A multiproxy approach to studying a large prehistoric enclosure in Ojców, Kraków Upland, Poland

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Abstract

Due to the presence of multiple caves and rock shelters as well as flint outcrops, Ojców Upland is a region with an exceptionally high concentration of prehistoric human settlement traces. It has attracted archaeologists for over 150 years, leading to what was considered to have been a proper prospection of the area. Nonetheless, the analysis of airborne laser scanning has recently brought surprising results. In the very centre of the upland, on the densely forested hill ‘Złota Góra’ (Golden Hill), the remains of an exceptionally large defensive structure in the form of several rows of embankments were found. The use of magnetic methods made it possible to confirm their anthropogenic origin and the likely type of embankment construction. In turn, the layout of embankments combined with the results of a surface survey and the analyses of the acquired artefacts and the settlement context speak in favour of linking this defensive structure with a high degree of probability with the Neolithic or Eneolithic, most likely the Lengyel-Polgár cycle or Baden culture. The presence of such a large fortification in the immediate vicinity of flint mines could shed new light on the image of the Late Neolithic-Early/Middle Eneolithic period in this part of Europe.

KEYWORDS

ALS, embankments, karstic landscape, lidar, magnetometry, Neolithic

1 INTRODUCTION

In the last few decades, the use of modern non-invasive prospecting methods has accelerated studies of large archaeological sites, including prehistoric embankments (Abbas et al., 2012; Bewley et al., 2005; Filzwieser et al., 2017; Gojda, 2004, 2006; Saunaluoma et al., 2019). It is especially important in densely forested areas (Chevance et al., 2019; Doneus et al., 2008; Inomata et al., 2020; Masini et al., 2018; Risbøl & Gustavsen, 2018). The already known sites can be studied relatively rapidly, and the conducted analyses can cover larger areas. Moreover, the use of aerial photography and light detection and ranging (LiDAR) brought new tools for earth structure recognition. In Central Europe, the chronological affiliation of this type of structures is complicated, as their chronology ranges in the region span from the early Neolithic (Podborský & Kovárník, 2006, p. 45) to the Iron Age (Sievers, 2006).

A large number of newly discovered embankments change our research perspective. However, their further studies seem to be

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problematic. Due to the apparent limitations of archaeological fieldwork, a discussion on the appropriate protocols for further studies of such sites is required. The current paper aims to discuss the extent to which a multiproxy, non-invasive approach can play a role in considerations about the dating and function of newly discovered embankments. The current paper focuses on large embankments newly discovered in Złota Góra (Ojców) at the heart of the well-known and well-studied Karstic region of Cracow Upland. The southern part of the Cracow Upland, especially its picturesque fragment referred to as the Ojców Upland (Kondracki, 1998, p. 255), is an area that occupies a special place on Poland’s archaeological map for many reasons. Primarily, one should mention the exceptional (on a nationwide scale) accumulation of archaeological sites from different periods, which, along with other mementoes of the past, form the significant research potential of the area. Undoubtedly, these include caves and rock shelters (Gradziński & Szelerewicz, 2004, p. 77), of which approximately 150 can be considered archaeological sites verified through field studies. One might add that numerous sites outside the caves supplement this image of the Ojców Upland’s rich past, including open settlements (cf. Chchorowska, 2006), places linked to flint exploitation and processing (Lech, 1981), cemeteries (cf. Jawrowska, 1962, p. 17–21) and examples of medieval defensive architecture (Kołodzięska, 2006; Wojnienka, 2018).

Another very significant factor proving the exceptionality of this microregion is the long and successful history of its excavations. This work began in caves of the karstic region of Prądnik and Saspów Valleys (southern Poland, 20 km north of Kraków) as early as 1871 (Olszyński, 1871; cf. Lech, 2001), and with a few interruptions, they have continued to this day. Analysing archaeological achievements so far in determining the past of the Ojców Upland, it should be stated that this is not only the cradle of Polish Prehistory (cf. Lech & Partyka, 2006) but also one of the best-researched corners of the country.

Therefore, the recent discovery we made in the Złota Góra massif, located in the very centre of Ojców, has come as all the more of a surprise. As indicated by the LiDAR images, we can count on the presence of a complicated system of segment embankments, which separates an area of over 76 ha, of which the longest structure is over 750 m long.

Unfortunately, due to the lack of excavations, the above-mentioned structure’s chronology and function must remain undetermined. Taking into account the significance of the finding, which in our opinion throws an entirely different light on the knowledge we had so far about the dynamics of former settlement processes in the vicinity of Ojców, we undertook multifaceted non-invasive studies of this impressive structure, which in their assumptions constitute the foundation for further research. The undertaken study aimed to identify the inner and external structure of the embankments and—by comparison with other similar structures—to come closer to its possible dating. Our structure’s prehistoric dimensions do not seem to raise any doubts in light of the accumulated data. The other goal was to test the prepared protocol to identify the extent to which it might be used in similar sites located in densely forested areas.

1.1 | Złota Góra (Golden Hill)

Złota Góra (458 m a.s.l.) is a hill with its eastern slopes descending steeply down to the Prądnik Valley, whereas the southern and western slopes descend to the Saspów Valley (Figure 1a). From the north, the hill transitions gently into the plateau of the Cracow Upland. By cutting through the limestone slopes of Złota Góra, both the Prądnik and Saspówka streams have almost completely uncovered vertical limestone rocks. The slopes descending to both valleys are additionally crisscrossed by deep ravines, constituting the most convenient routes to go down into the valley. Złota Góra, currently part of Ojców National Park, is almost completely covered with old-growth forests, predominantly consisting of beech trees.

Thus far, no open archaeological site has been discovered within the area of Złota Góra. However, there is a mention of the discovery of graphite burrs in the literature, found north of the castle in Ojców (Czarnowski, 1925, p. 301), whose location can be linked to the Złota Góra area. There are few archaeological sites on the southwestern slopes of the hill, such as the Wylotne Rock Shelter, the Branka Rock Shelter or the Ilowe Rock Shelter (Chmielewski, 1988).

In 1923, a plan for the protection of the landscape and natural assets of the Prądnik Valley was prepared, a part of which was a project aimed at moving the Ojców health resort located in the valley to the higher situated Złota Góra. In the 1920s, urban plans were formed for a new town, and they began to be implemented. For economic reasons, the plan was never executed in its entirety. However, in the LiDAR images, one can see the prepared roads’ outlines and demarcated land plots (Kot et al., 2018, pp. 141–142).

Before the plan was put into motion, the Złota Góra area had been almost completely covered with fir forests (Richter & Szafer, 1924). On the hilltop, there were individual deforested fragments with crop fields (Kot et al., 2018, Figure 6), traces of which are visible to this day. The LiDAR images also show earlier crop fields, probably in use in the second half of the 19th century (Kot et al., 2018, pp. 142–143). The individual fields are separated by baulks and characterised by a uniform field tillage direction. It is possible to observe changes in the tillage direction in some fields, suggesting a few phases of their utilisation. Only the southern part of Złota Góra does not bear any traces of agricultural work conducted there. In light of LiDAR imaging, these traces are younger than the enclosure that constitutes the subject of this article.

2 | METHODS AND MATERIALS

The embankments were found during the analysis of Saspów Valley’s microregion in the LiDAR imaging. In search of their chronology and cultural affiliation, archival maps of this area were also used (Figure 2). After analysing the history of modern settlement on the Złota Góra
and singling out the earthworks performed as part of the planned spa estate (Kot et al., 2018), the observed earth structures’ modern-time chronology was excluded. At the next stage, the work was carried out in two ways. Magnetic and electroresistivity analyses were carried out to determine their range and structure, whereas archaeological surveys aimed to collect data relevant for the discussion of the site's chronology. The collected material was subjected to traceological and morphological analysis. Additionally, geographic information system (GIS) models were created to show the microregion’s intensity of use in particular periods of Prehistory.

2.1 | Light detection and ranging (LiDAR)

The source of the point cloud used in the preparation of the analyses was airborne laser scanning conducted within the framework of an ISOK (IT system for protection against extraordinary hazards) project, which took place as part of The INSPIRE European Union directive. The project’s initial objective was to improve the quality of flood defences; however, Poland’s entire area was encompassed by the survey conducted between 2009 and 2015 (Maślanka & Wężyk, 2014). It was conducted with three levels of point cloud density (4, 6 and 12 points per square metre), with the size of the laser spot footprint in the terrain oscillating at approximately 50 cm in each case and the right angles not exceeding 25° in wooded areas (Kurczyński & Bakula, 2013). In the best case, the accumulated data set allows for achieving a digital terrain model (DTM) with a 50-cm spatial resolution. However, it remains significant that the model’s quality is significantly reduced in terrains covered with dense vegetation. Despite their imperfections, the acquired models based on the provided data set enabled remote sensing and analysis of archaeological sites preserved in the landform.

For the area under study, the point cloud with a density of four points per square metre was reclassified, whereas a DTM with a spatial resolution of 50 cm was prepared for acquired class 2 (points located on the ground).

Ojców National Park is a challenge for analyses with the use of LiDAR technology. The steeply descending slopes, numerous valleys, gorges and outliers form various landscapes with large denivelations. For this reason, many possible visualisations become almost useless, for example, hillshading and local dominance. As a result, a whole series of trial visualisations were made for the research area with
various parameters. A set of visualisations were used according to the
best practices adopted for this type of landscape (e.g., Challis
et al., 2011; Kokalj et al., 2011; Kokalj & Hesse, 2017).

The best results were achieved using the local relief model
(Hesse, 2010). The radius amounted to 15 m, which enabled the
observation of relatively small differences in the terrain altitudes,
simultaneously solving high denivelations. The resulting raster was
prepared using Global Mapper software; a histogram was extended
from 0.2 to 0.2.

At the first stage of the analyses, all the archive maps and archi-
tecture plans were analysed to exclude the modern age structures
(Figure 2). A separate paper focuses on modern-era settlement traces,
including the unfinished concept of building a new garden city and
spa in Złota Góra, which started in 1923 (Kot et al., 2018).

2.2 Magnetic studies

Fieldwork was conducted in April and December 2019. Magnetic and
electroresistivity methods were selected to conduct the surveys. The
research terrain was not easily accessible, as it was covered with for-
est. The ground cover consisted of rendzina-type soil. The bedrock
(limestone) was very shallow in some places.

The magnetic measurements, determining the gradient of the mag-
netic field’s vertical component, were performed using a Foerster
Ferrex 4.032 DLG transducer-type magnetometer (a fluxgate com-
pass) (Misiewicz, 2006, pp. 74–98) equipped with two probes with a
0.2-nT resolution. The measurement lines were at a distance of 1 m
from each other. Ten measurements per 1 m² were made. As a result
of the tests, numerous anomalies were established, diverse in their
nature. They were presented on magnetic maps prepared using the
Terra Surveyor 3.0.29.3 programme. The geodetic and magnetic test-
ing data were integrated with the QGIS 2.12.0 programme.

Magnetic testing was conducted in two isolated areas—northern
and southern (Figure 3). In the case of an area no. 1, measurements
were made in a continuous, compact area. (Figure 3—an area no. 1). In
the case of an area no. 2, the measurement area was divided into two
adjacent areas adapted to the found conditions of forest density.
(Figure 3—areas no. 2 and 3). Area no. 1 covered 1.5 ha, whereas
areas nos. 2 and 3 covered 0.75 and 0.50 ha, respectively.

The research area was determined by the embankment course
visible on the LiDAR images (Figure 3). They were also dependent on
the accessibility of the terrain for surveys. Forests cover this entire
area. In the northern area, the forest thickness made it completely
impossible to take measurements in the isolated promontory cut off
by the embankment, despite the expected interesting results. Conse-
quently, a decision was made to place the research polygons in such a
way as to take the measurements at the spot where the two longer
external embankments—2A and 2B—merged (Figure 3) to identify the
space between embankments nos. 1 and 2. In the southern area, the
measurements encompassed the edge of the hill’s western slope with
visible embankment no. 3 (Figure 1a) and part of the plateau at the
top of the hill (Złota Góra).

2.3 Electroresistivity tests

Electroresistivity tests were conducted using the ELMES ADA-5MP
apparatus for archaeological research and solving tasks linked to shal-
low geology. In the course of the surveys, a series of vertical electrical
resistivity probes were conducted. Such probing is intended to pro-
vide information about the resistivity layout in a given spot of the
study area. If the survey points are located along a particular line
(profile), the measurement results enable the preparation of a
geoelectrical cross-section along this line, that is, this cross-section
corresponds to the geological cross-section.
Geoelectrical probing was performed by applying a symmetrical 4-electrode arrangement (the Schlumberger arrangement), providing the highest localisation precision. The acquired results were analysed using Surfer Golden Software and presented in a map of apparent resistance isolines in select colour scales.

2.4 | Surveying

Thus far, the observation of unidentified structures on the imaging results has led to intensive and systematic surface surveying in the Złota Góra area. Surveying covered an area of ca. 100 ha (Figure 4). It was executed by a group consisting of two to five people using handheld GPS equipment and a photographic camera. The first verification, which took place in January 2019, focused on locating and confirming embankments in the terrain. During the second prospecting tour, lasting a few days, surveys were done to acquire the highest possible amounts of moveable surface material, which would enable dating of past human activities in the area.

The researched area was densely covered with forests and protected against any human encroachment. As a result, the best effects were achieved by prospecting in places in which wild animals or natural treefall pits had naturally disrupted the plant litter. As a result, a decision was made to not conduct the surveys according to the previously prepared regular grid. The group moved in slightly scattered formation around the person carrying the GPS receiver, searching for any spots worth more precise prospecting. All flint and ceramic finds were positioned using GPS (Figure 4).

2.5 | Archaeological material

Flint artefacts were studied with the use of morphometric, typological and technological attributes. The use-wear analysis was performed by applying a metallographic Nikon LV150 microscope and a digital Keyence VH-Z100R microscope. The items were studied at 50×, 100×, 200× and 300× magnification, which enabled the detailed identification of individual traces—micro-flake scars, linear traces and polishes. Detergent with warm water and acetone was used to clean the artefact surfaces. Experimental tools used for various activities that might have been done in Prehistory were used as the reference base, and a collection of such tools was kept at the Institute of Archaeology at the University of Warsaw.

Pottery was studied for its typological and technological features.

3 | RESULTS

3.1 | Light detection and ranging

In the Złota Góra area, LiDAR imaging revealed the presence of three embankments separating the rock promontory of Złota Góra rising above the area where the two streams, Prądnik and Saspówka, meet. The two shorter embankments separate two smaller promontories, whereas the third, the longest one, runs directly behind them, cutting off the entire promontory (Figures 3 and 5).

Embarkment no. 1, with a length of ca. 370 m, a width of max. 20 m, and a height of ca. 35 cm (Figures 5: 1 and 6b) was washed...
**FIGURE 4** A record of surface survey paths and marked locations of the acquired artefacts. ‘A’ denotes concentration of artefacts. ‘B’ denotes concentration of blade cores [Colour figure can be viewed at wileyonlinelibrary.com]

**FIGURE 5** Visualisation of the described structures' profiles prepared based on the data acquired using the ALS method. A multihillshading terrain visualisation was used as the background of the graphic [Colour figure can be viewed at wileyonlinelibrary.com]
away to no small extent. In its central part, it has been almost completely levelled by modern tillage. In its northern and southern parts, it was used as a boundary for cultivated land, functioning from sometime around the 20th century’s beginnings. This led directly to a small embankment formation, which should be interpreted as a field-forest border. This significantly lowers the possibility of analysing the morphology of the structure itself.

Embankment no. 2 should be divided into two parts (Figure 5). With a length of ca. 750 m, Part A runs from the rock outlier in a northeastern direction (Figure 5: 2A). The best-preserved central part has a width of ca. 12 m and a height of over 1 m (Figure 6). In front of the embankment, from the side with the plateau, one can see the remains of a dry moat with a depth of up to 40 cm and width of ca. 5 m, from which earth must have been used during the building of the structure. The embankment runs as far as the edge of the erosion valley, whereas its further course remains uncertain (part 2B—with a length of ca. 440 m, Figure 5: 2B). The LiDAR data analysis, especially the line risk model (LRM) visualisation, suggests that it might run consistently further in a northeastern direction, turning more eastward towards the end. However, this hypothesis raises certain doubts. Primarily, the layout of the borders of the cadastral parcels overlaps in this place with the embankment, as a result of which the rise in the terrain might be the effect of later agricultural activities and the formation of a baulk in this spot. Simultaneously, the possibility cannot be excluded that the border was made in this spot due to a previously formed embankment and leftover material difficult to plough. It could also be indicated by the fact that the embankment ending in the vicinity of the erosion valley at the junction of parts A and B seems justified by the defensive nature of such structures. Analysis of the LiDAR data does not provide conclusive answers to these uncertainties.

Embankment no. 3 is ca. 400 m long (Figures 5: 3 and 6c), ca. 7 m wide, and 2 m high from the hill slope’s side. The way it was constructed differs from that of embankments 1 and 2. In this case, the slope was undercut from the side located lower down, after which the soil was transported upwards, causing the construction to be similar in the cross-section to a ramp (Figure 5). It should be noted that for this type of structure to function correctly, the wall must have been reinforced. Following the geophysical study results, it can be concluded that a wooden structure was used for this purpose.

Attention should be paid to specific differences in the morphology of the enclosure visible in the LiDAR images. Embankment no. 1 is a strongly levelled structure. The high level of erosion caused by agricultural activities seems, in this case, would potentially speak in favour of earthen construction. Embankment no. 2A is a structure with a visible trench. Its state of preservation, enabling its observation in the terrain, may testify to building material used less susceptible to erosion, such as local limestone.

Against this background, the potential construction of embankment no. 3 seems to stand out. Based on the morphology, it seems to have been based on the undercutting and reinforcing of the slope, after which the output was transported upwards. However, another reinforcement may have been placed on the ramp constructed in this way in the form, for example, of a palisade.
3.2 | Magnetic studies and electroresistivity tests

A certain amount of magnetic anomalies was discovered as a result of the conducted surveys. Some minor dipolar anomalies, undoubtedly linked to ferrous items, are visible on all of the magnetometers. In the western part of the area no. 1 (Figures 3 and 7), a negative linear anomaly is observable, connected to the presence of the longest embankment called 2AB (Figure 7: 1). It was captured on a fragment measuring over 50 m. Its character indicates that the embankment was built from a nonmagnetic material, providing a negative anomaly against a backdrop of a layer of humus with positive magnetic resistivity. Considering the geological area in which the survey was conducted, the embankment must have been built from limestone debris. In area no. 1, a dipolar linear anomaly is observed and marked as no. 2 (Figure 7: 2). It is related to a natural structure (an erosive slit). In area no. 1, further linear anomalies with very low values are also visible (Figure 7: 3, 4). It is difficult to explain their nature conclusively. They were probably caused by natural objects (e.g., erosion troughs). However, their anthropogenic character cannot be excluded (e.g., forest roads). Two large positive point anomalies were also discovered in area no. 1 (Figure 7: 8, 9). They might have been caused by structures such as extensive pits or perhaps burnt material clusters (fire pits). They could have been formed by natural formations, such as basins (surface pondings) or large treefall pits.

In the southern area (no. 2), primarily, an apparent linear anomaly can be observed connected to the embankment surrounding the peak of the hill from the west (embankment no. 3) (Figure 7: 5). It is with a length of 150 m. It is, in fact, a series of thermoremanent and positive anomalies, forming a linear structure. Considering the relatively high values and amplitudes of the anomaly connected to the embankment, the presence of burnt material in its structure should be assumed.

This is probably evidence of fire of the embankment, which attests to its anthropogenic and defensive character. Two clusters of dipolar anomalies lie adjacent to the embankment from the western side (Figure 7: 6 and 10). Both correspond to hollows visible in the terrain. The larger of these, consisting of anomalies of higher values and higher amplitudes (Figure 7: 6), can be linked to the lime-kiln functioning in this region, identified on archival maps. The genesis of the second cluster of anomalies is difficult to explain. This might be linked to recreational infrastructure constructed here in the first half of the 20th century.

FIGURE 7 Magnetic maps overlaying the LiDAR images. The magnetic anomalies discussed in the text and the electroresistivity cross-section locations are marked on the maps [Colour figure can be viewed at wileyonlinelibrary.com]
Area no. 3 of the magnetic survey was located at the peak of Złota Góra. No anomalies that could conclusively be linked to archaeological structures were discovered, such as pits, recessed buildings, or mining shafts, even though they had been expected at the site. A certain number of positive point anomalies can be indicated in the discussed area (Figure 7: 7); however, their genesis remains unclear. Archaeological structures might be their source, but so could natural formations (animal burrows or treefall pits). It seems that due to soil determinants (light soils of the rendzina type, shallow-lying bedrock and a weakly developed humus layer), the possibility of discovering archaeological objects that would be the source of evident magnetic anomalies is slim.

A geoelectrical cross-section (Mościcki, 2012) of the long external embankment was conducted to supplement the magnetic surveys (Figure 7: A). For this purpose, a series of 22 electroresistivity probes were conducted at a distance of 1 m from each other, achieving a 22 m long and 5 m deep cross-section. A pronounced high-resistivity anomaly (650–750 ohms, with 150–250 ohms calc resistance) was linked to the embankment visible on the surface. This anomaly is approximately 11 m wide and 2.5 m deep (Figure 8: A). A smaller and weaker high-resistance anomaly neighbours it from the southern side (Figure 8: B). Anomaly ‘A’ is connected with the stone core of embankment no. 2, which is indicated by its high values (Misiewicz, 2006, tab. III). Anomaly ‘B’ probably consists of stone debris originating from the embankment.

To summarise the survey results, it can be stated that the anthropogenic nature of the external embankment (no. 2A) and of the embankment that cuts off Złota Góra (no. 3) has been confirmed by applying geophysical methods. The nature of the related anomalies allows for the conclusion that embankment 2A was probably constructed from limestone. In turn, embankment no. 3 is probably an earth or earth and wood construction. It underwent thermal transformations, probably falling victim to a fire. The soil cover and geological structure of the surveyed area, together with forest cover, are not conducive to the discernibility of anomalies related to archaeological structures. Therefore, it cannot be excluded that archaeological structures are present in the surveyed terrain but imperceptible by applying geophysical methods.

3.3 | Surveying

All of the traces of constructions noted on the images are perfectly visible in the terrain. Their height enables marking their course with high precision based only on their entire course’s visual observation. The high amount of forest coverage in the area containing the enclosure also does not impede such observation. During verification the destroyed fragment of embankment 2A was confirmed. The destruction was located by the protruding fragment of a car park and road leading from Ojców constructed in the 1960s (Kot et al., 2018, p. 138). In turn, traces of a small structure (Figure 3—area no. 2) were noted in the direct vicinity of embankment no. 3 in the form of shallow pit and brick fragments. These findings were interpreted as traces of a lime kiln or buildings related to it (Kot et al., 2018, p. 144).

The thick vegetation limited the number of artefacts found. During the prospecting, 10 individual finds and two distinct clusters were noted (Figure 4). The first cluster of artefacts, at which flint tools (four specimens) and pottery sherds (five specimens) were discovered, was found close to embankment no. 3 in a fenced-off area of the hill (Figure 4: A). The second cluster consisted altogether of 14 flint products, as well as brick fragments, glass items and what was probably a stone grinding plate, accumulated in the remains of the edges of
a baulk (Figure 4: B). These artefacts have been gathered by someone and placed in a pile most likely from one of the neighbouring fields where they had impeded its cultivation. The fields adjacent to the cluster were formed in the second half of the 19th century (Kot et al., 2018, p. 143); thus, the cluster of acquired cores seems to have been formed during that period. All the discovered flint products were made from brown variety ‘A’ of the local so-called Jurassic-Cracow flint (Kaczanowska & Kozłowski, 1976).

3.4 | Archaeological records

Alongside loose finds, represented mainly by noncharacteristic flakes, the artefacts found within the two clusters are especially significant. Five pottery sherds and four flint products were found in the first cluster. The ceramic collection includes small, unornamented shards of vessel bodies exclusively, with monochromatic fractures and rough surfaces of various colours—from beige to brick-red, indicating firing in an oxidising atmosphere. All of them were made from sandy clay and additionally thinned in two cases by a large amount of temper of grog. The ceramic material’s technological properties, including the admixture type, generally link these fragments with the Neolithic or Eneolithic period. The application of temper of grog was documented already for the oldest phase of this period (e.g., Rauba-Bukowska, 2014, p. 437); however, it gained great popularity in the fifth millennium BC, that is, during the period of the development of Malice culture (e.g., Kadrow, 1990, tab. 2; Kaczanowska, 1996, Figure 7; Kadrow & Rauba-Bukowska, 2017, tab. 2), as well as of Lengyel cultures, including the Pleszów group, especially the Modlnica phase (e.g., Kaczanowska, 2006, p. 43). Its widespread popularity has been confirmed about the youngest Danubian groups developing in the fourth millennium BC and represented by the Wyciąże–Złotników group (e.g., Kozłowski, 2006, p. 57; Grabowska & Zastawny, 2011b, fig. 29), the Lublin–Volhynian culture (e.g., Kadrow & Rauba-Bukowska, 2017, tab. 2) and the Baden culture (Bober, 2015). It corresponds to the flint artefacts accompanying the pottery, represented by a medial part of a regular negative blade (Figure 9: 1), a negative flake with an intentionally retouched notch (Figure 9: 2), an

![Figure 9](https://wileyonlinelibrary.com)
end-scraper formed on an almost entirely cortical blade (Figure 9: 3) and a truncated blade, equipped with atypical arched truncation, formed by a steep retouch on the distal edge of the blade and with intentionally retouched right edge (Figure 9: 4). The results of the use-wear analysis of the discussed specimens indicate that at least three of them had been used. Two tools stand out due to the distinct use-wear traces from work linked to processing cereal. They can be categorised as harvesting insets. Such use of flint tools was quite widespread throughout the entire Neolithic period (cf., e.g., Keeley, 1980, pp. 60–61; Vaughan, 1985, pp. 35–36; Anderson-Gerfaud, 1988; Van Gijn, 1990, pp. 40 & ff.; Juel Jensen, 1994; Korobkowa, 1999, pp. 126–138; Malecka-Kukawka, 1999, 2001). The first specimen is the above-mentioned middle part of a blade (Figure 9: 1), with one side covered by intensive ‘mirror’ sickle gloss, distinguished by its ‘flat’ texture, within the frame of which there are numerous linear marks in the form of thin and dark scratches (Figure 9a–d). These scratches are located more or less parallel or diagonally to the working edge. The use-wear traces reach deep into the flint surface, down to a few millimetres. The described traces are accompanied by small chippings visible on both sides of the working edge. In turn, the specimen’s parts not covered by sickle gloss traces have another type of mark. On the protruding parts, mainly the ridges and edges, abrasions and delicate traces of wear have been observed, with an unspecified genesis due to their underdeveloped form. These traces are probably evidence of the flint surface’s contact with organic hafts (cf. Rots, 2003, 2008a, 2008b, 2009, 2010; Rots et al., 2011; Rots & Vermeersch, 2004; Van Gijn, 2010). Analogous traces of use can be found on the next flint tool—a truncated blade (Figure 9: 4). Based on the trace morphology and location, it can be stated that the tool was embedded in the haft and served as a harvesting inset (Figure 9f–h).

In turn, the distinguished formal end-scraper (Figure 9: 3) shows traces of use extending along the working edge. Unfortunately, the distinguished polish has been modified by the activities of postdeposit factors, as a result of which the surface of the end-scraper is covered with shiny and whitish-blue patina. This specimen was used to scrape organic material, probably hide. Such use of the tool is evidenced by the layout of the scratchings—perpendicular to the working edge—and the morphology of the polished surface—translucent, slightly ‘greasy’, penetrating the flint’s microstructure (Figure 9e) (cf., e.g., Keeley, 1980, p. 49; Van Gijn, 1990, pp. 29–30; Hayden, 1993; Korobkowa, 1999, p. 29). The last of the specimens, a flake with a retouched notch (Figure 9: 2), does not have any microscopic use-wear traces. It should be stated that no postdeposition changes have been noted on its surface that would have influenced the image of potential functional marks.

In the second cluster, the predominant group of finds (eight specimens) consisted of single-platform cores for blades, abandoned at various exploitation stages (Figure 10). They are characterised by
a relatively low range of sizes, showing many shared morphological and technological features. These include the similar characteristics and sizes of the concretions of raw material selected for the cores and the planning of the striking platforms, especially the debitage surfaces, in each case located within the raw material's narrower surfaces. The scope of the preparation mortar is also similar, encompassing primarily the precise preparation of the striking platform (Figure 10a, b, c, e, and f), sometimes the removal of the cortex from the natural sides of the concretions (Figure 10d) and the stabilisation of the core apexes through the formation of a one-sided crest (Figure 10a). Additionally, the exploitation of part of the specimens was preceded by forming the frontal crests (Figure 10b, e). On the core surfaces, there are visible traces of repair procedures linked to their maximal usage in blade production. This tendency is manifested both in the procedures connected to the shifting or relocation of the debitage surfaces to the lateral or posterior parts of the cores (Figure 10d,f) and the systematic correction of the core angle, including the partial rejuvenation of striking platforms (Figure 10a, b, c, and e) and precise abrading of the platform edges (Figure 10a–e). The character and prevalence of these procedures also constitute a common feature of the discussed collection of cores. It also applies to the blade sizes obtained in the final phases of core exploitation, represented by specimens with a length of ca. 80–90 mm (max. 100 mm) and a 20–30 mm width.

4 | DISCUSSION

4.1 | Embankments

All the obtained results allow us to identify the presence of very large earth structures at the high promontory located in the conjunction of Prądnik and Sąpów Valley in the hearth of the Karstic region of the Ojców Upland. The whole earth structure consists of three embankments that enclose the most protruding part of the karstic promontory. The embankments are located on the relatively flat plateau above the river valleys. The longest embankment (no. 2) of at least 1200 m enclose the ca. 76 ha area. Two smaller embankments (nos. 1 and 3) are located inside the space enclosed by the large embankment. They are 370 and 400 m long and enclose two smaller promontories of 9 and 14 ha. Both promontories are divided by a steep gorge. The largest embankments are built of stone, whereas at least one of the smaller embankments, that is, no. 3 is built of earth. The embankment structure no. 1 could not be studied due to the dense forestation of the area.

All three described structures seem to form a coherent complex that separates a specific area. However, it is impossible to confirm or refute the coexistence or simultaneous functioning of the presented fortifications based on the visualisation analysis. The embankments might have constituted elements of one impressive fortification or functioned independently, separating a smaller area, appropriate for the population's requirements using it.

Embarkment nos. 1 and 3 enclosing Złota Góra (Figure 1a) constitute classical fortification elements separating settlements situated on promontories with natural defensive properties. Both embankments are located from the side with a gentle slope, which would require additional reinforcement. This principle was applied in all periods of Prehistory, as well as during later historical periods. Identifying the embankments' size and course does not make it possible to reach any conclusions concerning their chronology. Nonetheless, it allows for composing conclusive statements about their defensive character.

Long external embankments are much less typical structures. Their sizes and the courses they run are not typical, whereas in the case of embankment 2A, neither is the building material, because—as can be assumed based on non-invasive surveys—it was made from stone. Based on geological drillings conducted in the 1920s in connection with the planned construction of a residential estate in Złota Góra, (Kot et al., 2018) and recently stored in the National Archive in Krakow (sygn. No. 29/645/272), we can analyse the geological situation in the vicinity of the embankments (Figure 11). Under Holocene humus, which was not enlisted in the drills, a layer of loams covering layers of loams containing limestone debris can be found. Both layers have varying depths depending on the location. The bedrock is built of limestone rock. In certain places, limestone rocks are visible above the surface of the plateau. The largest embankments end up at one of the rocks facing the Sąpów Valley (Figure 1a). The other rocks can be found inside the area enclosed by embankment no. 3. In some places, limestone rock might be found as shallow as 50 cm under the recent Holocene humus, but it is located ca. 250–300 cm below the humus in most places. In the area near the largest embankment, limestone rock was not found in the 3-m deep drill (Figure 11). In light of these results, the fact that limestone rocks were used to construct fortifications, as indicated by magnetic studies, seems entirely plausible. On the other hand, geological drills confirm the anthropogenic origin of the structure.

Stone embankments are exceptionally rare in Poland and are always found in mountainous or quasi-mountainous terrains. The embankments known from southern Poland have been discovered mostly in loessial terrains. For this reason, stone was rarely used for their construction. Well-identified stone fortifications surround the Otomani culture settlement on Mount Zyndrama in Maszkowice in the Nowy Sącz poviat (Jędrysik & Przybyła, 2018). However, in formal terms, stone embankments found in the Śleża Mountain massif in Lower Silesia and on Łysa Mountain in the Świętokrzyskie Mountains are the most similar structures to those discovered in Ojców. The embankments constructed on the Śleża Mountain and neighbouring peaks have, in particular, been the subject of interest of numerous researchers for a long time. Their example is a perfect illustration of the issues one may encounter with determining such structures' age and function. Despite the embankments coexisting with stone statues and the large numbers of excavations in this area, the dating of the entire complex (the Bronze Age, the Hallstatt period, the La Tène period and the early Middle Ages) and the explanation of its function remain disputable (Gediga, 1996; Korta, 1988; Wozniak, 2004).
4.2 | Archaeological artefacts

Taking into account the collection of archaeological artefacts discovered in the vicinity of the enclosure, the presence of specimens with sickle gloss is highly significant from the perspective of the potential possibility of the chronological and cultural classification of the collection, as they constitute diagnostic and widespread components of the tool instrumentarium of the societies of the Danubian cultures, especially in the fifth millennium BC (cf. Balcer, 1983, pp. 68–70, 90).

The similar morphological and technological parameters and sizes of the individual cores make it possible to assume their homogeneous character in chronological and cultural terms while indicating their connection to the flint-based activities of Neolithic or Eneolithic societies, oriented towards the exploitation of mediolithic blades. It seems highly probable to assume their connection with one of the post-linear Danubian cultural groups developing in the upper Vistula River basin during the fifth and beginning of the fourth millennia BC. In particular, numerous close analogies are provided by the cores acquired in the area of the mining and processing sites of the Pleszów–Modlnica group of the Lengyel culture in Bębló and Sąpłów (Dzieduszycka-Machnikowa & Lech, 1976; Lech, 1980a, 1980c, 1981). These analogies are manifested simultaneously in the choice of raw material and the scope of core preparation, as well as in the course of flake exploitation and the sizes of the acquired blades, as well as the range and character of the repair procedures, primarily the correction of the core angle (Dzieduszycka-Machnikowa & Lech, 1976, pp. 117–118).

At least part of the finds from Złota Góra (the pottery and part of the flint material from both clusters) should be linked to the settlement activities of younger—though undefined—Danubian groups. The scope of the available data justifies as highly probable their general correlation with the period between the Pleszów phase of the Pleszów–Modlnica group of the Lengyel culture and the Wyciąże–Zlotniki group, that is, between ca. 4600/4500 and 3700/3600 BC (e.g., Kadrow & Zakoścelska, 2000, fig. 45; Nowak, 2009, pp. 110–137). According to the current periodisation system of the Younger Stone Age on the northern side of the Carpathians, this chronological and cultural framework falls between the Middle/Late Neolithic and the Middle Eneolithic (Włodarczak, 2017, fig. 1). The large abrasive plate probably found in the vicinity of the site at the beginning of the 20th century (Czarnowski, 1925, p. 301) also does not counter such an interpretation. Therefore, the possibility exists that the presented defensive structures were also constructed during this period and are linked to the above-listed cultural groups, thus corresponding to this oldest horizon of the existence of defensive settlements so far recorded in western Małopolska (Przybyła et al., 2019, pp. 328–329).

Indeed, their potential connection with the Late Eneolithic period or the Bronze Age cannot be excluded. The limited level, to which the site’s surface has been identified, as well as the loose nature, small quantities, and most likely incomplete chronological and cultural representativeness of the finds from Złota Góra, leave the issue of its actual settlement history open-ended, similar to the question of the settlement intensity during particular periods.

4.3 | Embankments and intensity of human occupation in the region

Considering that the preparation of such enclosures would have required a long time, one may assume that traces of intensive human occupation should be observable in the near vicinity. The GIS model based on archaeological artefacts (Data S1) found so far in all known
cave and open-air sites shows differences in human occupation intensity in the region throughout Prehistory (Figure 12). It should be stressed, however, that the data used in the settlement density estimation come from studies of a very varied nature (i.e., surveying and fieldworks). Therefore, due to a risk of overestimation or underestimation of the settlement intensity, the obtained estimations should be taken with caution.

The oldest large embankments are linked to the Linear Band Pottery Culture (LBK) (Podborský & Kovárník, 2006, p. 45). However, the current research state indicates that Prądnik Valley most likely was not occupied extensively by the oldest Neolithic communities (Figure 12: LBK). Traces of LBK have been identified in 12 caves, whereas in nine of them, fewer than 20 artefacts can be attributed to this culture, indicating somewhat ephemeral settlement camps.

A specific, though undefined, intensification of settlement activities might have occurred only in the first half of the fifth millennium BC, that is, in the development of Malice culture (Lech, 1981, p. 184) (Figure 12: malice culture). Thus far, finds from this culture have been made in over a dozen caves in the Prądnik Valley and two open-air settlements (Smardzowice 38 and Ojców 13; cf. Grabowska & Zastawny, 2011a, fig. 34). Simultaneously, the connection of this culture’s communities with the beginning of mining exploitation of local Jurassic flint deposits cannot be excluded (Nowak, 2009, p. 109). Such a possibility is indicated, for example, by the oldest radiocarbon dating of the flint mines in Śąspów (Lech, 1980c, p. 619).

For a long time, the oldest defensive structures identified in western Małopolska were those connected with the Pleszów–Modlnica group’s settlements of the Lengyel–Polgár cycle. Only at site 48 in Krakow-Nowa Huta-Mogila was a poorly preserved and only partially researched system of ditches connected with earlier Malice culture discovered (Godłowska, 1976, pp. 75–79, fig. 48). Currently, more numerous settlements of Malice culture surrounded by ditches are being discovered (e.g., at the settlement in Smroków in Miechów powiat, Fabiszak & Przybyła, 2021).

A very pronounced increase in settlement intensity took place in the middle and late horizons of the Lengyel–Polgár cycle (Figure 12: Lengyel–Polgár cycle). Particularly rich remains of the region’s intensive occupation are associated with the Pleszów–Modlnica group of the Lengyel culture (cf. Grabowska & Zastawny, 2011b, fig. 11), from ca. 4600/4500–4100/4000 BC (cf. Nowak, 2009, pp. 110–130). The high settlement activities of this culture’s communities in the mentioned region were probably primarily connected with the intensive exploitation of at least three flint mines operating at this time in the southern ridge of the Śąspów Valley and a fourth one located ca. 5 km further (Jakubczak et al., n.d.; Dzieduszycka-Machnikowa & Lech, 1976; Lech, 1980a, 1980b, 1980c). Apart from flint mining sites,
at least 31 cave sites bear traces of Lengyel-Polgár cycle settlement, including the caves located in the vicinity of the Sąspów flint mine, with very rich assemblages and cultural horizons (Dziękuszycka-Machnikowa & Lech, 1976). They can be interpreted as traces of seasonal occupation related to flint mining.

Defensive settlements of the Pleszów–Modlnica group of the Lengyel-Polgár cycle, surrounded by trenches and palisades, have been discovered in recent years in Zakrzowiec in the Wieliczka poviat (Jarosz et al., 2012, fig. 7) and perhaps in Targowisko in the Wieliczka region. These sites bear traces of Lengyel-Polgár culture (Jarosz et al., 2014, fig. 7) and it is likely that they were inhabited during the Late Eneolithic. In older research, settlements surrounded by a trench were identified in Kraków–Pleszów (Gadowska, 1976, p. 51) and Modlnica in Kraków poviat (Zurowski, 1933). This last site has, in recent years, become a place of multiplanar rescue excavations. They revealed that the entire settlement area was surrounded by a trench covered with loess and megaliths. Its stratigraphy can be stated as occurring during 3300–2800 BC (Przybyła et al., 2019, p. 330), which corresponds to the Late Eneolithic.

In considering the chronology of the structures discovered on Zlota Góra, one should note the possibility of them being linked to the Baden culture. In the mountainous regions of Slovakia, mainly in Spiš, numerous upland settlements of the Baden culture have been identified. Many of them are fortified in various ways—with palisades, embankments and trenches (Sojak & Fecko, 2015, p. 398). It must be emphasised that these are usually small structures, covering an area of under 1 ha. Such settlements have been discovered, for example, in Bajc–Vikanovo (Bistakova & Nevizansky, 2015), in Prešov-Solivar (Horváthová, 2015) and in Veľká Lomnica (Sojak & Fecko, 2015, p. 398, Obr. 4). In Zvolen, we know of a slightly larger settlement located on a mountaintop, probably surrounded by a stone embankment (Beljak-Pažinova et al., 2015). A relatively large defensive structure surrounded by a stone embankment was found on the top of the castle mountain Veľký Šariš. However, its connection with the Baden culture remains uncertain (Vízdaš & Karabinová, 2015, p. 86, Obr. 2–3). Both the preference to locate fortified settlements on mountaintops and surround them with a stone (or stone and earthen) embankment are features that appear in the Baden culture. However, it lacked large structures surrounded by trenches and embankments, covering a few tens of hectares. These, in turn, can be observed in loessial terrains in the western part of Małopolska in the context of the later phase of the Funnel Beaker culture (the Beaker-Baden phase). Thus far, a few large and very large defensive settlements linked to this cultural unit have been found: in Gniazdowice in the Proszowice poviat (Przybyła et al., 2015), in Marchowice in the Miechów poviat (Dušba et al., 2015; Przybyła et al., 2019, p. 331), in Miechów in the Miechów poviat, in Municzkowice in the Proszowice poviat (Przybyła et al., 2019, p. 331) and the largest, covering an area of 26 ha, in Bronocice in the Pińczów poviat (Kruk, Milisauskas, & Wołarczak, 2018, p. 77). The chronology of the horizon of their prevalence can be stated as occurring during 3300–2800 BC (Przybyła et al., 2019, p. 330), which corresponds to the Late Eneolithic.

In the fourth millennium BC, the settlement intensity in the Páradnik Valley declined. On the one hand, the scant Funnel Beaker culture remains, represented by the small pottery inventory, varied in terms of quantity, coming from only 12 caves (Figure 12: Funnel Beaker culture), whereas—on the other hand—by the individual traces of seasonal settlement by proto-Baden communities (the Bolera group), recorded only in the Puchacz Cave in Puchacz Rock (cf. Kowalski et al., 1965; Kozłowski, 1971; Rook, 1980; Zastawny, 2006). These last factors fit into the much broader context of the intensive and long-term impact of the Baden complex on the local late Polgár cultural environment (Wyciąże group), especially the FBC in western Małopolska (Zastawny, 2015a, pp. 120–121, fig. 2A–B). However, the currently available data indicate only occasional and short-term penetration of the Páradnik Valley by communities belonging to different cultures throughout the fourth millennium BC. A sharp increase in settlement intensity only took place in the period of the development of Baden culture proper (ca. 3100–2900 BC; cf. Zastawny, 2015b, pp. 200–203). In this case, one can indicate at least 17 cave sites with traces of stationary occupation (Figure 12: Funnel Beaker culture), as well as individual open-air settlement sites and flint axes workshops (Zastawny, 2015a, fig. 8). Additionally, at least several cave burials can be dated to this period (Wojenka et al., 2017, p. 165; Valde-Nowak et al., 2018, pp. 285–286). These data confirm the high settlement and economic activity of this culture’s communities in the Páradnik Valley and its immediate vicinity. One can see that the region and especially the caves were scarcely occupied in the Final Eneolithic (Figure 12: Corded Ware culture) and Early Bronze Age (Figure 12: Mierzanowice culture). It was only during the Late Bronze Age and Early Iron Age...
The presence and intensity of specific features in Neolithic up to Early Iron Age cultural entities

<table>
<thead>
<tr>
<th>Cultural entity</th>
<th>Similar enclosures recorded (in general)</th>
<th>The intensity of human occupation in the region</th>
<th>Presence of burials in the vicinity (10 km range)</th>
<th>Stationary settlement traces</th>
<th>Archaeological artefacts in the nearest vicinity of the structures</th>
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<tbody>
<tr>
<td>LBK</td>
<td>+</td>
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<tr>
<td>Malice culture</td>
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<tr>
<td>Lengyel-Polgár cycle</td>
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<tr>
<td>Funnel beaker culture</td>
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<tr>
<td>Baden culture</td>
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<tr>
<td>Corded ware culture</td>
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<td>Mierzanowice culture</td>
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<td>Trzciniec culture</td>
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<tr>
<td>Lusatian culture</td>
<td>+</td>
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<td>+</td>
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Note: +/+/-/+++ scale of intensity.

(Figure 12: Lusatian culture) that people from the Lusatian culture settled in Prądnik Valley and used the region more intensively (cf. Rydzewski, 2006, fig. 1). An open-air settlement was found recently in the Ojców Castle (Wojenka, 2016) and Modlnica and Modlniczka (Byrska-Fudali & Przybyła, 2012; Dziegielewski, 2015). Moreover, traces of ephemeral occupation have been identified in 19 caves and rock shelters.

Although linking the enclosure discovered on Złota Góra with the late Bronze Age and early Iron Age seems highly unlikely, it should be mentioned that the Cracow Jura area was settled during that period (Rydzewski, 1995). We also know of a Lusatian culture hillfort from this area, in Kraków–Tyniec, connected to its latest development phase (Gedl, 1982, pp. 27–29). In western Malopolska, defensive settlements of the Lusatian culture, with very diverse forms, have been identified for the entire period of its existence, beginning from the third period of the Bronze Age until the turn of the Hallstatt and La Tène periods (Przybyła et al., 2019, pp. 332–333). These include large complexes, such as the one discovered in Malżyce in the Kazimierza Wielka poviat, covering 8 ha (Wroniecki, 2016, p. 28).

In analysing the preserved enclosure on Złota Góra from the comparative perspective, it seems improbable that it comes from historical times. This remark applies to the early and late Middle Ages and to modern times. In the case of the first of the listed periods, it should be noted that even though early medieval defensive structures covering an area of dozens of hectares have been identified in southeastern Poland (cf. Poleski, 2004), they were characterised by a completely different arrangement of fortifications and locations within the landscape. It should also be added that in terms of their size, the preserved relics do not come close to comparing with the structure in Ojców. The most massive identified early medieval structures—Demblin, Tarnów poviat, and Stradów, Kazimierz poviat—cover 26–28 and 25 ha, respectively (Poleski, 2004, pp. 209–217, 425–429). It should also be noted that the chronology of these large defensive structures goes back to the prestate phases of the early Middle Ages, that is, the 8th–10th/11th century, and thus—to the period during which the Ojców region was in all probability empty of settlements (cf. Wojenka, 2012, p. 234; Kołodziejski, 2016, p. 63). Without a doubt, all this lowers the possibility of the early medieval chronology of the described relics, although—taking into account that during the later phases of the Middle Ages and in modern times, no structures were erected in this part of the country even remotely similar in typological terms or their size to the herein discussed fortifications—these later periods should also be excluded from our considerations.

The chronology of the Złota Góra enclosure should also be discussed in light of recent Holocene tufa sedimentation studies conducted at the bottom of the Sąpólow Valley (Gradziński et al., 2017). The results showed a local phenomenon of redeposition of loess-derived clastics emplaced into the tufa depositing system in the lower segment of the valley located just under the Złota Góra hill during the Atlantic period. The deposition of loess-derived siliciclastics results from the erosion of loess-like sediments, indicating at least partial deforestation of the surrounding area (Gradziński et al., 2017). Although the authors tried to correlate this phenomenon to the Lengyel–Polgár flint-mining activity in the uppermost part of the valley, recent results show another possibility. The presence of a large enclosure on the top of the Złota Góra hill, which was supposedly connected with deforestation of the hill, could be a better explanation for starting the erosional processes, leading to the emplacement of the loess-derived clastics into the tufa. In such a case, the presence of the clastics would confirm the Neolithic–Eneolithic chronology of the described defensive structures.

Therefore, taking into account the prehistoric settlement history in the region and the archaeological material acquired during the currently conducted research, it seems most likely to link the discovered
structures with the period between the Middle/Late Neolithic and Late Eneolithic, especially with the settlement of the Lengyel–Polgár cycle or the Baden culture.

If they would be of Lengyel–Polgár cycle chronology, their existence would even straighten our view of the important role of the nearby flint mines (Figure 13), which are the largest Lengyel–Polgár cycle flint mines recognised so far north of the Carpathians (Dzieduszycka-Machnikowa & Lech, 1976; Lech, 1980a, 1980b, 1980c, 1981). Even though the importance of the Sąspów flint and the mines within the Lengyel–Polgár cycle has been well recognised (e.g., Lech, 1982, pp. 52–64; Janák & Prichystal, 2007, pp. 10–19; Mateičiucová, 2008, p. 127), the presence of such embankments would instead stand for constant use of the whole complex rather than ad hoc use of the mine shafts by small groups of people.

If we would consider the embankments to be of a Baden culture chronology, they would also determine a permanent use of the regions and the importance of the nearby flint axe workshops and possible flint mining.

In both cases, the presence of such large embankments in the middle of the karstic region of Ojców Upland proves that early agrarian communities during the fifth and fourth millennia BC did use the karstic regions permanently; nevertheless, they had poor soil quality. In the case of Ojców Upland, it was most likely the flint, which attracted Stone Age people. In this context, traces of Neolithic and Eneolithic human occupation in the caves should be reconsidered. To date, Holocene artefacts have been treated as traces of temporal and ephemeral cave use (Chmielewski, 1988; Chchororowska, 2006; Jędrysik, 2016, 2018; Rook, 1980; Rydzewski, 2006; Wagner, 2008). Even if caves were not occupied permanently, the intensity of their use might have been much higher than it was supposed before. Therefore, the Neolithic and Eneolithic cave layers should be studied with the same level of caution as Pleistocene layers.

Considering all the arguments mentioned above, in trying to establish the observed enclosure's chronology, one should probably apply discriminative analyses. Similar monumental earth structures in the upper Vistula basin can be attributed to various cultural horizons from the Middle Neolithic (Pleszów–Modlinica group) through the Late Eneolithic (Wyciąże–Zlotniki group, Funnel Beaker culture, Baden culture) to the Early Iron Age (Lusatian culture) (Przybyła et al., 2019). Human occupation of the Early Iron Age is the least intensively represented in the region, which can be seen as an argument against such a chronology. Similarly, the Early Neolithic cultures (LBK and malice culture) are not well represented in the vicinity, apart from over a dozen cave sites. To date, in the extensive area on the northern side of the Carpathian Mountains, defensive structures connected to LBK are lacking. Their presence on Malice culture sites is scarce (Smroków).

5 | CONCLUSIONS

The most intensive human occupation of Prądnik Valley dated to the Lengyel–Polgár cycle, and Baden culture could argue for such a chronological attribution of the discovered enclosure. This could also be confirmed by the chronology of archaeological artefacts found on the surface and recent studies of Holocene tufa sedimentation in the Sąspów Valley. Therefore, one could conclude that most likely, the enclosure on Z iota Góra can be attributed primarily to the Lengyel–Polgár cycle or—possibly—the Baden culture. In both cases, it could be connected somehow with the intensive flint mining activities documented in the close vicinity of Z iota Góra.

The number of known sites with prehistoric embankments in southwestern Poland has grown rapidly in the last decade (Furmanek et al., 2015; Furmanek & Wroniecki, 2020). New discoveries are systematically filling the void visible in Poland on maps showing prehistoric fortifications and enclosures in Europe (Darvill & Thomas, 2001; Parkinson & Duffy, 2007). This indicates not a lack of archaeological sites of this kind but a lack of proper search methods until recent days.

The obtained results show that extending a multiproxy non-invasive approach might shed light on the site's chronology. Even though the use of magnetic fields was restricted due to the site's location in the dense forest, we were able to identify the inner structure of two out of three embankments. The heavily forested area also had a significant impact on the coverage of the field survey. However, the obtained results supported by technological and use-wear studies...
ACKNOWLEDGEMENTS

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES


