Non-invasive magnetometric prospection in forested area: the case study of Mirosław site 37 in Northwestern Poland

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Abstract

The following article concerns the results of a combined non-invasive and invasive fieldworks in Mirosław, site 37 (Piła county, Wielkopolska voivodeship, Northern Poland). The site is a Wielbark culture barrow cemetery located in a forested area, thus limiting it access to a variety of methods. With the usage of a single-sonde gradientometer it was possible to survey the site by the means of magnetometry. The magnetic map of the site indicated presence of eroded mound (possibly due to ploughing) with associated grave-pit as well as numerous other anomalies, including the position of a burnt structure in between the barrows. Consecutive excavations were aimed to verify the interpretation of the magnetometry survey and confirmed the presence of an denudated barrow with a grave-pit within. In the light of results, the visible anomalies seen as a specific forest type of ploughing should be treated as the main factor of the barrow destruction. Also the earthworks revealed that the anomaly interpreted as a burnt structure appeared to be a hearth. All of the excavated objects were associated with the Wielbark culture, thus indicating the potential of investigating areas between the preserved barrows, which might bear other features of funeral rites and similar activities.

Keywords: Magnetometry survey, Geomagnetics, Non-invasive prospection, forest archaeology, Wielbark culture, barrow cemetery, funeral rites.

1. Introduction

Archaeological excavations in Mirosław 37 were carried out during two seasons in July of 2016 and 2017. Discussed site is a barrow cemetery which was discovered by the means of the LIDAR (ALS) technology, obtained from the Polish geoportal (geoportal.gov.pl). The first field verification of the Digital Elevation Model produced from the ALS was conducted by J. Rola in 2015. In result of surface survey and archaeological excavations, the site was enlisted by the Polish Heritage Service.

The village of Mirosław is situated in Wielkopolska voivodeship, Piła County. The site 37 lies in the southern edge of the lower Noteć Valley on the Walkowice gacio-fluvial terrace (Fig 1.) (Kondracki 2000, 130). The barrows most certainly have survived, due to their location in forested area – the Sarbia

district of the Polish National Forests – in section 150a of Jabłonowo Forestry.

During the first season of fieldworks, excavations were started on one of the seven barrows forming the cemetery. Selected mound was slightly denudated by agricultural works and set apart from the main linear arrangement of barrows (Michałowski et.al. 2018, 110). Mound no. 7 was oval-shaped and 11.9 m in diameter. Its southern side was distinctively less preserved than the opposite one. Moreover, during the season of 2016 an additional trench in the barrow context was opened embracing 250 m^2.

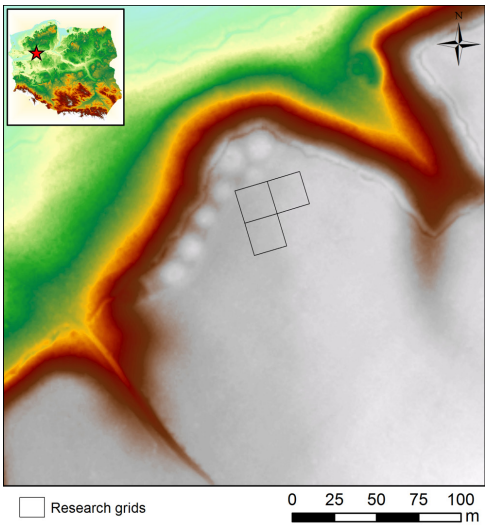

Fig. 1. Barrow cemetery in Mirosław (site 37). A shaded relief model obtained from geoportal.gov.pl with superimposed net of survey grids for the magnetometric prospection.

In the result of archaeological exploration in 2016, a total number of 13 archeological features were discovered. Excavations revealed that the mound was most probably erected in one act and the material for its construction comprised of sands and gravels. Below the barrow embankment, the exploration of grave pit (feature no. 8) was started. The grave was discovered at the depth of 1.5 m below the ground. Skeleton burial was oriented along the N–S axis, but preserved in poor condition (Fig. 2). Despite of that, the anthropological analysis showed, that in this grave, a young women (19-21 y.old) was buried (see Wrzesińska 2017). Besides that, in the area of barrow embankment another feature (6) was discovered. On the level of sterile earth few pits with small shards of Wielbark culture pottery or without materials, were recorded. They might be some remains of iron smelting. Moreover to the north side from mound a flat grave was discovered. Few fragments of human bones lied between 4 large stones. It was a burial of a small child, without any vessel.

The inventory of feature no. 8 was rich and typical for Wielbark culture (Michałowski et. al. 2018). Grave goods included: fibulae O. Almgren (1897) type AVII 213, AV series 8, AV 96, silver bracelets - 2 snake-shaped and 2 viper-head type IIIB by T. Wójcik (1982), 2 bronze belt ferrules, rectangular belt buckle type MLG 3 (Madyda-Legutko 1986), sliver S-shape buckle, sliver conical pendant. Basing on these artifacts, the site be therefore dated to the phase B2/C1 of the Roman Period (Michałowski, Teska 2017; Michałowski et.al. 2018).

Fig. 2. Feature no. 8 - young women grave discovered in first season in 2016 (photo A. Michałwoski).

The specifity of Wielbark culture barrow cemeteries is the diversity of the graves type. Particular site could often comprise both the inhumation or cremation practices (see Wołągiewicz 1981). Also, Wielbark cemeteries are usually characterized by the occurrence of pit graves which accompanies the grave mounds. Due to the fact, that the child flat burial in Mirosław was discovered outside the barrow no. 7, it was decided to expand research area in the subsequent season.

In order to provide an insight into the spatial distribution of archaeological features outside and in-between the main barrow alignments the magnetometric method was used. It was suspected to encounter the accessory features to the cemetery, such as ritual objects in type of fireplaces or accompanying burials.

1. Materials and methods

Magnetometry measures disturbances of the Earth's magnetic field gradient, related to the subsurface objects and layers of higher magnetic susceptibility (Schmidt 2007). Such anomalies emerge as a result of remanent magnetism characterized by stability in case of ferromagnetic, and induction which occurs in physical objects under the influence of external magnetic field. Various ranges of objects and features can be influenced by both remanent and inductive type of magnetism, i.a. metals, bricks, rotten or burnt or-

ganic features (wood, bodies etc.), rocks containing ferri- and ferromagnetic minerals. As the archaeological objects can be created from all of these features, the method is suitable enough to provide a distribution map of the remains of human activity.

During the research in Mirosław 37, a Fluxgate magnetometer of Bartington, model Grad-601 was used. The equipment comprised one probe with two sensors separated by a distance of 1m vertically. The prospection was held with a 0.1 nT accuracy, taking measurements each 0.25 m along the transect, while the latter were separated by a 1 m interval. The calibration of magnetometer was set in a remote area characterized by relatively stable magnetic field, which did not exceed the range of -1 – 1nT.

Magnetometric prospection took place in area delimited by three squares of 20 x 20 m each, arranged in a L-shaped manner (Fig. 1). In terms of the cemetery chorology, the survey embraced the southern and south-western area to the excavated barrow no. VII. This area presented the best terrain properties, as the entire cemetery context is dominated by the pine-tree forest. Three survey grids were established in a relatively less-densely forested place.

The analysis of the magnetometry results was held in Geoplot 3.0. However, all of the analysis of the resulting imagery was conducted in ArcGIS 10.1. Interpolation by the means of *TopoToRaster* tool allowed to create the color distribution map of magnetic anomalies, while toolboxes of *High* and *Low pass filters* and *mean grid* were applied in Geoplot to increase the visibility of archaeological features and omit the technical glitches. Visualization of the magnetic properties of the prospected area was presented in -5 – 5nT range (Fig. 3). This created the contrast between the natural features and archaeological objects, and therefore it allowed to better understand the distribution of anomalies.

It needs to be emphasized that the prospected terrain was set in a forested area, which might had an effect on the magnetic picture. Also in a nearby area there is a line of trenches from the Greatern Poland Uprising in 1918 and 1919. The suspected presence of military (mostly metal) remains also have to be considered while discussing the results of the survey.

After the prospection, the interpretation of magnetic map was submitted to verification by means of excavations and geological drillings. At first, the excavation area (10x30) was set accordingly to the magnetic plan in 2017. The excavations embraced an area of 300 m^2. Archaeological exploration was conducted with mechanic troweling of the layers each 20cm. The artifacts (only Wielbark culture pottery shreds), were documented within the quarters. In total, 14 archaeological features of various dimensions were discovered. Geological drill-

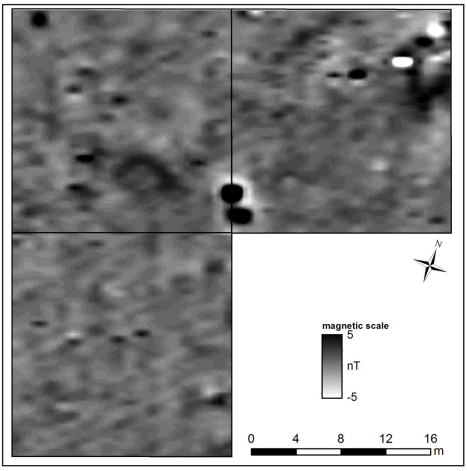

Fig. 3. Results of the magnetometric prospection in Mirosław 37.

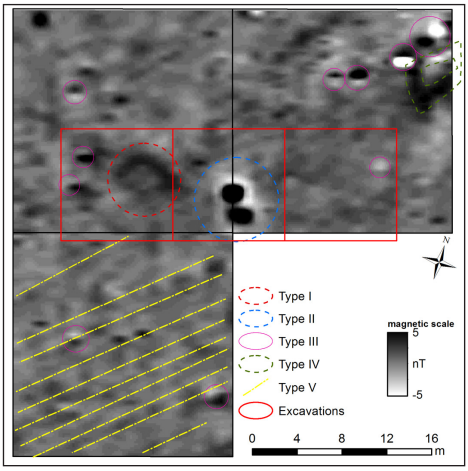

Fig. 4. Interpretation of the magnetometric prospection results with location of the excavated area.

ings were performed in the places of the occurrence of magnetic anomalies not subjected to the earthworks by excavations. The equipment used was the hand operated driller with half-open auger of 10cm width.

2. Results and discussion

The resulting magnetic imagery comprise of a relatively non-variated structure of the distribution of magnetic anomalies (Fig. 4). The real values for the three polygons prospected during the survey varies between -5 and 43nT, which suggest that the entire surface is slightly raised in terms of magnetic properties, perhaps due to the ferromagnetic minerals of the erratic rocks abundant in the subsoil layers. The latter comprise of fluvio-glacial sands and gravels which also might have contributed to the slightly elevated magnetic signals. However, the applied range of -5 to 5 nT range of the visualization shows that the background noise oscillates around 0 nT.

Magnetic anomalies registered in the prospected area differ in the nT values as well as in shapes and their distribution. Due to this differentiation it was decided to describe the anomalies by separating them into the particular types (Fig. 4).

Type I:

Only one anomaly was assigned to the first type and it was located in the southern part of grid 2 (Fig. 4). It have an ellipsoidal shape, elongated on an

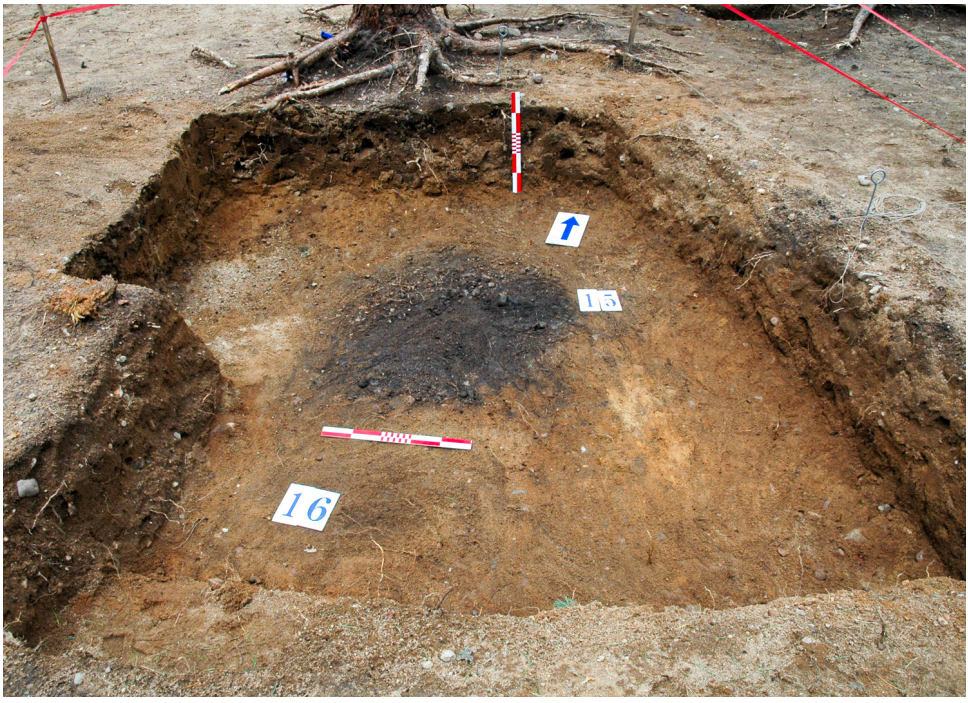

Fig. 5. Feature no. 15 interpreted as exhumed grave (photo W. Szambelan).

east-west axis. The meridional radius of this magnetic manifestation is app. 6.5 m, while the perpendicular length is 4.2 m. The anomaly is characterized by single-pole concentration of higher values (10-12nT) in form of a encirclement of an relatively neutral center (app. 1nT). Very similar manifestation in magnetometric imagery can be seen in case of denudated round barrows (comp. Makarowicz et al. 2016; 2018; Cwaliński et al. 2018). Also in this case, there are no visible morphological features like small hummock or elevation which would suggest the existence of a tumulus. The higher magnetic pass encircling the empty space within, can therefore be the result of an earlier existence of barrow's slope, along which occurred the transportation of ferromagnetic minerals downwards. The deposited fractions could thus create a circular manifestation on the magnetic map. During the excavations the oval-shape pit, mainly composed of the grey layer with ash and charcoals (Fig. 5) was discovered. Exploration showed there was also prehistoric cut, which interfered to the grave (Michałowski 2017, 3). However, the grave turned out to be empty, where only a spindle whorl on the top and one pottery sherd on the bottom were recovered. It appears that the exhumed grave was crowned by a spindle whorl (Michałowski et.al. 2018, p. 113). Most probably, before the exhumation,

Fig. 6. Two heats (features 17 and 18) form Mirosław site 37 (photo K. Krawczyk).

the symbolic fire was heated there. Feature form and its dimensions were in accordance with the Wielbark culture cremation burials.

The erosion or denudation of the barrow could have taken place due to the agricultural or forestry works (see Type V).

Type II:

The anomaly of type II was located in the border of grid 2 and 3 in the central part of the overall picture (Fig. 3 and 4). It formed two concentric high susceptibility poles and one negative signal adjacent from the north and north-west. The nT values of this type range from -10 to 43. This could represent the presence of burnt daub or perhaps the erratic rocks which contain the ferromagnetic minerals. However, the chronology of the site suggests that this anomaly could indeed represent the clay, subjected to a high temperature like the hearths. In case of Mirosław site, hearth-like features (features 17 and 18) were discovered at the depth of 60 cm b.g.l. (Fig. 6). Two regular and rectangular features (first –180x160cm, second – 170x190 cm) in the middle part of the excavation unit, were mostly built from burned stones. In the top layer, numerous sherds of pottery were found, while deeper only the charcoals were recorded (Michałowski 2017, 4). Moreover, in feature no. 18 laid unburned

fragment of the cattle mandible (see Warszczuk 2017). This suggests that the remains were put there after the fire was extinguished. All this indicates a ritual activities taking place in the space outside the barrows (see Michałowski et. al. 2018)

Type III:

Third type of anomalies were the singular anomalies of a dipole properties, registered in all of the research grids (Fig. 3 and 4). They comprise of various shapes, from few to over a dozen of centimeters. Anomalies of this type were characterized by bipolar arrangement of positive and negative values, aligned on a North-South axis. Their sizes as well as the specific order of magnetic poles, suggested that they manifest the metal objects or rocks with specific mineral contamination, that raises the magnetic record. In the north eastern part of grid 3, such anomalies are connected to very modern remains of excavations conducted a year before the prospection (in 2016). As such, these anomalies were not taken into the interpretation of the magnetic picture. Also, it is assumed that these objects could be the remains of the military activities in the XXth century. A drilling verification proved that most of these anomalies were related to the metal waste (bottle cans, metal pins etc.) or war relics – like remains of the belt chain.

Type IV:

Anomaly of type IV was recorded in the north eastern part of grid 3 (Fig. 4). It has a rectangular shape of a positive single-pole pattern in range from 5 to 15 nT. Its location and comparison with the excavations from the year before corresponds with the position of a earth pile which was created during the archaeological earthworks. The modern and surely anthropogenic character of this anomaly is supported by the rectangular shape and increased magnetic properties. It shows that the area of the anomaly comprise of a different or disturbed lithological material than the geological background.

Type V:

Anomalies assigned to type V comprise of an elongated, and linear features visible mostly in grid 1 (Fig. 4). At least ten lines are visible in this part of the research area, oriented on the north-east – south-west axis. The lines are characterized by raised magnetic signal in contrast to the background noise. Often such patterns are derived from the technical glitches due to the improper method of walking during the survey. In this case such explanation is not possible as the course of these lines do not follow the walking pattern from

south to north. Therefore, it should be assumed that such structures were created in result of anthropogenic disturbances in the soil structure. The parallel form of the linear alignments looks very similar to the forest ploughing, and as the area is densely overgrown by young pines, such explanation should be taken into account.

3. Conclusions

Inside the 1200 m^2, several different types of anomalies were registered, which have occurred in result of the prehistoric human activity (Type I and II) as well as during the modern times (Type III and V), which was shown by archaeological excavations and geological drillings. Anomaly reflecting the prehistoric burial was the round structure, revealed during the excavations as the denudated round barrow. One should also consider that anomalies of type V (the linear structures), interpreted as the ploughing remains could be the factor of the barrow destruction. The large bipolar anomaly of type II was verified to be the hearths - features no. 17 and 18.

It is worth noticing that in the space between the tumuli appearance, there were no morphological indications of other forms of human activity in the area. This points to the importance of conducting the non-invasive studies like magnetometry, which can reveal the associated sedentary or burial facilities in the areas of the barrow cemeteries.

Two seasons of multidisciplinary archaeological works, combined with the magnetometric prospection showed a great potential in revealing the funeral space within the cemetery.

There are no doubts, that the discussed cemetery was created and used by the Wielbark culture societies, which was confirmed by discovered artifacts. Also the radiocarbon dating indicates that the cemetery was in use during the 2nd and 3rd century AD. During two seasons, a large part of ritual area was recognized. As excavations have shown, not only the burial mounds were associated with ritual activities. This has been proved during the first season, when the child burial was discovered in the northern part of the site. In 2017 also other funeral practices, like exhumed grave and two large heats in burial zone, were revealed.

The Wielbark culture in Poland is characterized by diversified funeral customs. Its means, that these people used cremation and inhumation for burying, often on one cemetery. Also forms of graves were diverse; flat graves, grooved graves and barrows occurring together in one site, are known. Often these habits were practiced in the area between the barrows (see Wołągiewicz 1981). Sim-

ilar to features recorded in Mirosław site 37, were the ones discovered in the 19th century in Mirosław – Wilanowiec. Beside the cremation flat graves also hearth was found (Gałęzowska 2007, 182). It should be emphasized that so far in Mirosław 37 groove-type graves and also stone circles and pavement were not found. Nevertheless, in the northern part of barrow no. 7 lied a processed large stone, which most likely was a funerary stele and crowned the mound (see Michałowski et all 2018).

According to the discussed site in Mirosław and all archaeological features found there, future research is needed. Despite the substantial knowledge about local society's funeral behaviors, the space between the excavation area from 2017 and the burial mound no. 7 should be recognized. It's necessary to verify also one other barrow, to determine chronology of entire site. This paper shows how significant for comprehensive recognition and complementary knowledge, is the usage of magnetometric method on archaeological sites form the Iron Age. It is also important, that this method should be correlated with excavation results, or verified at least by the means of drillings and soundings.

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Prospecțiuni magnetometrice non-invasive în zona forestieră. Studiu de caz: situl Mirosław 37 din Polonia de nord-vest

Rezumat

În articol sunt reflectate rezultatele unei cercetări combinate non-invazive și invazive în situl Mirosław 37 (județul Piła, voievodatul Wielkopolska Polonia de Nord). Situl reprezintă o necropolă tumulară atribuită culturii Wielbark. Fiind situat într-o zonă împădurită, este limitat accesul la o varietate mai largă de metode. Utilizând un gradientometru cu o singură sondă, totuși a fost posibilă cercetarea sitului prin intermediul prospecției magnetometrice. Harta magnetică a sitului a indicat prezența unei movile erodate (posibil datorită aratului) cu groapă asociată, precum și numeroase alte anomalii, incluzând poziția unei structuri arse între tumuli. Săpăturile consecutive au avut ca scop verificarea interpretării sondajului de magnetometrie și au confirmat prezența unui tumul cu o groapă de mormânt în interior. În lumina rezultatelor, anomaliile care se prezintă ca un tip specific de arătură de pădure, trebuie tratate ca principalul factor de distrugere a tumulului. De asemenea, lucrările de teren au dezvăluit că

anomalia interpretată ca o structură arsă pare a fi o vatră. Toate obiectele excavate au fost asociate cu cultura Wielbark, indicând, astfel, potențialul investigării zonelor dintre tumulii conservați, care ar putea păstra alte structuri funerare și urme de activități similare.

Cuvinte cheie: prospecțiune magnetometrică, prospecțiune geomagnetică, prospecțiune non-invazivă, arheologie forestieră, cultura Wielbark, necropolă tumulară, rituri funerare.

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