,5	2,5	0,25	1	0,25	0,5	0,5	1	3,5	8,25
7	0,5	0,25	0,5	1,25	0	0,5	0	0,5	1	1	1	1	1	0	5	6,75
8	0,25	0,25	0,25	0,75	0	0	0	0	1	1	1	1	1	0	5	5,75
9	1	1	1	3	1	0,5	0,5	2,0	0	0,25	0,25	1	1	1	3,5	8,5
10	1	1	1	3	0,25	1	0	1,25	0	0,25	1	0,5	1	1	3,75	8
11	1	1	1	3	1	1	0,5	2,5	0,25	1	0,5	0,5	0,5	1	3,75	9,25
12	1	1	1	3	1	1	0,5	2,5	1	1	0,25	1	1	1	5,25	10,75

Point ranges: 5-7 7,25-9,50 9,75-10,75

Geomorphological values: 1a - Current status, 1b - Educational value, 1c - Geomorphological representativeness.
Added values: 2a - Aesthetic values, 2b - Cultural value, 2c - Neighbourhood of an animate nature object protected by law.
Utility values: 3a - Accessibility, 3b - Visibility, 3c - Degree of protection, 3d - Hotel services at a distance from the boulder, 3e - Restaurant services at a distance from the boulder, 3f – Promotion. Geosite number: 1 - erratic boulder in the forest buffer zone on the slope of Jabłowska Hill, 2 - anthropogenic lake in the area of the former limestone quarry in Piechcin, 3 - artificial geological outcrop in the area of the Wapienno Mining Plant, 4 - erratic boulder on the high, western shore of the Głęboczek Wielki Lake, 5 - St Hubert's Spring, 6 - erratic boulder "Kamienny Dom", 7 - erratic boulder in Czewujewo, 8 - a heap of erratics in Czewujewo, 9 - subglacial trough of the Lake Ostrówieckie, 10 – the “Turek” Hill, 11 – the Pniewy Lake, 12 – the Rogowskie Lake

Study area and its Quaternary geodiversity

According to the physical and geographical regionalisation of Macias et al. (2021), Pałuki is located within the macroregion of the Greater Poland Lake District (315.5) and its mesoregions (Figure 1) in the northern part of the Żnińsko-Mogińskie Lake District (315.58), and the eastern part of the Chodzieskie Lake District (315.53). As noted by Skoczylas (2006), a small northern and northeastern part of Pałuki lies in the Toruń-Eberswald pradolina, which, with reference to Kot et al. (2021) denotes the mesoregion: Central Noteć Valley (315.34) and Toruńska Valley (315.35).

The etymology of the word 'Pałuki' has been explained in various ways. Researchers (e.g., Kozierowski, 1924, cf. Adamczewski, 2002) are of the opinion that Pałuki is a topographical name. Since Pałuki (Polish *łuk* – Eng. *arch*) has a word-forming segment that means 'arch', the gently curving hills of this young post-glacial landscape could have given the region its name. There is also possibility (Świrko, 1964), that the name Pałuki originates from an old Slavic root: łęg / lye / łuk / łuh - meaning wet grass or marshes situated over a bend or arc of a river or lake. There is also an idea that the word Pałuki derives from the name of fishing nets, 'pałuk', which can still be found in the area. The study area covers four municipalities: Barcin, Łabiszyn, Gąsawa and Rogowo in the Żnin county and the Dąbrowa municipality in the adjacent Mogilno county (Figure 2). They belong to the Kujawsko-Pomorskie Voivodship. The twelve surveyed geosites are located in this region.

During the Pleistocene, a geological epoch that lasted from about 2.6 million to 11.7 ka BP, the Scandinavian ice sheet entered Poland several times. Its last maximum extent in the vicinity of Leszno during the Vistula Glaciation (also called the Weichselian) dates back to about 20 ka BP (= thousand years before present; Kozarski, 1995). As a result of climate change, the ice sheet began to retreat northwards. It was not a uniform movement, but an oscillating one - the ice front stopped along the way, first north of Poznań (during the Poznań subphase) and then for a short time near Brzeźno, each time leaving/revealing a hilly relief.

The deglaciation of the Pałuki area occurred between 18.8 ka BP (Poznań subphase) and 17.7 ka BP (Chodzież phase) (Kozarski, 2005). The shrinking ice sheet left behind many different shapes and deposits. This young glacial landscape is basically characterised by a moraine plain with little diversified relief (flat moraine plateau) (Sydow and Machowiak, 2004). The latitudinal valley of the Wełna River (marginal valley origin) and the associated system of lake channels cut into the plateau create a more varied landscape. Today they are filled with the waters of Tonowskie, Wolskie and Rogowskie Lakes, as well as Sobiejuje Duże and Mały Żnińskie Lakes. Larger deviations are associated with the moraine hill zones of the recessionary Ryszewo Oscillation (Kozarski, 1962) on the southern edge of the study area (south of Rogowo and Gąsawa) and the Chodzież phase (17.7 ka BP, Kozarski, 1995) in the north of the region. There is no shortage of glacial (fluvioglacial) accumulation forms (outwash plains, kames) and erosional forms

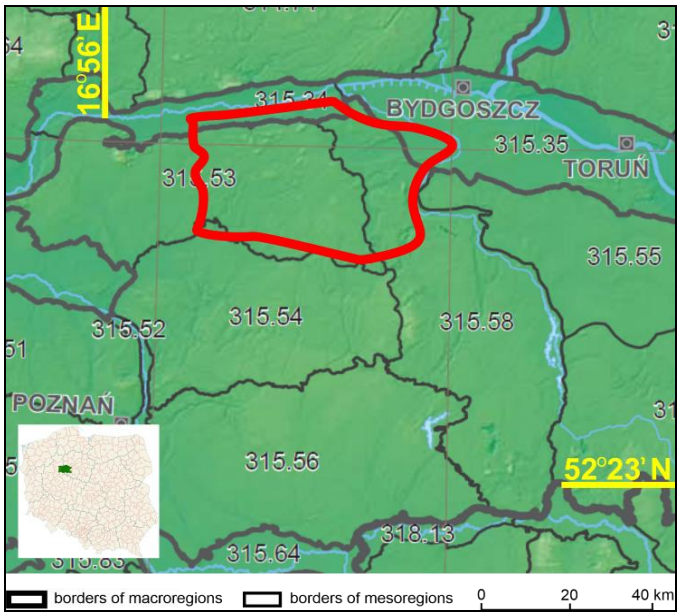

Figure 1. Location of the Pałuki region (red line) against the background of the macro- and meso-regions of this part of Poland. The study area is located in the SE part of Pałuki. After: Macias et al. (2021), changed

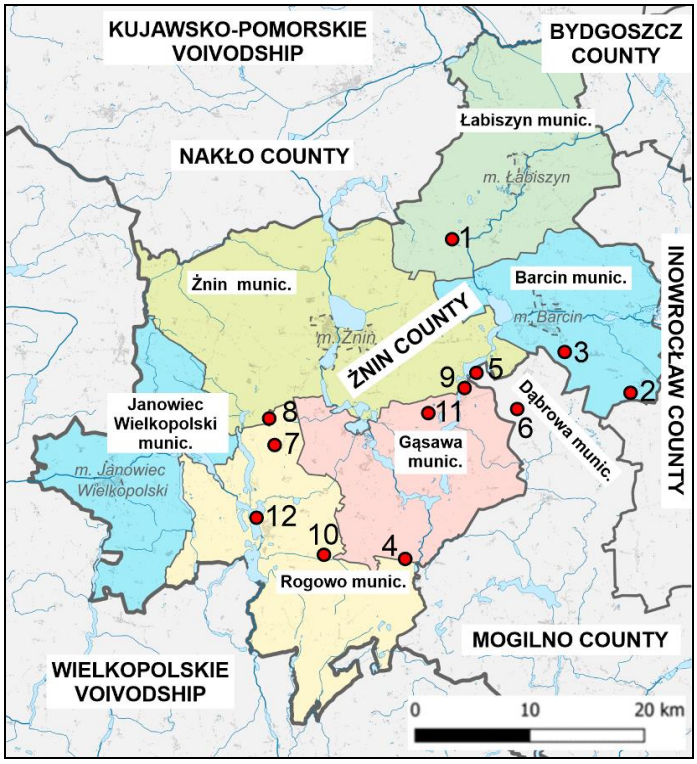

Figure 2. Location of 12 studied geosites within 4 municipalities Łabiszyn, Barcin, Gąsawa and Rogowo in the Żnin county and within the Dąbrowa municipality in the Mogilno county, in the south-eastern Pałuki. Numerical explanations: 1 – erratic boulder in the forest buffer zone on the slope of Jabłowska Hill, 2 – anthropogenic lake in the area of the former limestone quarry in Piechcin, 3 – artificial geological outcrop in the area of the Wapienno Mining Plant, 4 – erratic boulder on the high, western shore of Głęboczek Lake, 5 – Saint Hubert's Spring, 6 – erratic boulder "Stone House", 7 – boundary erratic boulder in Czewujewo, 8 – a heap of erratics in Czewujewo, 9 – subglacial channel Ostrówieckie Lake, 10 – "Turek" Hill, 11 – Pniewy Lake, 12 - Rogowskie Lake

(e.g. subglacial channels, now mostly used by streams, meltwater valleys, depressions left by dead ice - meltwater ponds). In addition to glacial and fluvioglacial processes, the relief includes complexes of fluvial, crenological, aeolian and swamp formations (Sydow and Machowiak, 2004), which together give this small area great geodiversity. In the Pałuki area, there are numerous forms under legal protection (Nature Protection Act, 2004). Among the forms of protection (http://crfop.gdos.gov.pl/CRFOP/index.jsf) we can mention the Żnińskie and Rogowskie Lakes Protected Landscape Area, natural and landscape complexes of lakes in the Rogowo Commune, Natura 2000 areas of the Gnieźnieńskie Lake District and the Barcińsko-Gąsawska Ostoja, the Długi Bród ecological utility and numerous monuments of abiotic nature (erratic boulders). In the latter group, three erratic boulders in the western and south-western part of Pałuki (Górska-Zabielska, 2010) and nine in the eastern and northern part of the region (Górska-Zabielska, 2022) should be mentioned, as well as those included in the Central Register of Geosites of Poland (managed by the Polish Geological Institute - National Research Institute). Many of the listed forms occur within forest communities.

Finally, it is worth mentioning that Pałuki is a region rich in archaeological and ethnographic sites. The prehistoric cultural heritage in the immediate vicinity of the lakes is well known to archaeologists. In the context of the functioning Archaeological Museum in the nearby village of Biskupin (https://biskupin.pl/), there is no need to expose these inaccessible geoarchaeological resources to anthropopressure (cf. Sisto et al., 2020).

Overview of geosites in south-eastern Pałuki

Given the large number of georesources in the study area and taking into account the above definitions, it was decided to characterise 12 geosites in detail. In the opinion of the authoresses, their educational and aesthetic value distinguishes them from the other georesources of the studied area. The authoresses know the region with its different georesources and have decided to disseminate only 12 of them, which meet the categories (Table 1). They are discussed in the order given in Figure 2.

1.Erratic boulder in the forest buffer zone on the slope of Jabłowska morainic hill (17°51'01" E, 52°54'52" N)

The unnamed boulder (Figure 3) on the south-eastern slope of Jabłowska Hill (152 metres above sea level) is the indicator erratic boulder - Åland rapakivi granite - with a characteristic internal structure and texture. It was eroded by the Scandinavian Ice Sheet at the base of today's Åland Islands on the Baltic isthmus between Stockholm and Helsinki. Its measured dimensions are: length 3 m, width 2.31 m, height 1.53 m. The converted dimensions (according to Schulz, 1999) are: volume 5.55 m^3, weight 15.25 t. The boulder has not been moved since its glacial deposition some 18 ka BP, so it is *in situ*, which is its greatest scientific and cognitive value. The boulder is in the middle of an agricultural field, making ploughing difficult. The owner of the field wanted to remove it, but the dimensions of the geological object exceeded his imagination. Today, unearthed, it is surrounded by a collar of sediment. It can only be reached in winter (Figure 3), when the vegetation is not growing.

Figure 3. The erratic boulder on the arable slope of Jabłowska Hill is accessible only in winter

The erratic boulder in question is not legally protected, which may indicate that it was excavated in the recent past (Górska-Zabielska, 2022). However, it was long enough for lichens to colonise its surface in some places.

2. Anthropogenic Piechcin lake in the area of a former quarry

The Piechcin Lake (Figure 4) is a former mining pit, which was part of the "Kujawy" Mining Plant. The plant's activities covered the area occupied by the Lafarge Cement SA - ZG "Kujawy" mining and processing plant in Bielawy, with a total area of approximately 1,092.5 ha (Ostręga et al., 2011). The Piechcin mine was closed down in 1966 following protests from local residents. Until then, the exploitation of the deposit below the groundwater level determined the recultivation of the excavation towards the water. The area around the mine was reforested. Another source (www.polskaniezwykla.pl) mentions that "an old quarry, closed since the 1960s, created a lake with an area of approximately 4.5 ha and a maximum depth of 25 m. White limestone rocks give the water a unique bright turquoise colour. Visibility ranges from 8 to 12 m. After rain, visibility is reduced by limestone deposits washed down from the slopes. At the bottom of the reservoir there are remains of the former mining operations, including pipes, steel plates, stairs, but also two sunken Fiat 126 cars, car tyres, a wooden 6.5 metre cabin sailing boat and a 12-metre sea yacht". At present, the artificial lake has been developed as a local diving centre, so the reservoir is already being used for recreation and relaxation.

3. Artificial geological exposure on the premises of the Wapienno Mining Plant

Mining in the Pałuki area goes back more than 150 years, resulting in numerous forms of anthropogenic sculpture.

One of them is an artificial exposure in the area of the largest stone raw material mine in Poland (Ostręga et al., 2011) - the "Wapienno" limestone mine belonging to the "Kujawy" Mining Plant (Figure 5).

It is an open-cast mine (excavation depth 60-100 m, ultimately 120 m) of Jurassic limestone raw material for the needs of the cement industry, with an annual mineral extraction of approximately 5 million tonnes (Pikies, 2009). The limestones and marls (marine origin) in the roof of the excavation are covered by Pleistocene sediments: the Wapienno Formation (fluvial sediments) in the lower part, and the Barcin Formation (glacial sediments) in the upper part. The mine is located on a moraine plateau formed by a thin ground moraine.

Figure 4. The anthropogenic lake in Piechcin is today a local diving center

Figure 5. The relief of anthropogenic genesis in the open pit of the "Wapienno" Jurassic limestone mine, belonging to the "Kujawy" Mining Plant, has great potential for the development of local geotourism

The Wapienno excavation will soon be connected with the Bielawy excavation (Kupczyk, 2010, cf. Drążek et al., 2010). The author adds that: "Over the course of more than 100 years, the quarries have managed to blend into the landscape of the Barcin area. These quarries are perceived as an integral part of the landscape with certain cultural and utilitarian values that enrich the geodiversity of the environment. For a naturalist, ecologist and biogeographer, they are a special research area". As the above-mentioned author further points out, areas transformed by humans and initially devoid of life are slowly coming back to life, with the appearance of plants and animals (e.g. mouflons from Corsica or Sardinia, acclimatised for hunting purposes; Ostręga et al., 2011). At present, the quarry itself is not open to the public (it is not possible to approach the site legally), except from a vantage point with a magnificent view of the mine. In the future, access to the mine site could be developed, not only because of its unique anthropogenic relief, but also because of the exposed geological riches. It is a geosite registered in the Central Register of Geosites of Poland (http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails.aspx?id=202) and was elaborated by Pikies (2009). The concept of recultivation and final development of the "Wapienno" limestone mine is presented by Ostręga et al. (2011). Figure 6 comes from this work, which clearly shows the planned functional zones for the development of the post-mining area.

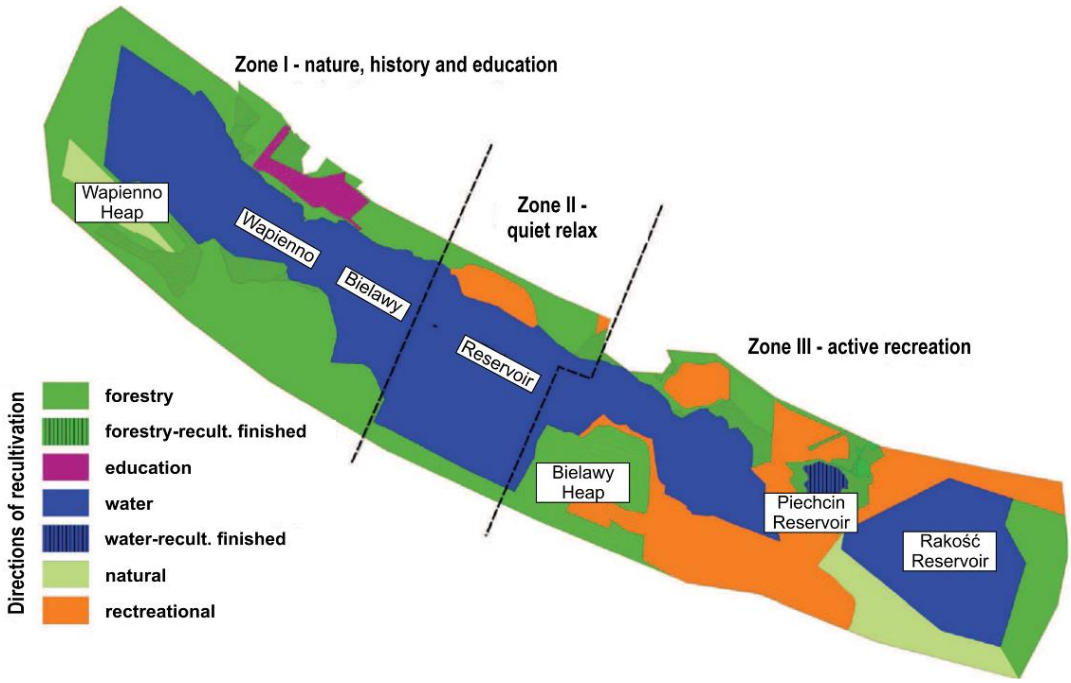

Figure 6. Designed functional zones for the development of the post-mining area of the Kujawy limestone mine reclamation plant (Source: Ostręga i in. (2011), changed)

4. An erratic boulder on the high, western shore of the Głęboczek Wielki Lake (52°42’06.3”N 17°48’10.5”E)

The unnamed boulder (Figure 7), located on the western, forested shore of the Głęboczek Wielki Lake (52°42'06.9"N 17°48'10.7"E), is the indicator erratic boulder - Åland rapakiwi granite - with characteristic feldspathic ovoids and round quartz crystals (Czubla et al., 2006). Its dimensions are: length - 1.2 m, width - 0.9 m, height - 0.8 m. The following conversions are: volume - 0.45 m^3, weight - 4.2 tonnes. The erratic boulder is anchored in the ground on the high shore of the Głęboczek Wielki Lake. It bears traces of anthropogenic destruction - fragments of a broken boulder lie nearby. This fact can be used in the geointerpretation of the site, drawing attention to its geoeducational, geoconservation and pro-environmental significance. Access to the boulder is difficult as there is no path to it. The area where the erratic boulder is located is not protected by law, but it is in the immediate vicinity (from the north) of the Gąsawka Spring Water Reserve, which is located within the Żnińskie Lakes Protected Area and the NATURA 2000 - Ostoja Barcińsko-Gąsawska Habitat Area. The erratic boulder also has great geotourism potential, as its *in situ* location in the eastern branch of the Żnin subglacial trough is of great scientific and cognitive value.

Figure 7. The indicator erratic boulder (Åland rapakivi) on the western, high shore of the channel Głęboczek Wielki Lake, which is visible in the background of the photo

5. Saint Hubert's Spring (52°49’37.59”N 17°51’43.41”E)

A small spring (Figure 8) emerges from the eastern slope of the Ostrów Gorge (near the town of Wiktorowo). The spring, located in Pleistocene formations - fluvioglacial sands and gravels of the Vistula glaciation (Uniejewska and Nosek, 1990), has been walled up and is currently located in a chapel built of erratic rocks of different sizes and finishes. The water flowing out at a rate of 8 litres per minute turns the underlying rocks a rusty colour, indicating that the water has a very high iron content. There is a legend associated with the chapel, according to which Borislav was an avid hunter and killed all the animals he encountered. The hunt was very successful, which worried his mother, who said that Satan himself must be behind it. When Borislav went hunting and missed Sunday Mass, his mother prayed fervently for him. Borislav saw a beautiful deer, which turned out to be led by Lucifer himself. The deer attacked him and the wounded Borislav could not reach the water. Then, thanks to his mother's prayers, a spring gushed out of the ground and, after washing his wounds, Borislav made an immediate recovery. Since then, the site has become a place of worship for the locals, who have built a chapel there dedicated to St Hubert - the saint patron of hunters (see the plaque next to the site for more information). It is worth mentioning the written records of Pałuki legends and folk tales. They contribute to a better understanding of the natural and, above all, immaterial cultural heritage of the area. The St Hubert's Spring, elaborated by Szarafin (2016), is registered in the Central Register of Geosites in Poland. (http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails.aspx?id=4321).

Figure 8. St Hubert's Spring

6. "Stone House" erratic boulder (17°54’50”E, 52°48’12”N)

Located in the forest between the villages of Annowo and Szczepankowo, it is the largest erratic boulder in Pałuki (Figure 9). Its measured dimensions are: length - 4.2 m, width -3.2 m, height - 2.5 m. However, the following conversions are: volume - 18.67 m^3, weight -51.35 t. From a petrographic point of view, it is most likely an anorthosite, which has its outcrop in the area between Uppland and the Åland Islands (Górska-Zabielska, 2022). From there it was carried by the ice sheet during the Vistulian glaciation about 18 ka BP and deposited on its retreat after the Ryszewo Oscillation in the same

place where it is found today. Its *in situ* location is the most important scientific asset of the site. Górska-Zabielska (2022) draws attention to the rounded edges of the boulder, which perfectly illustrate the destructive processes that took place in the glacial environment in the past. However, in the upper part of the rock, there are traces of contemporary morphogenetic processes that have sculpted the surface of the studied object in the form of exfoliation (surface weathering, mainly physical). Unfortunately, the rock shows anthropogenic alteration, as much of it has been splintered, making the site less valuable. The "Stone House", like many erratic boulders in Poland, is associated with the legend of an evil sorcerer who kidnapped children and turned his castle into an erratic boulder (there is an informative panel next to the site). It is not difficult to reach the object, as the boulder is located next to a forest path. There are also signs leading to the boulder, e.g. drawn on another erratic boulder (Figure 10). There are two informative panels with the same information next to the boulder. The table is not a sufficient source of knowledge, as there is no information about where such a large object appeared in the Pałuki area. The geoeducational information is fragmentary (size of the object, circumference, location and legend). It would be worthwhile to use good models (e.g. Górska-Zabielska, 2010, 2020, 2022, 2023; Stolz and Megerle, 2022) to improve the transfer of knowledge about this largest erratic boulder in the region.

Figure 9. „Stone House" erratic boulder – the biggest one in the Pałuki region

Figure 10. A signpost on an erratic boulder

Figure 11. Boundary erratic boulder in Czewujewo is located between fields, which belong to two farmers; the dotted line follows the boundary

The boulder is located in the Żnińskie Lakes Protected Landscape Area and is a monument of abiotic nature protected by law. It is also registered in the Central Register of Geological Sites in Poland (http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails.aspx?id=4305). The elaboration was prepared by Szarafin (2013).

7. An erratic boulder in Czewujewo (52°46'48.8"N, 17°39'21.7"E)

The erratic boulder (Figure 11), located in the small village of Czewujewo (52°46'48.9"N 17°39'21.7"E), lies on the divide separating fields of two farmers. The object therefore has a boundary function. In the past, erratic boulders were not only used as building material, but were also associated with a cult or used for boundary purposes. Similar examples are known from literature, e.g. from the Drawskie Lake District (Górska-Zabielska and Kamieńska, 2017; Górska-Zabielska, 2021) and from the Gowarczów commune in the north-western part of the Świętokrzyskie Voivodeship (Górska-Zabielska et al., 2020). The erratic boulder in Czewujewo is a gneiss, extruded by the Scandinavian Ice Sheet from the base of the Baltic Shield, transported during the Vistulian Glaciation and deposited in the surrounding field about 18.5 ka BP (Kozarski, 1962, 1995). From there it was moved to its present location, most probably due to obstacles in the field work. Its measured dimensions are: length - 1.3 m, width - 0.8 m, height - 1.3 m. The converted dimensions are: volume - 1.94 m^3, weight - 3.2 tons.

8. A heap of erratics in Czewujewo (52°47'53.8"N 17°39'24.9"E)

Figure 12. A heap of erratics in Czewujewo - anthropogenic landform formed from boulders and gravel from surrounding fields

Figure 13. The impact of artistic and educational workshops at the Tomaszówka Ranch in Czewujewo. The pebbles come from the village's erratics

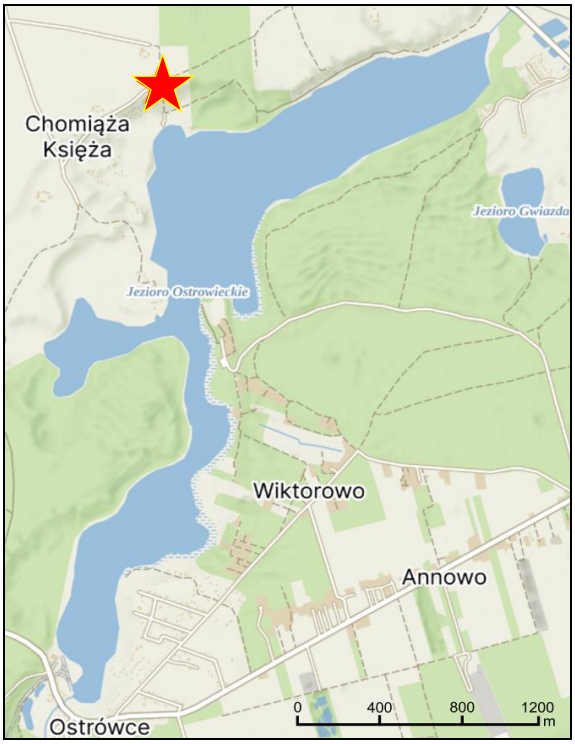

Figure 14. The Ostrówieckie Lake in a subglacial channel; ★ marks the place where the photograph (Figure 15) was taken (Source: https://pl.mapy.cz/zakladni? l=0&x=17.8567915&y=52.8198022&z=14)

In the northern part of the village of Czewujewo there is an anthropogenic heap, a heap of boulders and erratic pebbles collected from the surrounding fields during spring ploughing (Figure 12). At first glance, it might seem that such a collection of stone material would be a waste of money and of no use to anyone. Nothing could be further from the truth. The erratics of different size have great educational potential (geographical and geological workshops in nearby Tomaszówka Ranch (www.ranczotomaszowka.pl) and creative and artistic potential (painting on stone workshops there; Figure 13). The workshops are held for people of different ages under the supervision of qualified geo-interpreters and visual arts educators. By the way, it is worth noting that the Tomaszówka Ranch is an eco-agrotourism farm managed in a naturally valuable area (Jalinik, 2009).

9. Subglacial channel of the Ostrówieckie Lake

The Ostrówieckie Lake (Figures. 14 and 15), together with the long, deep lakes to its north and south, is located in a subglacial trough formed during the advance of the Scandinavian Ice Sheet about 18-20 ka BP. Channel lakes are formed "as a result of the erosion of subglacial water" (e.g., Boulton and Hindmarsh, 1987; Piotrowski, 1997; Rdzany et al., 2020). "The orientation of the trough is generally consistent with the former direction of movement of the ice sheet and perpendicular to its front" (Jaroszewski et al., 1985). When the blocks of dead ice, buried in the fluvioglacial sediments of all hollows (the subglacial channels as well), began to melt away as the ice sheet retreated, they were filled with meltwater and, over time, flowing surface water.

According to Choiński (2007), the area of the lake is 157.5 ha and its maximum depth is 28.6 m. The site on the Ostrówieckie Lake in Chomiąża Księża was chosen to investigate the geotourism potential of the study area because of its unique vantage point (Figure 15). From the terrace of the small Brzezina Resort, a 2.5 km long subglacial trough and the Ostrówieckie Lake water filling it, can be seen to the south (Figures. 14 and 15). So that not only the guests of the recreation centre can see this impressive view, a public viewing platform should be built (like the one in Lubin on Wolin Island, NW Poland, from which one can see the reverse delta of the Świna River). The local branch of the State Forest could be interested in the idea of such a geotouristic development of this place. The legend of the fishermen's island (Figure 15) on the Ostrówieckie Lake is another attraction (Malinowski, 2023).

Figure 15. View towards the south along the channel Ostrówieckie Lake from the Brzezina Resort terrace ★. The islet visible in the photo is shrouded in the legend of its angler

Figure 16. The small hill "Turek" (indicated by an arrow) - within the end moraines of the recessionary Ryszewo Oscillation of the Vistulian glaciation - is visible in background of the picture

10. „Turek" (pol. - a resident of Turkey) Hill

It is a small hill (125.6 m above sea level) located between the towns of Gałęzewo and Ryszewko, near the buildings of the Gałęzewko Colony. This place was once called "Sahara" because of its sandy soil. It belongs to the series of terminal moraines of the Ryszewo Oscillation of the Vistulian glaciation in this area (Figure 16). Although "Turek" is not the highest peak in Pałuki, it has its own history and legend. According to the legend, the hill was built out of sand by Turkish warriors on the orders of their leader, whose son had been kidnapped by the Pałukis and who had set him conditions - to leave the land of the Pałukis and not return, and he would get his son back.

The chief ordered the warriors to build a hill to show their strength. However, the Pałukis did not give in, and the Turkish units that followed were killed on unknown ground. The chieftain retreated and the hill remained a symbol of love for Pałuki and the courage of its inhabitants. According to oral tradition, during the Second World War the Germans built an observation tower on the top of "Turek" Hill, which also served as a triangulation tower. The tower was demolished many years ago. In the 1970s it was decided to reforest the hill, as its sandy soil made it unsuitable for agriculture (www.ryszewo.pl). The area is now privately owned.

11. Pniewy (or Pniewskie) Lake

The Pniewy Lake (Figure 17) is of glacial origin, i.e. formed as a result of melting ice (blocks of dead ice) in sediments, deposited on the foreland of the shrinking Vistulian ice sheet.

Figure 17. Pniewy Lake on an archival photo from 1936 (Source: Zwierzykowski, 2021)

According to Choiński (2007), the area of the lake is about 21 ha and the maximum depth is 18.5 m. The beach area is developed for tourism and recreation for all those who want to get away from the hustle and bustle of the city. No wonder, as the lake is surrounded by a forest and has very clean water, and the island in the lake adds to its charm.

Malinowski (2010) describes a legend that explains the creation of a tree-covered island in the middle of the Pniewy Lake (Figure 17). On the shore of the lake there used to be a rich nobleman's manor owned by the wise Pniew. He also had a daughter, Bogumiła, who was famous for her helpfulness. On the other side of the lake lived an impoverished nobleman who had a son, Gniewosz. Both men treated others badly. One day Bogumiła and Gniewosz met by chance. The boy immediately fell in love with the girl and tried to propose to her, but the engagement was rejected. Soon Bogumiła married another man and Gniewosz decided to take revenge. During the wedding party, he sailed to the Pniewo estate and set fire to the barn. All the wedding guests burned to death. Gniewosz escaped by boat and stopped in the middle of the lake to see the effect of his revenge. When he tried to swim away, it proved impossible. Soon his boat began to turn into a motionless island. He jumped out and tried to swim, but his legs began to grow into the ground and he turned into a tree. This was his punishment for killing innocent people.

12. Rogowskie Lake

It is a post-glacial channel lake (Figure 18). Together with the neighbouring water bodies, it is under legal protection in the form of the Rogowo Lakes Protected Landscape Area. According to Choiński (2007), the lake has a surface area of 285.3 ha and a maximum depth of 14.3 m.

On the shore of the Rogowski Lake, there is a municipal beach with attractive leisure facilities refurbished in 2022.

The lake was known and used as early as the Lusatian Culture (Middle and Younger Bronze Age and Early Iron Age - c. 1300 BC - 400 BC; Pospieszny et al., 2017), as people were willing to settle on its shores and in the vicinity – the numerous red asterisks (Figure 18) show archaeological sites located there. The legend "Rogowo dyke" (https://www.radiopik. pl/?idp=100&idx=1084) tells about the interesting fate of the inhabitants of Rogowo.

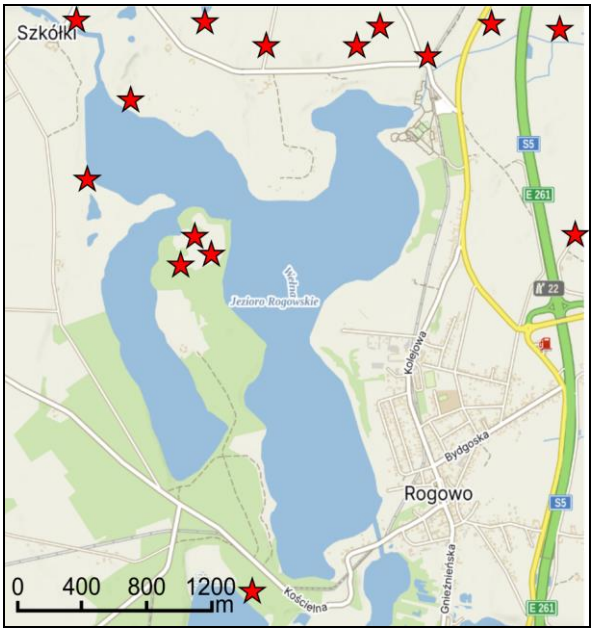

Figure 18. Archaeological sites (red asterisks) of the Lusatian culture on the shore of the Rogowskie Lake and in its vicinity (Sources: mapy.geoportal.gov.pl and Geoenvironmental map, sheet Rogowo, scale 1:50,000, Polish Geological Institute National Research Institute)

Valorisation analysis of twelve geosites in the study area

In the light of the conducted evaluation analysis (Table 2), taking into account the adopted categories and criteria (Table 1), in the south-eastern part of Pałuki there are objects with different assessments of geotourism attractiveness. The sum of the points of the evaluated geomorphological, added and utility values (Table 2) of twelve objects qualified for this analysis are in the range of 5-10.75. There are 6 objects in the research area with a value between 5 and 7. There are five geosites in the intermediate group, moderately attractive in terms of geotourism. Only one site was rated as very attractive for geotourism. There is no geosite that has been given zero points due to the valuable geoheritage of the research area. In the category of geomorphological values, the sites with the highest score (3) are: the Ostrowieckie Lake subglacial channel (no. 9 in Table 2), the "Turek" hill (no. 10), the Pniewy Lake (no. 11), and the Rogowskie Lake (no. 12). The high geomorphological representativeness of these geosites explains their high score. Due to their excellent condition (undamaged), they have high geo-educational potential for interested public.

The second place in this category was taken by an unnamed erratic boulder on the western shore of Głęboczek Wielki Lake (No. 4). Its high score - 2.5 - is due to its good condition and high geo-educational potential.

Only one site - an anthropogenic lake on the site of a former limestone quarry in Piechcin - scored one point in the geomorphological values category of the assessment analysis. Its low score is due to the fact that it is not a natural creation, but the result of human activity. The lake is not an educational facility, but has been converted into a diving centre.

In the category of added value, the geosites with the highest number of points - 2.5 – are: the Rogowskie Lake (no. 12), St. Hubert's Spring (no. 5), the Pniewy Lake (no. 11), and "Kamienny Dom" erratic boulder (no. 6). The Rogowskie Lake is characterised by high aesthetic values, which are appreciated by tourists who like to choose it for water recreation. The lake is located within the Rogowo Lakes Protected Landscape Area, and numerous archaeological sites have been identified in several places on the shores of the lake and in its vicinity (Figure 19).

St. Hubert's Spring, the Pniewy Lake and the "Kamienny Dom" erratic boulder were chosen for their high aesthetic and cultural values (the objects are shrouded in legends, which are also related to geomorphology), as well as for their proximity to objects of living nature protected by law, which further increases their geotouristic and educational value.

The second place in this category went to the subglacial channel of the Ostrówieckie Lake (No. 9; 2.0 points). It provides beautiful panorama views, is shrouded in legend and is located within a protected landscape area. In the category of added value, there is one site that received the lowest number of points in the evaluation analysis - 0. This site is a heap of erratics in the village of Czewujewo. The low score is due to the lack of aesthetic values, there are no legends associated with it. The stony material was transported from the surrounding farmland due to obstruction in arable field.

The geoobject is not located in the immediate vicinity of one or more objects of biotic nature protected by law. In the third **category of utility values**, the geosite with the highest score is the Rogowskie Lake (No. 12) with 5.25 points. This score is due to the nearby and very attractive tourist development, rich cultural heritage, and excellent (compared to other geosites surveyed) promotion and accessibility.

Second in this category is St Hubert's Spring (No. 5) - 4.25 points. This high score is due to its excellent accessibility and very good promotion, as well as its proximity to tourist infrastructure.

The lowest scores (2.5 points each) in the category of utility values were obtained by: an artificial geological outcrop on the premises of the Wapienno Mining Plant (No. 3) and an erratic boulder in the forest buffer zone on the slope of the Jabłowska Hill (No. 1). The low rating of both sites is mainly due to poor accessibility (the boulder is almost impossible to reach), but also to the distance from hotels and restaurants. In the case of the boulder, an additional problem is the complete lack of promotion. Results of valuation analysis of geosites in south-eastern Pałuki.

As a result of the evaluation analysis carried out on twelve geosites in south-eastern Pałuki, in order to assess and valorise their geotourism potential for the development of geotourism, it should be noted that

- the highest rated geosite is the Rogowskie Lake (No. 12, Table 2), which received 10.75 points (out of 12 possible points),
- the lowest rated geosite is the artificial geological outcrop in the area of the Wapienno Mining Plant (no. 3, Table 2), which received 5 points (out of 12 possible).

The Rogowskie Lake is exceptionally attractive compared to other sites in the area. It is the only one of the 12 geosites surveyed to receive points in all but one category. Moreover, the lake gained this attractiveness thanks to the highest score (5.25 points) in the category of utility values. In the category of geomorphological values, the Rogowskie Lake was placed with the maximum number of points (3 points) in one place with the subglacial trough of the Ostrówieckie Lake (No. 9), the "Turek" Hill (No. 10) and the Pniewy Lake (No. 11). The Rogowskie Lake is valuable from the point of view of prehistoric cultural heritage; there is also a legend connected with it, which mentions post-glacial surface deposits.

The second most attractive object according to the evaluation analysis is the Pniewy Lake, which scored 9.25 points. Like the Rogowskie Lake, it received the maximum number of points in the category of geomorphological values. It lost the most points due to its low score in the utility value category (long distance from restaurants and hotels). St Hubert's Spring came third in the analysis. Although it did not score full points for geomorphological values, the location of the site close to restaurants and hotels, as well as the high score for added value, proved decisive. The fourth place with the highest score - 8.25 points - was occupied by the erratic boulder "Kamienny Dom". This geosite could not achieve the maximum number of points in the category of geomorphological values because it was destroyed by a man. However, it has the highest score of any site in the added value category because of the nearby infrastructure. The rock loses points because of its low level of protection and also because it is located next to a tourist path, which undoubtedly facilitates anthroporepression. The artificial geological outcrop at the Wapienno Mining Plant received the lowest score - 5 points - in the entire evaluation analysis. Its low score is due to the fact that it is very difficult to access and there are no legends associated with it.

DISCUSSION

Possibilities for the development of geotourism

There is currently no geotourism in the study area. Although the area is developed for tourism, geotourism does not operate in this area. In the light of the first research of this kind carried out in Pałuki, the authoresses concluded that there is a possibility of developing this branch of tourism here. Twelve geosites, proving the rich geodiversity of the research area, have the potential to develop this type of nature tourism. An important factor in the development of geotourism in Pałuki will undoubtedly be the involvement of local authorities. It is necessary to adapt facilities for tourists to ensure their comfortable visit without compromising the protection of geosites (e.g. Sisto et al., 2022).

In order to communicate information effectively, a tourist must first be aware of what he or she is observing. The authoresses suggest placing informative panels next to each geosite. A provided brief description of the geological history of the Pałuki region should be accessible to the average tourist, but at the same time retains an educational value. In some convenient places, stopping points can be set up where tourists can rest and read about what they see (e.g. about the history of the formation of the slightly undulating relief of the area, while understanding the non-obvious name of Pałuki). In order to best present the geological history of the area, high-quality information material (e.g. a separate mini-publication, folder or leaflet) should be provided, available, for example, from the Tourist Information Office in Żnin. In the longer term, it is worth trying to establish a geopark. The main purpose of such an area would be the protection and management of the geological heritage and necessary improved quality of life for locals by providing geoeducation/geostorytelling (e.g., Wolniewicz, 2019, Kubalíková et al., 2021) and preparing geosites for tourists (e.g., Zouros, 2008; Farsani et al., 2012, 2014). The currently active quarry in Wapno will be closed in the future. Like other water reservoirs that mark the end of the exploitation of mineral resources, e.g., in Babin, in the cross-border (with Germany) Geopark Łuk Mużakowa (e.g. Koźma, 2011), the lake to be, has great potential for the development of recreation, water tourism (including diving) and geotourism. The well-known Polish examples of the adaptation of abandoned quarries for geo-educational purposes (e.g., Geosfera in Jaworzno; Chećko et al., 2022, the European Centre for Geological Education on Góra Rzepka in Chęciny https://www.eceg.uw.edu.pl/en/ or the Centre of Geoeducation of the Świętokrzyski Geopark http://geonatura-kielce.pl/centrum_geo/) can certainly inspire local authorities to build such a facility in the Pałuki area.

Author's geotourist trail "Geodiversified Pałuki". As a result of an objective bonitation analysis, it is known which of the 12 surveyed geosites are the most attractive in terms of geotourism. They will be offered to the recipient in the form of two new geotourist trails. They are different in length: the longer one goes through 11 geosites, the shorter one through 5 ones.

Given that among the participants of the tourist movement there are people with different sensitivities to the beauty of abiotic nature, representing an education not necessarily related to earth sciences, the authoresses suggest that tourists should be accompanied by an expert, competent in the field of abiotic nature and familiar with the local environment. Geological content is perceived as difficult by society, so the geointerpreter must demonstrate the ability to transfer knowledge in a simple and understandable way (e.g. Zafeiropoulos et al., 2021).

Both routes are thematic routes, i.e. linear forms of environmental penetration (Styperek, 2002), passing through areas that, from the geotourist's point of view, are characterised by special values of abiotic nature. They share similar themes, e.g. genesis, age of formation of geosites, types of rocks/sediments exposed *in situ*. The thematic trail should signposted and equipped with illustrative informative panels and folders. Among the trails, the educational trail deserves special attention, as it is one of the basic, active forms of environmental education (e.g. Stolz and Megerle, 2022).

The main theme, which unites 11 or 5 geosites, is the activity of the last Scandinavian Ice Sheet in Pałuki. This includes its erosion, transport and accumulation activities. In addition to recording the functioning of this ice sheet, the geosites show fluvial (rivers), crenological (springs), aeolian (blown aeolian sands) and contemporary morphogenetic processes (manifested on the surface of erratic boulders). Several of the geosites show human activity based on abiotic natural resources and therefore the application role of geoheritage. The set of geosites of different origins clearly shows that Pałuki has a high geodiversity. This fact, so far unknown in the research area, deserves to be loudly and decisively articulated and promoted. The authoresses propose to do this by means of two geotourism trails under the common name of "Geodiversified Pałuki". Tourist activities on valuable (because they represent a wealth of expert knowledge) geological objects, here locally related to the south-eastern part of Pałuki. Such an activity, known as geotourism, is familiar around the world as an effective flywheel of the local economy, often increasing even individual people (geointerpreters, experts, geography teachers, local patriots; spatial landscape planners, designers of geostops, informative panel, folders, leaflets, maintenance services cleanliness along the trail) a financial revenues, improving their quality of life (e.g. Farsani et al., 2017; Lorenc, 2020; Frey, 2021; Herrera-Franco et al., 2022).

Geotourism is a proven lever for the standard of living of the inhabitants of peripheral and indifferent tourist areas (Smoleński, 2012). We cannot talk about such areas in Pałuki, as we have already shown. But who says that the tourist offer can't be diversified in order to attract a different segment of tourists? Not to mention the implementation of the slogan of sustainable development in areas of natural value into life in Pałuki (cf. Majdak, 2013).

Geotourist Trail "Geodiversified Pałuki" - longer version

Route: geological outcrop on the territory of the "Wapienno" Mining Plant – artificial lake in Piechcin – "Kamienny Dom" erratic boulder – subglacial channel of the Ostrówieckie Lake – St Hubert's Spring – the Pniewy Lake – erratic boulder on the high western shore of the Głęboczek Wielki Lake – the "Turek" Hill – the Rogowskie Lake – boundary erratic boulder in Czewujewo – a heap of erratics in Czewujewo. All geosites have been described in detail above.

The trail is about 100 km long if you travel by car (Figure 19), but it can also be done by bike and on foot. There are refreshment points along the way, and accommodation is available, for example, at the Ranczo Tomaszówka agritourist farm (www.ranczotomaszowka.pl). The trail is accessible to almost everyone. People with disabilities will not be able to reach the erratic boulder on the high western shore of the Głęboczek Wielki Lake and the top of "Turek" Hill. However, they will be able to see the latter from the car windows in form of a panorama view.

Geotourist trail " Geodiversified Pałuki" - shorter version

Route: "Kamienny Dom" erratic block – St Hubert's Spring – subglacial channel of the Ostrówieckie Lake – the Pniewy Lake – the Rogowskie Lake.

The trail, about 50 km long (Figure 19), runs through naturally valuable areas, free of polluting industrial plants. It can be covered by car, bicycle and on foot. There are refreshment points along the way, and accommodation is available in the nearby Ranczo Tomaszówka, the aforementioned agritourist farm. The trail is open to everyone. All the geological sites have been mentioned above. Both trails provide tourists with cognitive benefits - they learn about the abiotic heritage of the region, where the last Scandinavian Ice Sheet left its numerous traces. While following the trail, tourists will find themselves in areas that are used in different ways: in the forest (Górska-Zabielska, 2022), on arable land and on the shores of channel lakes, which

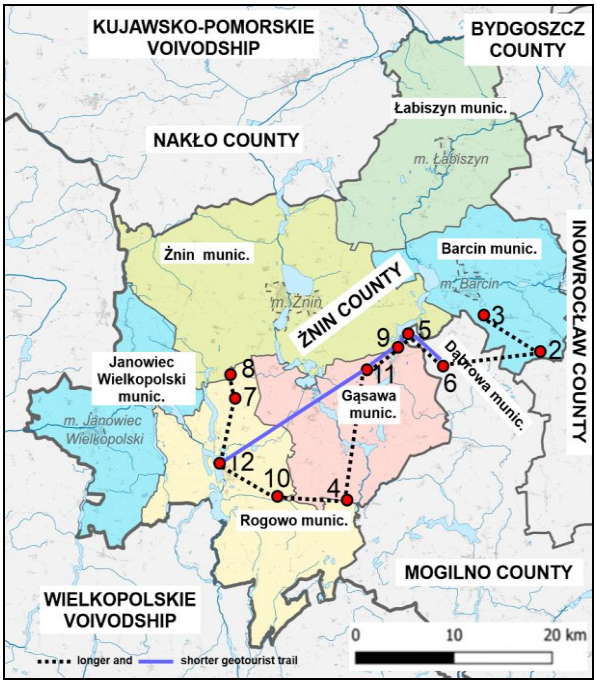

Figure 19. The simplified course of the longer (dashed black line) and the shorter (continuous blue line) geotourist trail under the common name " Geodiversified Pałuki"; Numerical explanations: 3 – artificial geological outcrop in the area of the "Wapienno" Mining Plant (inaccessible in 2023 for individual tourists), 2 – anthropogenic lake in the area of the former limestone mine in Piechcin, 6 – "Kamienny Dom" erratic boulder, 5 – St Hubert's Spring, 9 – view point on the subglacial trough of the Ostrówieckie Lake, 11 – the Pniewy Lake, 4 – erratic boulder on a high, western shore of the Głęboczek Wielki Lake, 10 – the "Turek" Hill, 12 – the Rogowskie Lake, 7 – border erratic boulder in Czewujewo, 8 – a heap of erratics in Czewujewo

offer recreation by the water. Thanks to the ideal terrain for walking, the trails are at least partly accessible on foot. Walking is a very popular leisure activity that allows you to admire morphologically beautiful natural areas and colour contrasts. These aesthetic impressions make you want to stay longer. Contact with pure nature, which is offered by protected areas on designated paths, provides psychological benefits. In such places you can calm down, take care of your weakened nervous system, cut yourself off from the world for a while, just take care of your well-being.

CONCLUSION

The work discusses the theme of geoheritage of the south-eastern part of the Pałuki area, which is not used for geotourism. It is mainly related to the presence and traces of the last Vistulian Ice Sheet in this area in its recessionary Ryszewo Oscillation (Kozarski, 1962) about 18.5 ka BP. The geosites also show the effects of fluvial, crenological, aeolian, modern morphogenetic and anthropogenic processes in the form of corresponding landforms.

The applied research method allows us to conclude that there is a great potential for the development of geotourism in the south-eastern part of Pałuki. This is especially the case in the Rogowskie Lake, which is characterised by high quality geomorphological values. The geo-educational needs can be fully met here. Utility values, extremely important for tourists, were also highly rated. Not worse in this sense is the Pniewy Lake, which is attractive mainly because of its geomorphological values. At the same time, it should be noted that the catering and accommodation services, which are necessary needs of tourists cannot be met in the immediate vicinity of the geosite. It is worth taking a look at the potential of the St Hubert's Spring for the development of geotourism. Today it is attractively developed, with easy access, parking and nearby catering and hotel facilities.

Geotourism in Pałuki can certainly develop on the basis of numerous, very large erratic boulders occurring *in situ*. One of them is the "Stone House", which, although anthropogenically destroyed, is no less worthy of inclusion in the region's development plans. Easy access to the tourist trail, good (in scale of Pałuki) development of the geosite, the subject of a legend and the fact that it is the largest geosite of this type in the region make it another very attractive geosite.

Pałuki is a region with developed tourism, as the Piast Trail, important for the beginnings of Polish statehood and for its rich archaeological monuments, passes through its area. However, tourism can and should be developed, especially as geotourism resources are available and can be used to diversify the (geo)tourist offer.

Dissemination and promotion of the resources discussed in the text are already carried out by some locals during competitions and manual geoworkshops among children, and know-how and workshops sessions for students. Geowatching, orienteering walk, and hiking/biking rally can be provided for interested adults.

In order to increase the possibilities of developing geotourism, the paper presents two proposals for thematic geotourism trail focusing on the most interesting geosites in the research area. The possible development and preparation of geo-objects for collection by geotourists, their effective promotion, the transfer of knowledge, the organisation of walks with a geo-interpreter, are just some examples of services that can generate new jobs and, at the same time, improve the quality of life of the people involved in these projects.

A necessary condition for success, apart from the availability of geo-objects, is the incorporation of the results of scientific research (like ours) social into the activities of regional tourist offices, local authorities and local action groups. Author's Geotourism Trails is an initiative that should be of interest to other institutions established for this purpose, including PTTK, schools, provincial methodological centres, local activity groups. Among the recipients, we cannot forget the guests of agritourist farms. Through an interesting tourist offer in the area, this type of rural tourism can increase the attractiveness of such a farm and thus improve the quality of life of its hosts.

It is worth considering the creation of a local geopark with both tangible and intangible geoproducts based on the attractive geological assets of the Pałuki region. The phenomenon of geo-product creation is so significant that it has been included in the UNESCO documents on the establishment of global geoparks (UNESCO, 1999). The first substantive documentation is provided in this article.

The relatively short distance between interesting local abiotic heritage objects (with a guaranteed tourist infrastructure) allows us to hope that geotourism has a chance of success, provided that local hosts are genuinely interested in the sustainable development of the region. Today, it guides economic activities that ensure the ecological security of society and increase the economic quality of life. It will be necessary to eliminate the current weaknesses and to use the existing opportunities mentioned in this article. The quality of life of the inhabitants of south-eastern Pałuki has a great chance of improving if the geotourism flywheel is implemented in the local economy.

Author Contributions: conceptualisation M.G.Z; methodology M.G.Z.; fieldwork M.G.Z., I.N., N.B.; data management M.G.Z.; formal analysis N.B.; writing - preparation of the original draft N.B., M.G.Z.; writing - editing and proofreading M.G.Z., I.N., N.B.; iconographic layer M.G.Z., I.N., N.B.; correction - M.G.Z.; supervision M.G.Z.; project administration – M.G.Z. All authoresses have read and agreed to the published version of the manuscript

Funding: research projects No. SUPB.RN.23.097 and SPOZ.RN.23.011 from the Jan Kochanowski University in Kielce, Poland

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study may be obtained on request from the corresponding author.

Acknowledgments: The authors acknowledge to (anonymous) reviewer(s) for.

Conflicts of Interest: The authoresses declare no conflict of interest.

REFERENCES

Adamczewski, J. (2002). Budownictwo ludowe na Pałukach. *Studia Lednickie* 7, 193-238. https://bazhum.muzhp.pl/media/files/Studia_Lednickie/Studia_Lednickie-r2002-t7/Studia_Lednickie-r2002-t7-s193-238/Studia_Lednickie-r2002-t7-s193-238.pdf

Bollati, I., Fossati, M., Zanoletti, E., Zucali, M., Magagna, A., & Pelfini, M. (2016). A methodological proposal for the assessment of cliffs equipped for climbing as a component of geoheritage and tools for earth science education: The case of the Verbano-Cusio-Ossola (Western Italian Alps). *J. Virtual Explor.*, 49, 1-23.

Boškov, J., Kotrla, S., Tomić, N., Jovanović, M., & Rvović, I. (2015). Perspectives for geotourism development in the Bela Crkva municipality (Serbia). *Acta Geoturistica*, 6(1), 1-10.

Boulton, G.A., & Hindmarsh, R.C.A. (1987). Sediment deformation beneath glaciers; rheology and geological consequences. *Journal of Geophysical Research.* American Geophysical Union 9,2 (B2), 9059-9082. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/JB092iB09p09059

Brilha, J. (2016). Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: A Review. *Geoheritage*, 8, 119-134.

Bruschi, V.M., & Cendrero, A. (2005). Geosite evaluation; can we measure intangible values? *Il Quaternario*, 18(1), 293-306. https://amq.aiqua.it/index.php/amq/article/view/499/438

Bruschi, V.M., & Cendrero, A. (2009). Direct and parametric methods for the assessment of geosites and geomorphosites. In *Geomorphosites; Reynard, E., Coratza, P., Regolini-Bissig, G., Eds.; Pfeil: München, Germany, 73-88.*

Carrión-Mero, P., Ayala-Granda, A., Serrano-Ayala, S., Morante-Carballo, F., Aguilar-Aguilar, M., Gurumendi-Noriega, M., Paz-Salas, N., Herrera-Franco, G., & Berrezueta, E. (2020). Assessment of geomorphosites for geotourism in the northern part of the "RutaEscondida" (Quito, Eecuador). *Sustainability*, 12, 8468. https://doi.org/10.3390/su12208468

Carrión-Mero, P., Borja-Bernal, C., Herrera-Franco, G., Morante-Carballo, F., Jaya-Montalvo, M., Maldonado-Zamora, A., Paz-Salas, N., & Berrezueta, E. (2021). Geosites and Geotourism in the Local Development of Communities of the Andes Mountains. A Case Study. *Sustainability*, 13, 4624. https://www.mdpi.com/2071-1050/13/9/4624

Carrión-Mero, P., Mata-Perelló, J., Herrera-Narváez, G., Sánchez-Zambrano, E., & Berrezueta, E. (2021). Assessment and Promotion of Geotouristic and Geomining Routes as a Basis for Local Development: A Case Study. *Minerals*, 11(4), 351. https://doi.org/10.3390/min11040351

Chećko, A., Jelonek, I., & Jelonek, Z. (2022). Study on restoring abandoned mine lands to economically usable state using the post-occupancy evaluation method. *Land Degradation & Development*, 33(11), 3-45. https://onlinelibrary.wiley.com/doi/10.1002/ldr.4265

Choiński, A. (2007). *Katalog jezior Polski [Catalogue of Polish lakes]*, Wydawnictwo Naukowe Uniwersytetu im. Adama Mickiewicza w Poznaniu.

Chrobak, A., Novotný, J., & Struś, P. (2021). Geodiversity Assessment as a First Step in Designating Areas of Geotourism Potential. Case Study: Western Carpathians. *Front. Earth Sci.*, 9, 752669. https://doi.org/10.3389/feart.2021.752669

Coratza, P., & Giusti, C. (2005). Methodological proposal for the assessment of the scientific quality of of geomorphosites. *Alp. Mediterr. Quat.*, 18, 307-313.

Czubla, P., Gałązka, D., & Górska, M. (2006). Eratyki przewodnie w glinach morenowych Polski [Fennoscandian indicator erratics in glacial tills of Poland]. *Przegląd Geologiczny*, 54(4), 352-362. https://geoturystyka.ujk.edu.pl/ MGZ/PDF/Eratyki%20przewodnie%20w%20glinach%20morenowych%20Polski.pdf

Czubla P., Petera-Zganiacz, J. (2019). Fotografia dokumentacyjna w naukach o Ziemi. *Folia Geographica Physica*, 18, 7-28. https://doi.org/10.18778/1427-9711.18.01

Dowling, R., & Newsome, D. (eds) (2006). *Geotourism*, Elsevier/Heineman Publishers, Oxford, Great Britain.

Drążek, J., Chmiel, J., & Kupczyk, M. (eds) (2010). *Krajobrazy pałuckich wapieni. 150 lat białego górnictwa [Landscapes of the Pałuki limestone. 150 years of white mining]*, Wyd. Stowarzyszenie Ekologiczne w Barcinie, Barcin.

Drinia, H., Voudouris, P., & Antonarakou, A. (eds) (2022). Geoheritage and Geotourism Resources: Education, Recreation, Sustainability. *Geosciences* 12, 251. https://doi.org/10.3390/geosciences12060251

Ehsan, S., Leman, M.S., & Ara Begum, R. (2012). Geotourism: A tool for sustainable development of geoheritage resources. *Adv. Mater. Res.*, 622-623, 1711-1715.

Evelpidou, N., Karkani, A., Komi, A., Giannikopoulou, A., Tzouxanioti, M., Saitis, G., Spyrou, E., & Gatou, M.A. (2022). GIS-Based Virtual Field Trip as a Tool for Remote Education. *Geosciences*, 12, 327. https://doi.org/10.3390/geosciences12090327

Fancello, D., Columbu, S., Cruciani, G., Dulcetta, L., & Franceschelli, M. (2022). Geological and archaeological heritage in the Mediterranean coasts: Proposal and quantitative assessment of new geosites in SW Sardinia (Italy). *Front. Earth Sci.*, 10, 910990. https://doi.org/10.3389/feart.2022.910990

Farsani, N.T., Coelho, C., Costa, C., & Carvalho, C.N. (eds) (2012). *Geoparks & Geotourism. New Approaches to Sustainability for the 21st Century*, Brown Walker Press, USA

Farsani, N.T., Coelho, C.O.A., Costa, C.M.M., & Amrikazemi, A. (2014). Geo-knowledge Management and Geoconservation via Geoparks and Geotourism. *Geoheritage*, 6(3), 185-192. https://link.springer.com/article/10.1007/s12371-014-0099-7

Farsani, N.T., Mortazavi, M., Bahrami, A., Kalantary, R., & Bizhaem, F.K. (2017). Traditional crafts: a tool for geo-education in geotourism. *Geoheritage*, 9(4), 577-584. https://link.springer.com/article/10.1007/s12371-016-0211-2

Fassoulas, C., Mouriki, D., Dimitriou-Nikolakis, P., & Iliopoulos, G. (2012). Quantitative assessment of geotopes as an effective tool for geoheritage management. *Geoheritage*, 4, 177-193.

Frey, M.L. (2021). Geotourism-Examining Tools for Sustainable Development. *Geosciences*, 11(30). https://www.mdpi.com/2076-3263/11/1/30

Fuertes-Gutiérrez, I., & Fernández-Martínez, E. (2010). Geosites Inventory in the Leon Province (Northwestern Spain): A Tool to Introduce Geoheritage into Regional Environmental Management. *Geoheritage*, 2, 57-75.

Gaidzik, K., & Chmielewska, M. (2020). Post-Mining Objects as Geotourist Attractions: Upper Silesian Coal Basin (Poland). In *Bahram Nekouie Sadry (ed.), The Geotourism Industry in the 21st Century, Wyd. Apple Academic Press.*

Garofano, M. (2015). Geowatching, a Term for the Popularisation of a Geological Heritage. *Geoheritage*, 7, 25-32.

Gioncada, A., Pitzalis, E., Cioni, R., Fulignati, P., Lezzerini, M., Mundula, F., & Funedda, A. (2019). The Volcanic and Mining Geoheritage of San Pietro Island (Sulcis, Sardinia, Italy): The Potential for Geosite Valorization. *Geoheritage*, 11(6), 1567-1581. https://link.springer.com/article/10.1007/s12371-019-00418-6

Górska-Zabielska, M. (2010). Głazy narzutowe w Wielkopolsce [Erratic boulders in the Wielkopolska region]. *Prace i Studia z Geografii i Geologii*, 18. Bogucki Wyd. Naukowe, Poznań.

Górska-Zabielska, M. (2020). Nowe obiekty geoturystyczne na południowym Podlasiu [New geotourist objects in southern Podlasie]. *Przegląd Geologiczny*, 68, 2, 91-99. https://www.pgi.gov.pl/dokumenty-pig-pib-all/publikacje-2/przeglad-geologiczny/2020/2-luty/7591-nowe-obiekty-geoturystyczne-na-poludniowym-podlasiu/file.html

Górska-Zabielska, M. (2021a). In the footsteps of the ice sheet in the area of the planned geopark "Postglacial land of the Drawa and Dębnica rivers (the Drawskie Lakeland, Poland)". *Landform Analysis*, 40: 37-56. http://geoinfo.amu.edu.pl/sgp/LA/LA40/landfana-040-002.pdf

Górska-Zabielska, M. (2021b). The Rock Garden of the Institute of Geography and Environmental Sciences, Jan Kochanowski University—A New Geo-site in Kielce, Central Poland. *Geosciences*, 11(3), 113. https://doi.org/10.3390/geosciences11030113 (Górska-Zabielska, M., (2022). Geoheritage in a Forest: Traces of Ice Sheets in Pałuki, Western Poland. *Sustainability*,14(12), 7190 https://doi.org/10.3390/su14127190

Górska-Zabielska, M. (2023a). A New Geosite as a Contribution to the Sustainable Development of Urban Geotourism in a Tourist Peripheral Region—Central Poland. *Resources*, 12(6), 71. https://doi.org/10.3390/resources12060071

Górska-Zabielska, M. (2023b). New Geoeducational Facilities in Central Mazovia (Poland) Disseminate Knowledge about Local Geoheritage. *Sustainability*, 15, 16115. https://doi.org/10.3390/su152216115

Górska-Zabielska, M., & Kamieńska, K. (2017). Geotourism potential of the Drawskie Lake District as a support for the planned geopark named "Postglacial land of the Drawa and Dębnica rivers". *Quaestiones Geographicae*, 36(1), 15-31. https://doi.org/10.1515/quageo-2017-0002

Górska-Zabielska M., Kusztal, P., & Witkowska, K. (2019). Wybrane głazy narzutowe północno-zachodniego obrzeżenia Gór Świętokrzyskich – współczesne znaczenie i potencjał geoturystyczny (Wyżyna Przedborska i Kielecka). *Przegląd Geologiczny*, 67(9), 767-774. http://dx.doi.org/10.7306/2019.45

Górska-Zabielska, M., Wieczorek, D., Zabielski, R., & Stoiński, A. (2022). Głazy narzutowe z regionu Przedborza jako obiekty geodziedzictwa oraz ich znaczenie dla geologii czwartorzędu i geoturystyki [The erratic boulders of the Przedborze region as geoheritage objects and their significance for Quaternary geology and geotourism]. *Przegląd Geologiczny*, 70(1), 34-49. http://dx.doi.org/10.7306/2022.2

Górska-Zabielska, M., Witkowska, K., Pisarska, M., Musiał, R., & Jońca B. (2020). The Selected Erratic Boulders in the Świętokrzyskie Province (Central Poland) and Their Potential to Promote Geotourism. *Geoheritage*, 30, 1-14. https://doi.org/10.1007/s12371-020-00453-8

Gray, M. (2013). *Geodiversity: valuing and conserving abiotic nature*, second ed., Wiley Blackwell, Chichester.

Gray, M. (2018). Geodiversity: the backbone of geoheritage and geoconservation. In *Reynard E., Brilha J. (eds), Geoheritage: assessment, protection, and management*, 13-25). Elsevier, Amsterdam.

Herrera-Franco, G., Mora-Frank, C., Kovács, T., & Berrezueta, E. (2022). Georoutes as a Basis for Territorial Development of the Pacific Coast of South America: a Case Study. *Geoheritage*, 14, 78. https://doi.org/10.1007/s12371-022-00711-x

Hose, T.A. (2005). Geotourism and Interpretation. In *Dowling R.K., Newsome D. (eds), Geotourism, 221-241*, Elsevier Butterworth-Heinemann, Oxford.

Hose, T.A. (2012). 3G's for Modern Geotourism. *Geoheritage*, 4, 7-24.

Jalinik, M. (2009). Zarządzanie gospodarstwem ekoagroturystycznym na obszarach przyrodniczo cennych [Eco-tourism farm management in nature-rich areas]. *Zeszyty Naukowe Politechniki Białostockiej. Ekonomia i Zarządzanie*, 14, 85-94.

Jaroszewski, W., Marks, L., & Radomski, A. (1985). *Słownik geologii dynamicznej [Glossary of dynamic geology],* Wydawnictwa Geologiczne, Warszawa.

Kicińska-Świderska, A., & Słomka, T. (2004). Projektowanie tras geoturystycznych [Designing geotourism routes]. *Folia Turistica*, 15, 179-184.

Kot, R., Andrzejewski, L., Macias, A., Bródka, S., Kubacka, M., Lechnio, J., & Malinowska, E. (2021). Pradolina Toruńsko-Eberswaldzka (315.3) [Toruń-Eberswalde Pradolina (315.2)]. In *A. Richling, J. Solon, A. Macias, J. Balon, J. Borzyszkowski, M. Kistowski (eds), Regionalna geografia fizyczna Polski*, 162-170, Bogucki Wydawnictwo Naukowe, Poznań.

Kozarski, S. (1962). Recesja ostatniego lądolodu z północnej części Wysoczyzny Gnieźnieńskiej a kształtowanie się Pradoliny Noteci–Warty [Recession of the last ice sheet from the northern part of the Gniezno Plateau and the formation of the Noteć–Warta pradolina]. *Prace Komisji Geograficzno-Geologicznej*, Poznańskie Towarzystwo Przyjaciół Nauk, Wydział Matematyczno-Przyrodniczy, 2(3).

Kozarski, S. (1995). Deglacjacja północno-zachodniej Polski: warunki środowiska i transformacja geosystemu (~20 ka →10 ka BP) [Deglaciation of northwestern Poland: environmental conditions and geosystem transformation (~20 ka →10 ka BP)]. *Dokumentacja Geograficzna*, 1, Continuo Publisher, IGiPZ PAN, Wrocław.

Koźma, J. (2011). Transgraniczny geopark Łuku Mużakowa [Muskau Arc Cross-Border Geopark]. *Przegląd Geologiczny*, 59(4), 276-290.

Kubalíková, L. (2013). Geomorphosite assessment for geotourism purposes. *Czech J. Tour.*, 2, 80-104.

Kubalíková, L., Bajer, A., & Balková, M. (2021). Brief Notes on Geodiversity and Geoheritage Perception by Lay Public. *Geosciences*, 11, 54. https://doi.org/10.3390/geosciences11020054

Lorenc, M. (2020). *Ścieżka dydaktyczna „Na tropach lądolodu". Przewodnik po ścieżce dydaktyczej [Nature trail "On the tracks of the ice sheet". Guide on the nature trail]*. Wyd. Bogucki Wydawnictwo Naukowe, Poznań.

Macadam, J. (2018). Geoheritage: Getting the message across. What message and to whom? In *Reynard E., Brilha J.B. (eds), Geoheritage: Assessment, Protection, and Management*, 267-288, Elsevier: Amsterdam, The Netherlands.

Macias, A., Bródka, A., Kubacka, M., Kot, R., & Andrzejewski, L. (2021). Pojezierze Wielkopolskie (315.5) [Wielkopolskie Lakeland (315.5)]. In *A. Richling, J. Solon, A. Macias, J. Balon, J. Borzyszkowski, M. Kistowski (eds), Regionalna geografia fizyczna Polski*, 178-190, Bogucki Wydawnictwo Naukowe, Poznań.

Majdak, P. (2013). Turystyka i rekreacja na obszarach przyrodniczo cennych. Konflikty i kompromisy w świetle koncepcji rozwoju zrównoważonego [Tourism and recreation in naturally valuable areas. Conflicts and trade-offs in the light of the concept of sustainable development]. *Problemy Ekologii Krajobrazu. Rekreacja w krajobrazach o wysokim potencjale*, 34, 163-168.

Malinowski, F. (2010). *Diabeł Wenecki i inne legendy pałuckie [The Devil of Venice and other legends of the Pałuki region]*. Wyd. Magraf S.C, Bydgoszcz.

Malinowski, F. (2023). *Legendy pałuckie II [Legends of the Pałuki region II]*. Wydawnictwo Dominika Księskiego Wulkan, Żnin.

Mamoon, A. (2014). Geotourism: Why Do Children Visit Geological Tourism Sites? *Dirasat: Human and Social Sciences*, 41(1), 653-661. https://www.researchgate.net/publication/262932646

Mapa Geośrodowiskowa, ark. Rogowo, w skali 1:50 000 [*Geoenvironmental Map*, Rogowo arc., scale 1:50 000]. Archiwum Kartograficzne Państwowego Instytutu Geologicznego Państwowego Instytutu Badawczego [Cartographic Archive of the Polish Geological Institute National Research Institute], Warszawa.

Marescotti, P., Castello, G., Briguglio, A., Caprioglio, M.C., Crispini, L., & Firpo, M. (2022). Geosite assessment in the Beigua UNESCO Global Geopark (Liguria, Italy): A case study in linking geoheritage with education, tourism, and community involvement. *Land*, 11, 1667. https://doi.org/10.3390/land11101667

Meyer, K.D., & Lüttig, G. (2007). Was meinen wir mit Leitgeschiebe? *Geschiebekunde Aktuell*, 23(4), 106-121.

Migoń, P., & Pijet-Migoń, E. (2017). Viewpoint geosites — values, conservation and management issues. *Proceedings of the Geologists' Association*, 128(4), 511-522. https://doi.org/10.1016/j.pgeola.2017.05.007.

Miśkiewicz, K. (2016). Promoting geoheritage in geoparks as an element of educational tourism. In *Szponar A., Toczek-Werner S. (eds), Geotourism: organization of the tourism and education in the geoparks in the Middle-Europe Mountains*, 37-48, University of Business in Wrocław. https://www.researchgate.net/publication/308627346_Promoting_geoheritage_in_geoparks_as_an_element_of_educational_tourism#fullTextFileContent

Newsome, D., & Dowling, R. (2018). Geoheritage and Geotourism. In *Reynard E., Brilha J. (eds), Geoheritage*, 305-321, Elsevier, Amsterdam, The Netherlands.

Ng, Y. (2022). Editorial: Special issue on geodiversity. *International Journal of Geoheritage and Parks*, 10 (4), A1-A3. https://doi.org/10.1016/j.ijgeop.2022.11.004

Orłowska, A. (2017). Evaluation of geotourism potential of selected geological sites in the eastern part of the borderland between Siedlce Upland and Łuków Plain. *Geotourism/Geoturystyka*, 46-47(1-2), 17-30.

Ostręga, A., Uberman, R., Stożek, Ł., & Muzykiewicz, B. (2011). Koncepcja rekultywacji i docelowego zagospodarowania Kopalni Wapienia „Kujawy" [Concept for the reclamation and target development of the "Kujawy" Limestone Mine]. *Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej nr 132. Studia i Materiały*, 39, 207-224. http://www.miningscience.pwr.edu.pl/The-reclamation-concept-and-target-redevelopment-of-the-Kujawy-limestone-mine,59910,0,2.html

Pabian, G. (2015). Kierunki zagospodarowania terenów pogórniczych na przykładzie wybranych geostanowisk Wzgórz Chęcińskich – stan aktualny i perspektywy rozwoju [Directions of development of post-mining areas on the example of selected geostationary sites of the Chęciny Hills - current status and development prospects]. *Przegląd Geologiczny*, 63, 470-474.

Pasquaré Mariotto, F., Drymoni, K., Bonali, F.L., Tibaldi, A., Corti, N., & Oppizzi, P. (2023). Geosite Assessment and Communication: A Review. *Resources*, 12, 29. https://doi.org/10.3390/resources12020029

Pena dos Reis, R., & Henriques, M. (2009). Approaching an integrated qualification and evaluation system for geological heritage. *Geoheritage*, 1, 1-10.

Pereira, P., & Pereira, D. (2010). Methodological guidelines for geomorphosite assessment. Géomorphol. *Relief Process Environ.*, 1, 215-222.

Pereira, P., Pereira, D., & Caetano Alves, M.I. (2007). Geomorphosite assessment in Montesinho Natural Park (Portugal). *Geographica Helvetica*, 62(3),159-168.

Pijet-Migoń, E., & Migoń, P. (2022). Geoheritage and Cultural Heritage—A Review of Recurrent and Interlinked Themes. *Geosciences*, 12, 98. https://doi.org/10.3390/geosciences12020098

Pikies, R. (2009). Opracowanie karty nr 000202: Zakład Górniczy Wapienno [Sheet No. 000202: Wapienno Limestone Mine]. *Centralny Rejestr Geostanowisk Polski*. http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails.aspx?id=202

Piotrowski, J.A. (1997). Subglacial hydrology in north-western Germany during the last glaciation: groundwater flow, tunnel valleys and hydrological cycles. *Quaternary Science Reviews*, 16(2), 169-185. https://www.sciencedirect.com/science/article/abs/pii/S0277379196000467?via%3Dihub

Płoskonka, P. (2018). *Edukacja przyrodniczo-leśna w świetle koncepcji etyki środowiskowej Leave No Trace [Nature and forestry education in the light of the Leave No Trace concept of environmental ethics]*. In *Gila W. & Szewczykiewicz J. (eds), Współczesne problemy Komunikacji społecznej i edukacji w leśnictwie [Contemporary issues of Social Communication and Education in Forestry]*. 95-110, Instytut Badawczy Leśnictwa, Sękocin Stary.

Pospieszny, Ł., Sobkowiak-Tabaka, I., & Nowaczyk, S. (eds) (2017). *Megalityczny grobowiec kultury amfor kulistych z Kierzkowa na Pałukach. Milczący świadek kultu przodków w epoce kamienia [A megalithic tomb of the amphorae culture from Kierzków in the Pałuki region. A silent witness to ancestral worship in the Stone Age]*. Wydawnictwo Biskupin.

Rdzany, Z., Frydrych, M., & Szmidt, A. (2020). Rozwój rynny Miazgi–Wolbórki (Polska środkowa) w świetle analizy jej wypełnienia [Formation of the Miazga–Wolbórka tunnel valley (central Poland) based on an analysis of its infill]. *Przegląd Geologiczny*, 68, 584-600. http://dx.doi.org/10.7306/2020.23

Reynard, E. (2009). Geomorphosites: Definitions and characteristics. In *Reynard E., Coratza P., Regolini-Bissig G. (eds), Geomorphosites*, Verlag Dr. Friedrich Pfeil, München.

Reynard, E., Fontana, G., Kozlik, L., & Capozza, C. (2007). A method for assessing the scientific and additional values of geomorphosites. *Geographica Helvetica*, 62, 148-158.

Reynard, E., & Giusti, C. (2018). Chapter 8 - The Landscape and the Cultural Value of Geoheritage. In *E. Reynard, J. Brilha (eds.), Geoheritage. Assessment, Protection, and Management*, 147-166. https://doi.org/10.1016/B978-0-12-809531-7.00008-3

Rodrigues, J., De Silva, E.C., & Pereira, D.I. (2023). How Can Geoscience Communication Foster Public Engagement with Geoconservation? *Geoheritage*, 15, 32. https://doi.org/10.1007/s12371-023-00800-5

Saurabh, M., Sudhanshu, S., Singh, S.K., & Mathur, S.C. (2021). QualitativeAssessment of Geoheritage for Geotourism Promotion: A Case Study from Mehrangarh Ridge in Jodhpur City, Western Rajasthan, India. *Geoheritage*, 13, 80-100. https://doi.org/10.1007/s12371-021-00604-5

Schulz, W. (1999). Sedimentäre Findlinge im norddeutschen Vereisungsgebiet. *Archiv für Geschiebekunde*, 2(8), 523-560.

Serrano, E., & González Trueba, J.J. (2005). Assessment of geomorphosites in natural protected areas; the Picos de Europa National Park (Spain). *Géomorphol. Relief Process Environ.*, 1, 197-208.

Serrano, E., & Ruiz-Flano, P. (2007). Geodiversity. A theoretical and applied concept. *Geographica Helvetica*, 62(3), 140-147.

Sisto, M., Di Lisio, A., & Russo, F. (2020). The Mefite in the Ansanto Valley (Southern Italy):a Geoarchaeosite to Promote the Geotourism and Geoconservationof the Irpinian Cultural Landscape. *Geoheritage*, 12, 29. https://doi.org/10.1007/s12371-020-00450-x

Sisto, M., Di Lisio, A., & Russo, F. (2022). Geosite Assessment as a Tool for the Promotion and Conservation of Irpinia Landscape Geoheritage (Southern Italy). *Resources*, 11, 97. https://doi.org/10.3390/resources11100097

Skoczylas, J. (2006). Złoża kopalin użytecznych w dziejach Pałuk [Useful mineral deposits in the history of the Pałuki region]. In *Wyrwa A.M. (ed), Studia i materiały do dziejów Pałuk. Terra Palucensis et Monasterium in Lokna: XXV lat badań archeologiczno-architektonicznych w łekneńskim kompleksie osadniczym [Twenty-five years of archaeological and architectural research in the Lekno settlement complex]*, vol. 6, Wydawnictwo „Dig", Warszawa.

Smoleński, M. (2012). Modelowanie przestrzeni turystycznej peryferyjnych regionów turystycznych [Modeling of destination regions in fringearea]. *Economy and Management*, 1, 64-91.

Stolz, J., & Megerle, H.E. (2022). Geotrails as a Medium for Education and Geotourism: Recommendations for Quality Improvement Based on the Results of a Research Project in the Swabian Alb UNESCO Global Geopark. *Land*, 11, 1422. https://doi.org/10.3390/land11091422

Štrba, L., Rybár, P., Baláž, B., Molokác, M., Hvizdák, L., Kršák, B., Lukác, M., Muchová, L., Tometzová, D., & Ferencíková, J. (2015). Geosite assessments: Comparison of methods and results. *Curr. Issue Tour.*, 18, 496-510.

Styperek, J. (2002). *Linearne systemy penetracji rekreacyjnej [Linear systems of recreational penetration]*, Bogucki Wydawnictwo Naukowe, Poznań.

Suzuki, D., & Takagi, H. (2018). Evaluation of Geosite for Sustainable Planning and Management in Geotourism. *Geoheritage*, 10, 123-135. https://doi.org/10.1007/s12371-017-0225-4

Sydow, S., & Machowiak, W. (2004). *Objaśnienia do Szczegółowej mapy geologicznej Polski w skali 1:50 000, ark. Rogowo (nr 397) [Explanations to the Detailed Geological Map of Poland in the scale 1:50 000, sheet Rogowo (no. 397)]*. Archiwum Państwowego Instytutu Geologicznego Państwowego Instytutu Badawczego, Warszawa.

Szafarczyk, A., & Gawałkiewicz, R. (2023). An inventory of opencast mining excavations recultivated in the form of water reservoirs as an example of activities increasing the retention potential of the natural environment: a case study from Poland. *Geology, Geophysics & Environment*, 49, 4, 401-418, Wydawnictwa AGH. https://doi.org/10.7494/geol.2023.49.4.401

Szarafin, T. (2013). Opracowanie karty nr 004305: Głaz narzutowy Kamienny Dom [Sheet No. 004305: Erratic boulder Stony House]. Centralny Rejestr Geostanowisk Polski. http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails.aspx?id=4305

Szarafin, T. (2016). Koordynacja i weryfikacja merytoryczna karty nr 004321: Źródło św. Huberta [Coordination and substantive verification of Charter No. 004321: St Hubert's Spring]. *Centralny Rejestr Geostanowisk Polski*. http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails.aspx?id=4321

Szyda, B., & Karasiewicz, T. (2017). Znaczenie obszarów przyrodniczo cennych w rozwoju funkcji turystycznej stref podmiejskich wybranych polskich miast [The importance of naturally valuable areas in the development of the tourist function of suburban zones of selected Polish cities]. *Studia i Materiały CEPL w Rogowie*, 19, 52, 3, 174-181.

Tetik, N. (2016). The Importance of Interpretatıon Role of Tour Guıdes in Geotourısm: Can We Called Them as Geotour Guıdes? *International Journal of Education and Social Science* 3, 2, 41-53. https://www.academia.edu/34545497/The_Importance_of_Interpretat%C4%B1on_Role_of_Tour_Gu%C4%B1des_in_Geotour%C4%B1sm_Can_We_Called_Them_as_Geotour_Gu%C4%B1des

UNESCO (1999). UNESCO Geoparks Programme - A New Initiative to Promote a Global Network of Geoparks Safeguarding and Developing Selected Areas Having Significant Geological Features, 156EX/11 Rev. PARIS, 15 April 1999.

Uniejewska, M., & Nosek, M. (1990). Szczegółowa mapa geologiczna Polski w skali 1:50 000, arkusz Gąsawa (398) [Detailed geological map of Poland in the scale 1:50 000, sheet Gąsawa (398)]. *Wydawnictwa Geologiczne*, Warszawa.

Urban, J., Migoń, P., & Radwanek-Bąk, B. (2021). Dziedzictwo geologiczne [Geological heritage]. *Przegląd Geologiczny*, 69, 1, 16-20. http://dx.doi.org/10.7306/2021.1

Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody [the Nature Conservation Act of 2004, in Polish]. *Dz.U. 2004 Nr 92 poz. 880*. https://www.teraz-srodowisko.pl/media/pdf/prawo-reglamentacja/385.pdf

Vale Caetano, J.M., & Corral Martins de Oliveira Ponciano, L. (2021). Cultural Geology, Cultural Biology, Cultural Taxonomy, and the Intangible Geoheritage as New Strategies for Geoconservation. *Geoheritage*, 13, 79. https://doi.org/10.1007/s12371-021-00603-6

Van Geert, F. (2019). In situ interpretation and ex situ museum display of geology. New opportunities for a geoheritage based dialogue? *Int. J. Geoheritage Parks*, 7, 129-144. https://doi.org/10.1016/j.ijgeop.2019.05.001

Vlachopoulos, N., & Voudouris, P. (2022). Preservation of the Geoheritage and Mining Heritage of Serifos Island, Greece: Geotourism Perspectives in a Potential New Global Unesco Geopark. *Geosciences*, 12, 127. https://doi.org/10.3390/geosciences12030127

Vujičić, M.D., Vasiljević, D.A., Marković, S.B., Hose, T.A., Lukić, T., Hadžić, O., & Janićević, S. (2011). Preliminary geosite assessment model (GAM) and its application on Fruškagora Mountain, potential geotourism destination of Serbia. *Acta Geogr. Slov*., 51, 361-377. https://doi.org/10.3986/AGS51303

Warowna, J., Zglobicki, W., Kolodynska-Gawrysiak, R., Gajek, G., Gawrysiak, L., & Telecka, M. (2016). Geotourist values of loess geoheritage within the planned Geopark Malopolska Vistula River Gap, E Poland. *Quatern. Int.*, 399, 46-57.

Wolniewicz, P. (2019). Bringing the history of the Earth to the public by using storytelling and fossils from decorative stones of the City of Poznań, Poland. *Geoheritage*, 1, 1827-1837. https://doi.org/10.1007/s12371-019-00400-2

Wolniewicz, P. (2021). Beyond Geodiversity Sites: Exploring the Educational Potential of Widespread Geological Features (Rocks, Minerals and Fossils). *Geoheritage*, 13, 34. https://doi.org/10.1007/s12371-021-00557-9

Zafeiropoulos, G., Drinia, H., Antonarakou, A., & Zouros, N. (2021). From Geoheritage to Geoeducation, Geoethics and Geotourism: A Critical Evaluation of the Greek Region. *Geosciences*, 11, 381. https://doi.org/10.3390/geosciences11090381

Zorina, S.O., & Silantiev, V.V. (2014). *Geosites, classification of.* In *Encyclopedia of Mineral and Energy Policy.* Springer: Berlin/Heidelberg, Germany.

Zouros, N.C. (2008). European Geoparks Network: transnational collaboration on Earth heritage protection, geotourism and local development. *Geotourism*, 1, 12, 3-22.

Zwierzykowski, Z. (2021). *Gąsawa i okolica na starych widokówkach [Gąsawa and surroundings on old postcards]*, Wyd. Wulkan, Żnin

Zwoliński, Z. (2004). Geodiversity. In *Goudie A.S. (ed), Encyclopedia of Geomorphology, 1, 417-418,* Routledge.

Żbikowski, J. (2018). Zagospodarowanie turystyczne gminy Łuków [Tourism development of Łuków municipality]. In *Mizerski W. et al. (eds), Na krawędzi platformy", 86. Scientific Meeting of Polish Geologists Society, Łuków 2–5.09.2018, Summaries: 51–52.*

*** Atlas of Poland Encyclopaedia of the World Geography (2000), Wydwanictwo Press, Warszawa, Poland.

http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails.aspx?id=202

http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails. aspx?id=4305

http://geostanowiska.pgi.gov.pl/gsapp_v2/ObjectDetails.aspx?id=4321

www.ranczotomaszowka.pl

https://www.radiopik.pl/?idp=100&idx=1084

https://biskupin.pl/

Article history: Received: 22.12.2023 Revised: 25.01.2024 Accepted: 29.02.2024 Available online: 22.03.2024