

CONCEPTION OF THE “UNIQUE FERDYNANDOVIAN FLORA” GEOSITE IN THE ŁUKÓW PLAIN

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Abstract

Geosites are places of particular importance for understanding history of the Earth. An example of such a place may be the Łuków site with fossil Ferdynandovian flora. The development of vegetation covers over 140 000 years of Pleistocene in this reference profile. The Łuków profile is one of only a few European complete profiles, in which two Ferdynandovian interglacial climatic optima are recorded.

The scientific uniqueness of the Łuków profile was evidenced by numerous papers. However, the site was not analysed in terms of its usefulness for tourism and educational purposes. In order to fill this gap, the method of geosite evaluation has been used to evaluate geotourism potential. The following features of the site were evaluated: scientific value, educational value, state of the object (including threats), and accessibility. The evaluation was qualitative in a scale 1–5. We propose to establish the geosite named “Unique Ferdynandovian flora”. As a result, it will be possible to improve the accessibility and protect this site, as well as promote it as an object of nature tourism.

KONCEPCJA STANOWISKA GEOTURYSTYCZNEGO “UNIKALNA FLORA FERDYNANDOWSKA” NA RÓWNINIE ŁUKOWSKIEJ

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Słowa kluczowe: stanowisko geoturystyczne/geostanowisko, interglacjał ferdynandowski, turystyka przyrodnicza, Równina Łukowska.

Abstrakt

Stanowiska geoturystyczne (geostanowiska) są to miejsca o szczególnym znaczeniu dla poznania dziejów Ziemi. Takim przykładem może być stanowisko kopalnej flory ferdynandowskiej na Równinie Łukowskiej. Przedstawia ono wzorcowy profil rozwoju szaty roślinnej w ciągu 140 tys. lat trwania plejstocenu. W skali europejskiej profil ten dołącza do zaledwie kilku pełnych tzw. dwuoptimalnych profili ferdynandowskich.

Naukowa wyjątkowość profilu Łuków podkreślona jest licznymi publikacjami. Nie była ona jednak analizowana pod kątem udostępnienia dla turystyki i edukacji. W celu uzupełnienia tej luki stanowisko kopalnej flory ferdynandowskiej poddano waloryzacji metodą stosowaną dla geostanowisk. Zakres jej ewaluacji obejmuje następujące cechy stanowisk: wartość naukową, wartość edukacyjną, stan obiektu i jego zagrożenia oraz dostępność. Waloryzacja była jakościowa w skali 1–5. Wykazano wysokie walory edukacyjne analizowanego obiektu dające podstawę do utworzenia stanowiska geoturystycznego pt. „Unikalna flora ferdynandowska”. Zaprezentowana koncepcja geostanowiska przyczyni się do poprawy dostępności i ochrony obiektu wyjątkowego w skali europejskiej oraz jego promocji w zakresie szeroko rozumianej turystyki przyrodniczej.

Introduction

Geotourist sites (geosites) are valuable geological objects, which are of particular importance for understanding the history of the Earth (REYNARD 2004). Geosites are established in order to expose and protect the natural landscape elements, and to present the knowledge of their geological history. They are element of widely-understood geoheritage, focused on geology and landscape (cf. DOWLING and NEWSOME 2010, DOWLING 2011). These objects of inanimate nature (abiotic elements) are usually a record of geological-geomorphological processes forming landforms of different origin (e.g. GARAVAGLIA and PELFINI 2010, cf. MIGOŃ 2012). Fossil vegetation successions (biotic elements) are much less often exposed in geosites, though they provide equally valuable information on the geological past, including the history of life and climate changes. Reconstruction of these changes is mainly based on the analysis of plant remains (pollen, spores and macrofossils), which are very well preserved in the deposits of fossil lakes and mires.

From among numerous geological sites the stratotype profiles are especially noteworthy as they serve as the standards of reference in the reconstruction of the history of individual geological periods. This is the case of the sites with fossil Ferdynandovian flora occurring in the Łuków Plain – the mesoregion in eastern Poland (Figure 1). Their scientific uniqueness was evidenced by numerous papers published in leading Polish and international journals in the field of palaeobotany, palaeoecology and palaeoclimate (among others PIDEK 2013, PIDEK and POSKA 2013). However, these sites were not analysed in terms of their usefulness for tourism and educational purposes. In order to fill this gap, the method of geosite evaluation (cf. MIGOŃ 2012) has been used to evaluate geotourism potential of the Łuków site, which is the most representa-

tive, unique profile with the fossil Ferdynandovian flora. The purpose of our study is to present this evaluation and conception of the geosite together with the model of information board.

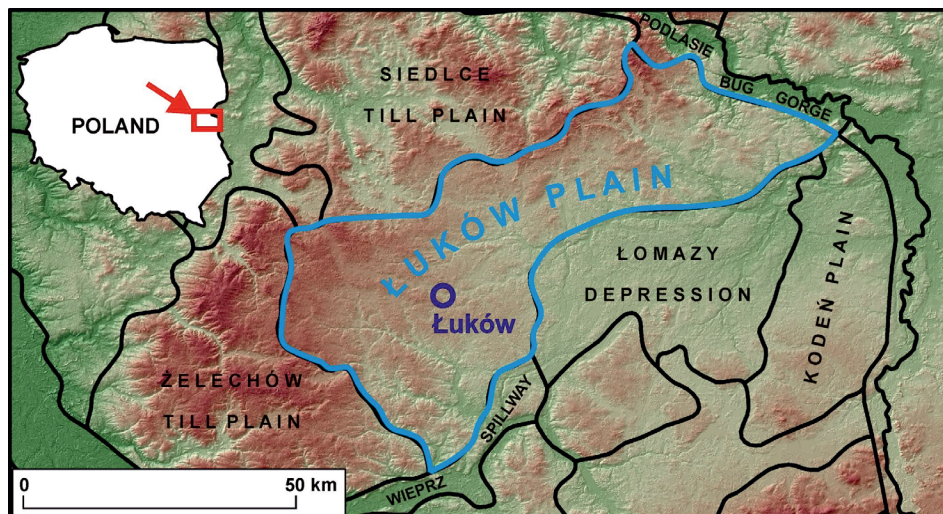


Fig. 1. Location of the Łuków geological site in the Łuków Plain mesoregion in relation to physico-geographical regionalization of Poland (authors' own study based on regions determined by Kondracki 2009)

Research area

The Łuków site with the fossil Ferdynandovian flora is located in the Łuków Plain. This physico-geographical mesoregion is a part of the South Podlasie Lowland macroregion (Kondracki 2009, Figure 1). It is flat area gently descending towards the SE from 170 to 140 m a.s.l. It is mainly composed of fluvioglacial sands and gravels, which were deposited on flat alluvial plains by braided rivers supplied with meltwater that flowed from the Wartanian ice-sheet front about 210 000–130 000 years ago.

Surface deposits of the Łuków Plain are underlain by fossil deposits of cyclically recurring cold (glacial) and warm (interglacial) periods, i.e. glacial sands, gravels and tills, and interglacial lacustrine and mire deposits. Within these deposits there were found the profiles with the so-called Ferdynandovian flora correlated with the Cromerian interglacial in Western Europe (Figure 2). Among them, the most unique is the Łuków site with the lacustrine-mire deposits filling the fossil basin of a lake formed 620 000 years ago. The site is located within the city of Łuków, in its eastern part, in the Zapowiednik quarter. A characteristic feature of the site location is a small distance (up to

100 m) from the forest complex (State Forests National Forest Holding, Łuków Forestry) surrounding the site from the west, north, and east, and from the Łuków – Lublin railway line in the south.

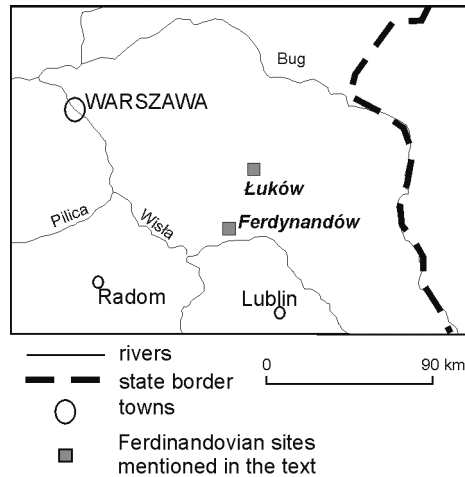


Fig. 2. Sites of the Ferdynandovian flora in the Łuków Plain

The site of Ferdynandovian flora in Łuków has been known since the 1960s due to the investigations conducted by SOBOLEWSKA (1969), but only the detailed research in 2010 indicated that the exceptionally complete vegetation succession (representing the Ferdynandovian s.l. period that lasted from 620 000 to 480 000 years ago) was recorded the lacustrine-mire deposits (PIDEK and MAŁEK 2010). This succession represents two interglacial periods together with separating them glacial cooling. Two warm climate units are named Ferdynandovian 1 and 2, and separating them cooling – Ferdynandovian 1 / 2 (LINDNER et al. 2004). The Ferdynandovian deposits are 13.6 m thick, and are covered by till deposited during the next glacial (Sanian 2).

Methods

The evaluation of geotourism potential of the Ferdynandovian flora site in Łuków was carried out in several stages, using the method developed by KNAPIK et al. (2009) and KNAPIK and MIGOŃ (2010).

In the first stage the sites with Ferdynandovian flora in the Łuków Plain were inventoried, based on the analysis of primary source materials, i.e. the

authors' own scientific publications. Then the most representative site (Łuków-3a) was selected.

The next stage of the work was the evaluation of the site for geotourism purposes. The following features of the site were evaluated: scientific value, educational value, state of the object (including threats), and accessibility. The evaluation was qualitative; each feature was evaluated in a scale 1–5 (*vide* Table 1).

Table 1
Elements of geosite evaluation according to KNAPIK et al. (2009) and KNAPIK and MIGOŃ (2010) method

Subject of evaluation	Description	Point value
Scientific value	the only site in the region; unique in over-regional scale; presented in international scientific journals	5
	object very important for regional studies; presented in national and international scientific journals	4
	object important for regional studies; presented in national and international scientific journals	3
	typical site of mediocre scientific value, presented in popular scientific magazines	2
	no special distinguishing features; the lack of publications	1
Educational value	number of presented problems: 5 and more	5
	number of presented problems: 4	4
	number of presented problems: 3	3
	number of presented problems: 2	2
	number of presented problems: 1	1
State of the object	well preserved, with no visible signs of degradation	5
	slightly disturbed structure of the site	4
	partially destroyed	3
	heavily changed by man	2
	destroyed, loss of geosite nature	1
Accessibility	site situated directly on the tourist trail or nature trail	5
	site situated off the trail but well visible from the trail, near a road or path	4
	site not visible from the tourist trail and poorly visible from other points, situated more than 500 m away from a road or path	3
	site difficult to access, e.g. overgrown or accessible by a route difficult to walk	2
	site inaccessible for tourists	1

Evaluation results

Scientific value

The results of geosite evaluation indicate that the Łuków site has the greatest geotourism potential in terms of scientific value (5 points). Scientific problems studied in the site are exceptional in regional scale, unique in over-regional scale, and the results are published in international scientific journals. The most important, unique feature of the site is a complete record of two interglacial warmings, which were characterized by climate warmer than nowadays, and exceptionally rich composition of vegetation communities, including also exotic species that do not occur in Poland nowadays. The history of vegetation near Łuków during 140 000 years is presented in the pollen diagram (Figure 3).

The phase of pioneer birch forests (Ł-1), following the retreat of the Sanian 1 ice sheet, represents the beginning of the Ferdynandovian 1 interglacial. The analysis of plant macrofossils has provided important information about the development of palaeolake and its trophy. The lake was very deep from the beginning of the interglacial. On the edge of the lake, in the peat-covered places, the communities of sedge rush developed, in which the plants typical of transitional mires occurred (among others *Cyperaceae*, *Menyanthes trifoliata*, *Comarum palustre*). *Typha latifolia* and *Schoenoplectus lacustris* occurred in the belt of typical rush (STACHOWICZ-RYBKA 2015). The complete succession of the Ferdynandovian 1 interglacial is represented by eight pollen zones (Ł-1–Ł-8), illustrating the development of rich, multi-species forests, at first dominated by elm and oak, and then with a high proportion of hazel and lime, and an admixture of exotic thermophilous tree (*Celtis*) and shrubs (*Buxus*, *Ligustrum*, and several other Mediterranean species). Vegetation composition indicates that climate was warm and humid, and the mean temperature of July was higher by at least 2°C from the present-day temperature, and annual precipitation total reached 800–900 mm (PIDEK and POSKA 2013). The occurrence of numerous seeds of *Najas marina* and *N. minor* (two species of the Hydrocharitaceae family) among macrofossils indicates that water in the lake was very eutrophic. The presence of *Zannichellia palustris* in the rush belt suggests the occurrence of habitats with varying water level and thereby with a high content of mineral salts (STACHOWICZ-RYBKA 2015).

The subsequent zones of the pollen diagram (Ł-9–Ł-11) reflect the stadial-interstadial changes occurring during a cold period of glacial nature (Ferdynandovian 1/2). The beginning of this period was characterized by the spread of boreal pine communities with spruce admixture. Then they were replaced by open steppe-tundra communities of herbs (grasses, *Artemisia*, sedges), and again by boreal birch and pine-birch forests.

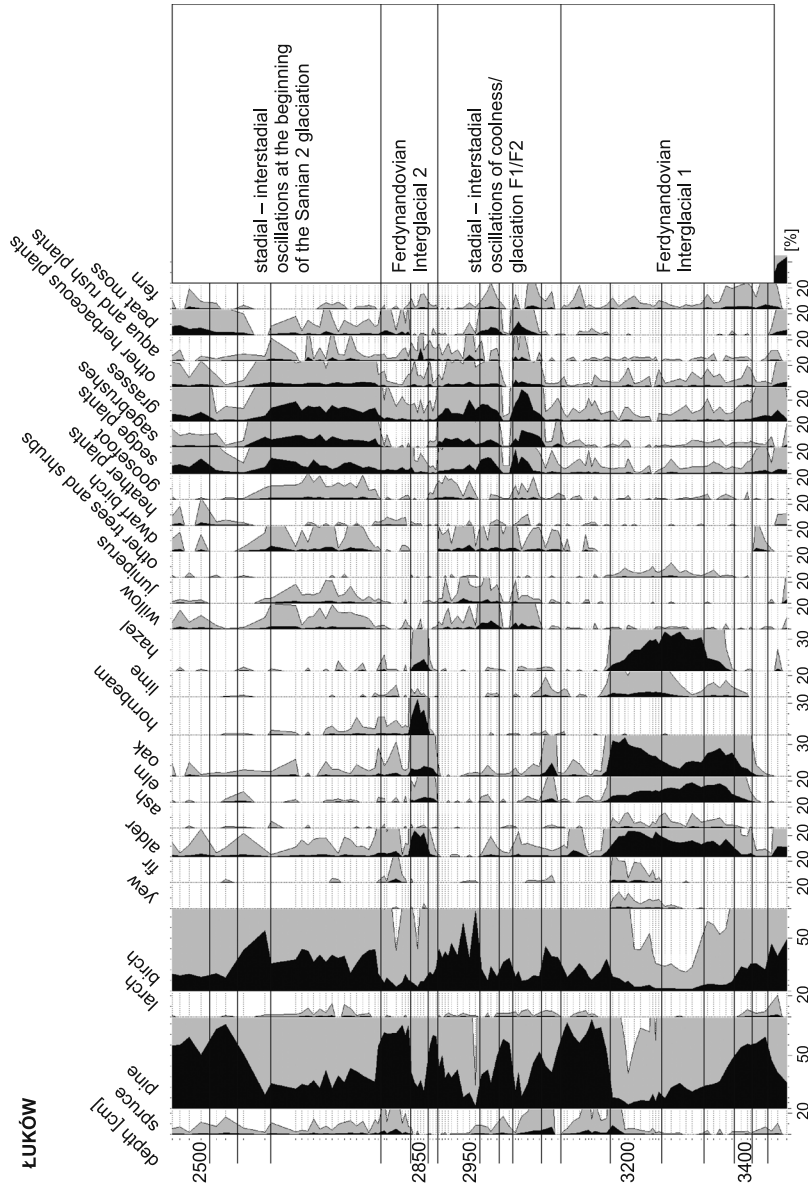


Fig. 3. Schematic pollen diagram of fossil lacustrine-mire deposits in the Łuków profile

The next interglacial succession (Ferdynandovian 2), including pollen zones Ł-12–Ł-15, is very different from the older one. This period was primarily characterized by the occurrence of vast hornbeam forests with an admixture of oak, lime, and hazel. Riverine communities, with elm, oak, and ash, were also present but the proportion of exotic species was lower than in the older interglacial. The estimated temperature and humidity seem to indicate that the climate was somewhat more continental though also warm, with the July mean temperature reaching 19°C (PIDEK and POSKA 2013). *Brasenia borysthenica* and *Aldrovanda borysthenica*, which were found among macrofossils, are very exotic taxa (STACHOWICZ-RYBKA 2015).

The next zones (from Ł-16) represent glacial conditions. The vegetation succession was characterized by the alternating occurrence of boreal forests of taiga type and steppe-tundra herbaceous communities.

Educational value

The analysis of educational value of the Łuków site indicates its high usefulness (5 points) for the explanation of phenomena and processes occurring in natural environment over 140 000 years of the early stage of Pleistocene. It was the period of several ice-sheet advances, which were separated by warmings when rich, multispecies, often exotic vegetation reappeared. Such changes are recorded in deposits due to the unique properties of exine (external membrane) of pollen and spore grains, which may be preserved under low-oxygen conditions for millions of years. The whole South Podlasie Lowland is unique in Europe because in this area there are preserved the fragments of fossil lakelands of different ages, which developed during different interglacials (ŻARSKI et al. 2005). These facts are not known to the broader public, but only discussed among scientists. In comparison with other sites located in the South Podlasie Lowland the Ferdynandovian flora site in Łuków is exceptional. In the Łuków profile we find a complete and continuous record of vegetation and climate changes during two warm interglacial periods separated by cold glacial period, i.e. the Ferdynandovian s.l. The overlying deposits represent the Sanian 2 glacial, and their vegetation succession is characterized by the alternating occurrence of boreal birch and pine-birch forests and replacing them herb-dwarf-shrub communities of steppe-tundra type. The West European authors also stress the exceptional value of the Ferdynandovian deposit sequences in eastern Poland (TURNER 1996, ZAGWIJN 1996), and the Łuków site is one of three profiles most suitable for reconstruction of the Cromerian climate and vegetation changes. Taking into account the fact that in the West European profiles the record of these changes is

incomplete and fragmentary, we think that the Łuków sequence should be exposed to the public for educational purposes.

Based on these new palaeobotanical data, it is possible not only to reconstruct the changes of climate and vegetation cover during the Ferdynandovian s.l. climatostratigraphic unit (LINDNER et al. 2004) but also to undertake broader palaeogeographical interpretations concerning the Southern Podlasie region. This region is of essential importance for the identification of palaeogeographical and palaeoclimate conditions in the periods of functioning of fossil lakelands of different ages (ŻARSKI et al. 2005).

State of the object

Location of the Łuków site, which is surrounded by forest and far from housing estates, has been favourable to its state of preservation. Therefore, the site should be assessed as well preserved, without visible signs of degradation (5 points). Due to such a location, it will be also possible to preserve the geological site for future generations.

However, good access to the area where the site is located may be a threat to it. The proximity of the access road may facilitate destructive actions or acts of vandalism. In addition, the proximity of the railway line with heavy traffic (domestic and international transit) may cause noise disturbing sightseeing or pose a threat to the visiting tourists.

Accessibility

As the Łuków-3a site is located within the limits of the city of Łuków, it is easy accessible from other cities of the region and the whole country due to well-developed road and railway infrastructure. Provincial roads from Radzyń Podlaski, Stoczek Łukowski and Siedlce intersect in Łuków making possible easy access to the site also from more distant cities: Warsaw, Lublin and Białystok. The Warszawa – Terespol railway line runs through the city, so it is also possible to easily reach the site also from further regions of the country (Figure 4).

According to the method of geosite evaluation for geotourism purposes the Łuków site is easily accessible (4 points). The site is situated off the tourist trails but in the short distance from them. The bike red trail named "Trail of the Łuków Land" runs about 7 km from the site, and the bike blue trail – about 3 km (Figure 4), so in the future it will be possible to establish trails running to the site itself. This solution is favoured by the location of the site on an access road, so that the access to it is easy.

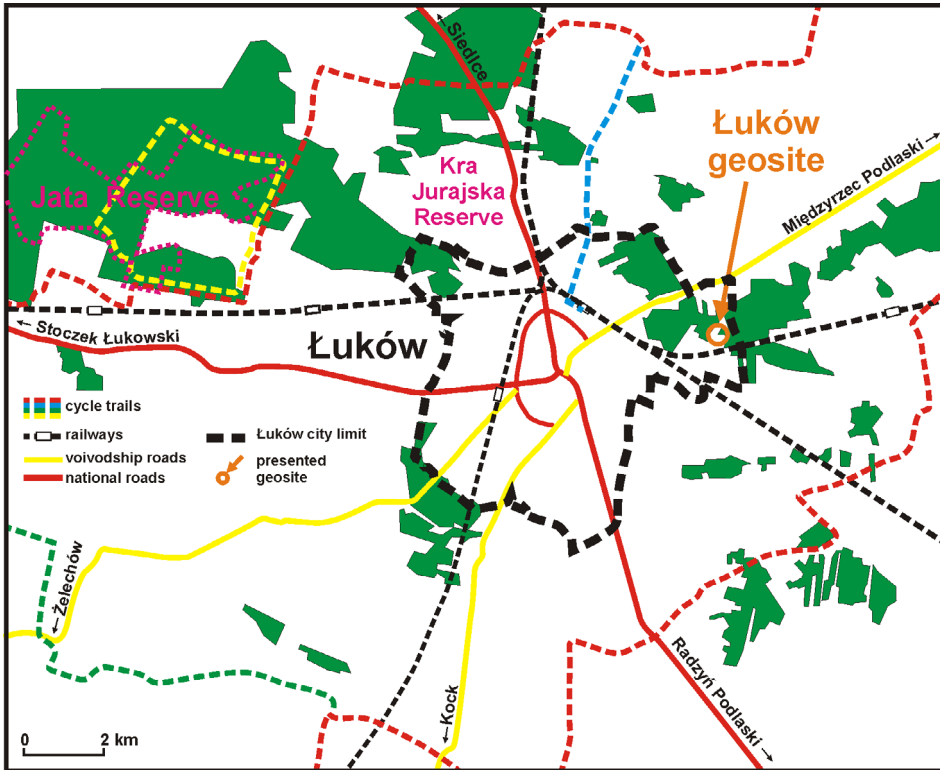


Fig. 4. Location of the Łuków-3a site against the background of the sketch of communication accessibility and tourist trails in the surroundings of the city of Łuków (author's own study based on the fragment of Sketch of communication accessibility and tourist trails in the surroundings of the city of Łuków by the Community Council of Łuków)

It is worth noting that in the city there are also other forms of nature protection, which present issues of geology, botany, etc. (Figure 4):

1) Jata Reserve – located in the Łuków Forests, protects the present vegetation of multispecies forest with fir reaching here the its north-western limit; springs of the Northern Krzna and Southern Krzna rivers occur in the reserve; three tourist trails run across the reserve: nature educational trail, historic walking trail, and historic bike trail. The fir forest in lowlands is never to be found in Europe. Its occurrence here is of special interest (*Centralny Rejestr...* 2017, Community Council of Łuków, own data).

2) Kra Jurajska Reserve – protects a rare geological object in the European scale, i.e. raft, which has been transported and left by the Scandinavian ice sheet; this very large slab of Jurassic clay is rich in fossils, especially ammonites (*Centralny Rejestr...* 2017, Community Council of Łuków, own data).

"Unique Ferdynandovian flora" geosite

The evaluation of geotourism potential of the Łuków-3a geological site indicates its high usefulness (19 points) for geotourism purposes. Therefore, we think that the site is suitable to establish geosite, i.e. the place where valuable geological information, recorded in the fossil deposits of the Łuków Plain, will be presented. In the case of such a geosite type the most common form of making knowledge about it available to the tourists is information board (MIGOŃ 2012). An example of such a board has been designed for the analysed Łuków-3a site (Figure 5).

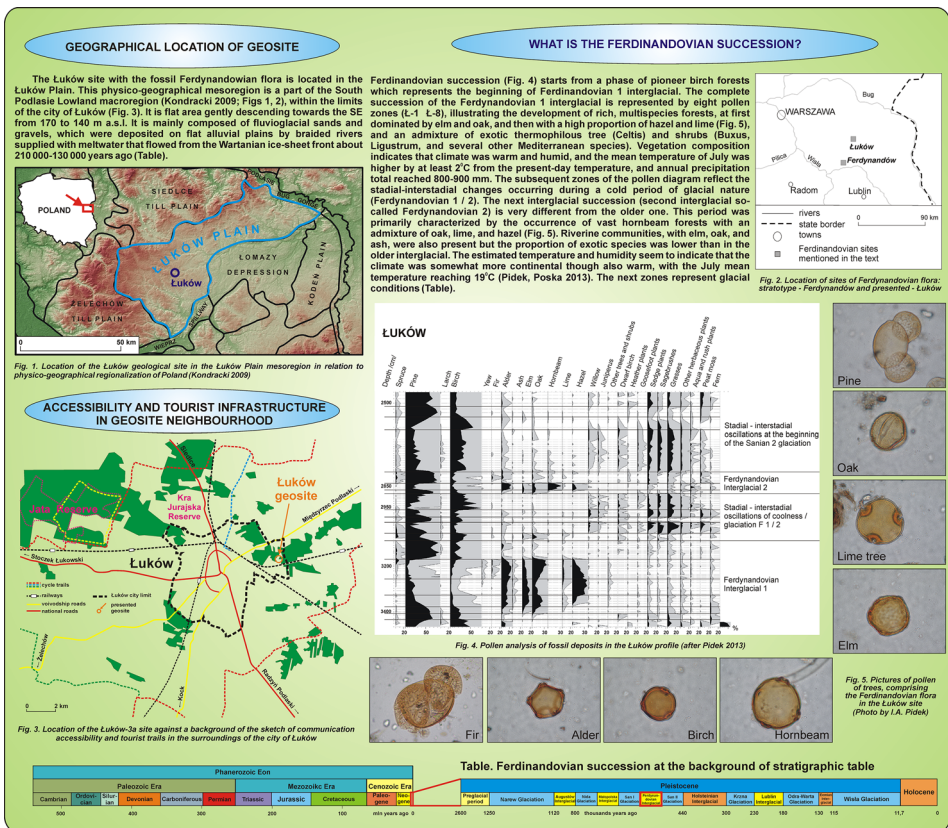


Fig. 5. Information board of Łuków-3a geotourist sites/geosite (authors; own study, pollen diagram plotted in the POLPAL software Nalepka and Walanus 2003)

Information board for a geosite should be prepared based on information resulting from the evaluation of scientific and educational values of a site, its state of preservation and accessibility. Information board should present all the knowledge about a geosite in a way accessible to potential unprofessional

tourist. The clear layout is a necessary form facilitating the assimilation of presented information. In addition to text information the proposed information board contains clear drawings (including the location map), tables and photos explaining and illustrating the processes, which have formed the fossil deposits with the Ferdynandovian succession in the analysed site.

Conclusions

The evaluation of geotourism potential of the Łuków-3a geological site leads to the following conclusions:

1. The abundance of information on the Pleistocene glacial – interglacial environment, which is recorded in the deposits of the Łuków Plain, is an excellent contribution to the education in the field of palaeoenvironmental sciences.

2. Based on the palynological data, it is possible not only to reconstruct the changes of climate and vegetation cover in the period of 140 000 years of Pleistocene (i.e. during the Ferdynandovian s.l. climatostratigraphic unit) but also to undertake broader palaeogeographical interpretations concerning the Southern Podlasie region, which is of essential importance for the identification of palaeogeographical and palaeoclimate conditions in the periods of functioning of fossil lakelands of different ages.

3. The analysis of plant macrofossils has provided important information about the development of palaeolake and its trophy.

4. Natural values of the geological site with the Ferdynandovian flora in Łuków, confirmed by scientific research, as well as the rarity of such sites (recording two interglacials in stratigraphic superposition) in Poland and in Europe indicate that the site meets the criteria for the establishment of another nature/geological reserve within the city of Łuków.

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References

- Centralny Rejestr Form Ochrony Przyrody (Central Register of Environmental Protection Forms)* 2017. Generalna Dyrekcja Ochrony Środowiska, <http://crfop.gdos.gov.pl/CRFOP/>, access: 10.03.2017.
- DOWLING R.K. 2010. *Geotourism's global growth*. *Geoheritage*, 3(1): 1–13.
- DOWLING R.K., NEWSOME D. 2010. *Global geotourism perspectives*. Goodfellow Publishers, Oxford.
- GARAVAGLIA V., PELFINI M. 2011. *Glacial geomorphosites and related landforms: a proposal for a dendrogeomorphological approach and educational trails*. *Geoheritage*, 3: 15–25.
- KNAPIK R., JAŁA Z., SOBczyk A., MIGOŃ P., ALEKSANDROWSKI P., SZUSZKIEWICZ A., KRAPIEC M., MADEJ S., KRAKOWSKI K. 2009. *Inwentaryzacja i waloryzacja geostanowisk Karkonoskiego Parku*

- Narodowego i jego otuliny oraz wykonanie mapy geologicznej tego obszaru.* Arch. Karkonoskiego Parku Narodowego, Jelenia Góra.
- KNAPIK R., MIGOŃ P. 2010. *Karkonoski Park Narodowy z otuliną jako geopark krajowy.* Prz. Geol., 58: 1065–1069.
- KONDRACKI J. 2009. *Geografia regionalna Polski.* PWN, Warszawa.
- LINDNER L., GOZHİK P., MARCINIĄK B., MARKS L., YELOVICHEVA Y. 2004. *Main climatic changes in the Quaternary of Poland, Belarus and Ukraine.* Geol. Quart., 48(2): 97–114.
- MIGON P. 2012. *Geoturystyka.* PWN, Warszawa.
- NALEPKA D., WALANUS A. 2003. *Data processing in pollen analysis.* Acta Palaeobot., 43(1): 125–134.
- PIDEK I.A. 2013. *Pollen-based vegetation and climate reconstruction of the Ferdynandovian sequence from Łuków (E Poland).* Acta Palaeobot., 53(1): 115–138.
- PIDEK A., MAŚEK M. 2010. *A bi-partite Ferdynandovian succession from Łuków, Eastern Poland, a new palynostratigraphic approach.* Geol. Quart., 54(1): 69–84.
- PIDEK I.A., POSKA A. 2013. *Pollen based quantitative climate reconstructions from the Middle Pleistocene sequences at Łuków and Zdany (E Poland): species and modern analogues based approach.* Rev. Palaeobot. Palynol., 192: 65–78.
- REYNARD E. 2004. *Geosite.* In: *Encyclopedia of Geomorphology.* Ed. A.S. Goudie. Routledge, London, pp. 440.
- SOBOLEWSKA M. 1969. *Osady interglacjalne w Łukowie na Podlasiu w świetle analizy pyłkowej.* Biul. Inst. Geol., 220: 105–114.
- STACHOWICZ-RYBKA R. 2015. *Record of environmental and climatic changes in middle Pleistocene sediments from Łuków (eastern Poland) on the basis of plant macroremains analysis.* Acta Palaeobot., 55(1): 67–91.
- TURNER CH. 1996. *A brief survey of the early Middle Pleistocene in Europe.* In: *The early Middle Pleistocene in Europe.* Ed. Ch. Turner. Balkema, Rotterdam: 295–317.
- ZAGWIJN W.H. 1996. *The Cromerian Complex Stage of the Netherlands and correlation with other areas in Europe.* In: *The early Middle Pleistocene in Europe.* Ed. Ch. Turner. Balkema, Rotterdam, pp. 145–172.
- ŻARSKI M., NITA M., WINTER H. 2005. *Nowe stanowiska interglacjalne w rejonie dolin Wilgi i Okrzejki na Wysoczyźnie Żelechowskiej (Polska Południowo-Wschodnia).* Prz. Geol., 52: 137–144.