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EDITORIAL

Over the past quarter-century, archaeological research has undergone significant development, with discoveries at various chronological and thematic levels. This progress is partly the result of new opportunities created by advances in the exact and natural sciences, which have broadened archaeology's methodological framework. Such acceleration is also evident in the study of the vast, millennium-long period during which communities associated with the Urnfield circle flourished in Central and Western Europe. Numerous scholarly works have recently been published on this subject, and various research projects have been carried out. Newly discovered materials originating from fieldwork have also been discussed at academic conferences and in professional journals. Nevertheless, there remains space for further original contributions. The widespread interest in the Late Bronze Age and Early Iron Age has inspired us to prepare a special thematic issue dedicated to the Urnfield communities.

This volume of *Sprawozdania Archeologiczne* contains fifteen scholarly articles addressing various aspects of this topic. Among other matters, it presents new data on the origins and cultural changes that led to the appearance of 'urnfields' on the map of Bronze Age Europe. Considerable attention is also devoted to questions of settlement and defensive settlements, as well as to spiritual culture, particularly in relation to the organisation of space within cemeteries and the reconstruction of funerary rituals.

A separate group of contributions focuses on the deposition of metal hoards and on archaeometric studies of metallurgy and other forms of production from this period.

We encourage all researchers interested in the Late Bronze Age and Early Iron Age, understood here as the period of the development of Lusatian urnfields and other taxa associated with this cultural phenomenon, to engage with this volume.

With the thematic volume of *Sprawozdania Archeologiczne*, we wish to commemorate the eightieth anniversary of archaeology at Maria Curie-Skłodowska University in Lublin.

Marcin Maciejewski, Halina Taras and Piotr Włodarczak

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Elżbieta Kłosińska[1]

REMARKS ON THE RESEARCH ON THE SIGNIFICANCE AND ORGANISATION OF SPACE WITHIN THE CEMETERIES OF THE LUSATIAN CULTURE POPULATION IN THE LUBLIN REGION

ABSTRACT

Kłosińska E. 2025. Remarks on the research on the significance and organisation of space within the cemeteries of the Lusatian culture population in the Lublin region. *Sprawozdania Archeologiczne* 77/1, 9-20.

This text addresses the issue of the layout of space within the cemeteries of the Lusatian culture communities of the Bronze Age and Early Iron Age in the Lublin region. It was observed that the local, typically small necropoleis had a linear layout, with the graves arranged along the NE-SW axis. It can be assumed that the history of a cemetery started either from the east or at the most significant culmination within the area. The cemeteries were likely the primary focal points of attention for the local population within specific settlement regions.

Keywords: Lublin region, Lusatian culture, Bronze Age, Early Iron Age, space within cemeteries
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The subject of this short study is the space within the Bronze Age and Early Iron Age cemeteries. When working on the necropoleis of the Lusatian culture population, archaeologists always devote a great deal of attention, apart from the essential determinations relating to the morphology and periodisation of the finds, to the issues concerning the layout of the graves and the shape of the cemetery. They also attempt to determine the

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extent of these sites, specifically cemeteries and the presence of additional infrastructure dedicated to them, such as dug-out structures and pyres within them. The work of Jacek Woźny (2000) should be regarded as the most up-to-date and comprehensive attempt to elaborate on these issues. It also shows a somewhat different approach to the discussed matters.

I, without, of course, aspiring to the brilliant achievements of the researcher mentioned above, would also like to take a slightly different look at the cemeteries of the Lusatian culture. To do so, I have chosen necropoleis from the Lublin region. This is not an easy task because, despite the relatively large number of cemeteries in this area (to date, nearly 200 sepulchral sites are known from the region), the identification of their spatial structure leaves much to be desired. It can be said that only two cemeteries in the Lublin region have been thoroughly examined. These are the cemetery in Kosin, Kraśnik district, Site II, explored by Michał Drewko in 1925 (Miśkiewicz and Węgrzynowicz 1974) and the cemetery in Wołkowiany, Chełm district, Site 3, researched by Zygmunt Ślusarski in 1963, which has never been published.

Before moving on to the issue of space within the cemeteries of the Lublin region, I would like to list some basic features of these sites:

– cremation is definitely the dominant type of burial, and the graves are mainly in urns (only occasionally with accompanying grave goods). The inhumation graves recorded in the south-eastern margins of the Lublin region belong to the Wysocka culture,

– graves are shallow, and burial pits are usually not perceptible,

– the cemeteries are linear in form; most commonly, the line of graves runs along the E-W or EEN-WWS axis,

– there is a lack of continuity between Bronze Age and Early Iron Age cemeteries (however, this may be due to the state of research),

– unprecedented features appeared in the early Iron Age. These included large, usually mass graves, where some of the dead were burnt in situ. Wooden structures often occur in graves. However, whether we are still dealing with the urn culture in the case of these cemeteries is uncertain.

Undoubtedly, cemeteries are the best context for studying prehistoric spiritual culture (Gediga 1979, 320). They are the places which, not only in colloquial but also in scientific reasoning, harbour extraordinary qualities and characteristics (Woźny 2007, 217). The space of the hereafter, identified with them, undeniably belonged entirely to the realm of the sacred. It is believed that the decisions made by people building a grave, burying a deceased member of the community and choosing grave goods for them may have resulted from various circumstances, such as tradition, emotions, or deeper religious motivations (Lewartowski 2001, 140). However, it seems that when faced with death, all these circumstances were intertwined.

Apart from the practical criteria of site selection, such as proximity to the settlement (from where the body was moved), proximity to a forest (providing the building material for the grave structures and fuel for the pyres), safe distance from rivers (but at the same time appropriate to extinguish the pyre and wash the bones), the presence of dry (Węgrzynowicz 1973, 102), loose and permeable ground (facilitating the construction of the graves), the act of creating a necropolis was subject to certain symbolic conditions. A cemetery became a specific fragment of space where death was tamed and overcome, and these essential acts took place according to strictly established cultural rules. Burials were thus ritualised here, and the memory of them was perpetuated (Woźny 2007, 217). The spatial arrangement of the cemetery could also be a reflection of social relations, wealth, gender differences, or a way of distinguishing one's own and strangers, *etc*. The cemetery stabilised the settlement network and was a crucial point of reference, reinforcing the identity of the community inhabiting the region. It also provided a place of mediation between the living people, the ancestors, and the world of the gods.

Observation of the distribution of Lusatian culture necropoleis in the Lublin region leads to the conclusion that they functioned individually within small micro-regions as central and dominant features set against the background of one or more settlements, *e.g.*, Perespa, Tomaszów Lubelski district, Site 54 (Kłosińska 2006), Wronowice, Tomaszów Lubelski district, Sites 5A, 5B (Wichrowski 1989), or they also occurred in the form of several, contemporary 'branches' – used, perhaps, by representatives of separate lineages living within one settlement, *e.g.*, Topornica, Zamość district, Site 1 (Głosik 1958), Wieprzec, Zamość district, Site 1 (Dziedziak 2003).

Notable routes likely connected the burial sites and the settlements nearby. However, they were separated by natural, artificial, and probably symbolic boundaries. These real barriers, such as rivers or palisades, were also rich in symbolic content. It is worth mentioning here that the fact of separating settlements from cemeteries was noted in various places within the range of the Lusatian culture (Malinowski 1962, 92, 93; Węgrzynowicz 1973, 101, 102), and in the Lublin region, it could have taken place in the case of sites from Wieprzec and Topornica, separated from each other by valleys of minor watercourses, tributaries of the rivers Topornica and Wieprzec (Fig. 1), and Wronowice and Wieprzec, where relics of a palisade were found. Due to their exposed location, we can also assume that the cemeteries were visible from both the settlement and, at least, from some areas that were economically exploited. This trait reinforced the connection with the ancestors. These burial sites played an essential role in consolidating the local community, defining its religious status, referencing the past, and sanctioning the future exploitation of previously occupied land (Woźny 2007, 221); in the same way that cemeteries and accompanying religious buildings do in modern times. They undoubtedly had the respect of the living (Węgrzynowicz 1973, 102).

However, the most important motivations for establishing cemeteries lay in the system of prevailing beliefs, as these places belonged not only to the dead, 'immersed' in their secret existence, but also to their descendants, performing rituals for the good of their ancestors and their own. The place where the cemetery was founded had to be, by all

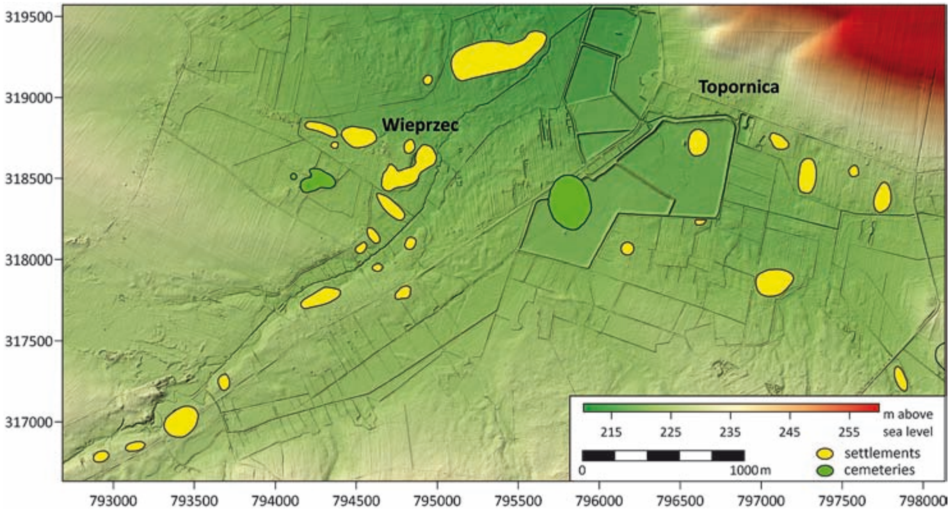

Fig. 1. Map of the cemeteries of the Lusatian culture population in Topornica, Site 1 and in Wieprzec, Site 1, together with the contemporaneous settlement sites. The map is plotted on a base map that consists of a digital terrain model. LiDAR data source: www.geoportal.gov.pl. Horizontal coordinate system: PL-1992. Elevation system: PL-KRON86-NH (developed by M. Piotrowski)

means, appropriate, chosen intentionally from the universal space known to the community. The shape, size, and internal layout of spaces of this type reflected the prevailing religion, social order, and various cultural norms. It is also believed that the spatial order in which the cemetery was created was a symbolic creation of the cosmic order, and that when another feature of this type was established. More graves were placed within it; reference was made to the original pattern, the archetype at the centre of the contemporary world. A cemetery was the meeting point of all levels – heaven, earth, and the underworld, as well as of the powers operating within them (Woźny 2007, 219-221). The burial space was valorised accordingly. Its creation was based on various imperatives and prohibitions. It had designated gates and boundaries (stone and wooden structures). Areas of varying degrees of sacredness lay within it (Woźny 2000, *passim*). Its size was probably predetermined. However, this was not likely to have been influenced by natural factors alone (Buśko 1987, 69) but by a preconceived idea deriving from religious motivations. In the case of the necropoleis in the Lublin region, this space was demarcated not only by the wooden elements of the sarcophagi, *e.g.*, Bliskowice, Kraśnik district (Gurba 1965); Krupy, Lubartów district, Site 1 (Misiewicz 2003; 2005); Jakubowice Murowane, pow. Lublin district, Site 5 (Kurzątkowska and Rozwałka 1990), suspected fences and palisades, *e.g.*, Bielsko, Opole Lubelskie district, Site 1 (Kłosińska and Klisz 2003); Wronowice, or poles, *e.g.*, Świeciechów Duży, Kraśnik district, Site 1 (Wichrowski 2006); Wojciechów, Chełm district, Site 8 (Gołub 1987), stone structures, *e.g.*: Wojciechów; Wołkowiany, but also firepits, *e.g.*, Bielsko; Kosin; Wojciechów; Wołkowiany), 'turfing' and small embankments (Kosin; Wieprzec). The demarcation of space was likely also associated with the relationships present within the community that used the cemetery. Small, linear, circular or amorphous clusters of graves lying within larger linear structures may have reflected, for example, family quarters or social ties of a different order, resulting from the funerary norms of the day.

Thus, certain places in the terrain were particularly predestined to fulfil a ceremonial role. Above all, hills were chosen as symbols of the sacred mountain, the centre of the world, where all levels of the cosmos of the time and points of communication between humans and supernatural beings were concentrated. Ideal sites were also located near water, a distinctive tree or stone (Woźny 2007, 220). In the Lublin area, the basis for the recognition of the sacrum within a particular space was the existence of exposed places lying next to bodies of water. It is challenging to confirm the presence of the other components of an ideal sacred site using archaeological methods. Seemingly, the places were located on raised sandy areas within small valleys, such as slopes, folds, headlands, and elevations with all-around exposure. In significant valley areas, they were located within the terraces above the floodplain and on its edges. The preferred soil chosen for cemeteries was definitely sandy (Nosek 1957, 109), permeable and not troublesome when constructing a grave or embedding an urn. The linear layout of the burial ground sometimes corresponded to the course of a watercourse. However, most probably, it was not due to the topographical conditions within the valley but to the symbolic intention of its creators and users. The people of the Lusatian culture likely located necropoleis near forests. So far, only in the case of the wooden structure of the grave at Bliskowice were the tree species identified, and these were oak and pine (Gurba 1965, 274). The latter species was probably often found accompanying cemeteries established on dunes.

A linear arrangement of graves was observed in all the cemeteries in the Lublin region that have been adequately studied (Figs 2-4). It seems that with their special arrangement, they showed the way to the land of ancestors, following the celestial path of the sun across the sky, and reflected the mythical understanding of the world at that time. This would not be surprising when one considers the dominance of solar cults in the Bronze Age and early Iron Age. Undoubtedly, the experience of natural processes and the daily observation of astronomical phenomena formed the basis for the establishment of cemeteries and the development of belief structures around them. Accordingly, the space of the necropolis was delimited, and value was assigned to specific zones, where, it is believed, especially the eastern and southern ones were categorised positively (Kłosińska and Klisz 2003, 59-61; *cf.,* also Woźny 2007, 222). These zones were associated with the rising, travelling and setting sun, *i.e.*, the carrier of celestial fire that dispels darkness, brings order to chaos, abolishes death, and regenerates life (Kowalski 2007, 516). A new world was thus constructed, in essence, recreating the work of a divine being (Eliade 1995, 146). The place where the history of the cemetery began was most probably the highest point or the eastern edge of the elevation chosen to establish the burial ground, both of which now, after many centuries, are almost imperceptible in the field. The first 'foundation' graves placed here may have been significant as models relating to the burial traditions of the ancestors. These first graves likely sought to align with the point of sunrise at the given time, establishing the model direction of the cemetery's succession. Perhaps, within a single burial field, representatives of particular social macro-structures (lineages?) commenced its use in two places at similar times, creating two (or more) lines of graves. It appears that these two lines of model graves marked the beginning of the main part of the cemetery in Wołkowiany (Fig. 2). At this location, among other features, we can observe a line composed of a few sparsely spaced graves. Most likely, this was the oldest part of the cemetery, which began with Grave 128, located in the easternmost section. In this burial, the burnt remains of the deceased were placed in a vessel with a pointed base, closely resembling the forms of the late phase of the Trzciniec culture. Younger graves formed another line, extending above the first one and characterised by a high density of burials. Both lines of graves were oriented along the NE-SW axis. What is noteworthy here is that within the dense line of graves, there were further linear microstructures oriented along the NNE-SSE or NNW-SSE axis.

The observation of linear arrangements of the graves within the necropoleis of the Lublin region brings interesting conclusions. The sites were generally oriented along the E-W axis, but with some apparent deviations. Only three of them had the most accurate east-west orientation: Bielsko, Kosin, and probably Wieprzec.

It seems that when locating these first 'foundation' graves at any of the above-mentioned sites, not only was the point of sunrise at a given time observed, but simple technical

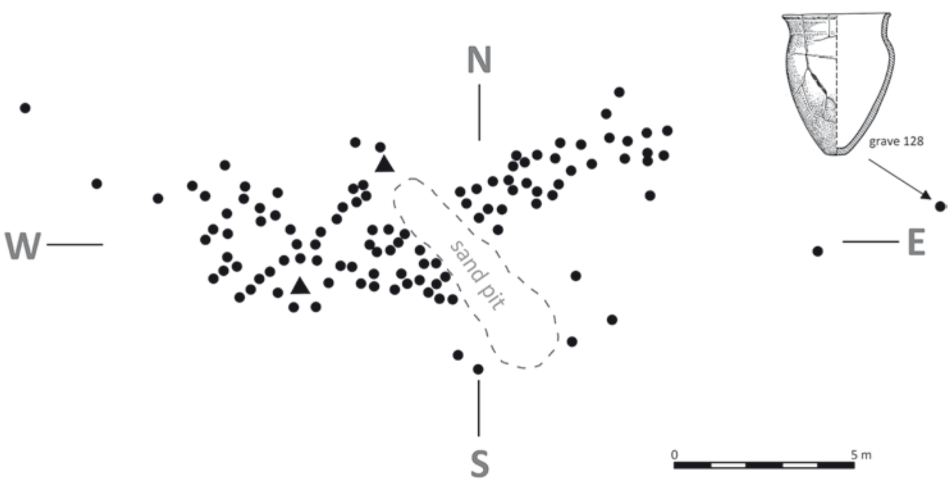

Fig. 2. Wołkowiany, Site 3. The overview of the central part of the Bronze Age cemetery.
Legend: ● – cremation urn burial; ▲ – cremation pit burial
(according to unpublished documentation from the collection of the National Museum in Lublin)

means were also used, such as posts driven into the ground, casting a shadow – a reference line, so to speak, for the initiation of the cemetery. This was probably also how the time of the day was read (in some traditional societies, until recently, the time of the day was determined by measuring the length of the shadow – Kowalski 2007, 461), and mythical time was created. It is worth mentioning at this point that relics of poles, stabilised with stones, were recorded in Krupy, Świeciechów Duży, and Wojciechów.

It is believed that a road led to the sacred centre within a given cemetery, which its users used in order to cross various boundaries and levels, functioning both in reality and in the symbolic sphere (Woźny 2007, 221). The existence of such a route in the case of the necropoleis of the Lublin region is difficult to confirm unequivocally, mainly due to the state of exploration of these sites. Such a path probably ran within the space, along rows of graves and between their smaller clusters. It cannot be ruled out that such a route commenced on the positively valorised side of a given cemetery. In Wołkowiany, the communication tract leading to the main line of graves may have originated from the southeastern side, within the empty space between bonfires and patches of burnt earth. It has been noted that this was a particular canon in Bronze Age and Early Iron Age cremation cemeteries, as the area on the south-eastern side was particularly valued. Furthermore, it is thought that an entryway and open space extended here, which led to the sacred place where the dead resided, and that traversing it reflected an upward movement towards the sun. Rituals of great significance took place there (Woźny 2007, 222). It is assumed that corpse burning, for example, may have taken place in this zone (Woźny 2007, 222). However, in the case of the Lublin region, and many other provinces inhabited by the people of the Lusatian culture, no remains of pyres have ever been encountered, neither there nor elsewhere. Hence, there is a belief that bodies were burnt entirely outside the burial space (Dąbrowski 2001, 42).

An interesting observation in this respect was made regarding the cemetery in Topornica, which, in a sense, had been 'opened' on the eastern side by a cluster of small ceramic forms, among which there were small vessels, a rattle, and a figurine of a rider on a horse (Kłosińska and Klisz 2003, 63). This was probably the 'entrance' place, a symbolic gateway, where mediation took place between the rising sun and those performing ritual acts, probably on their own behalf and on behalf of the dead. A similar situation may have been repeated at the cemetery in Pniówek, Zamość district, Site 1 (Kuśnierz 1990), where the alleged 'entrance' zone was opened by a place where a vessel was deposited – a shoe, viz. an object usually used in rites of passage (*cf.*, Górka 2000) and as a universal amulet with various prerogatives (Górka and Groblica 2007).

It has already been mentioned that at several of the cemeteries analysed within the Lublin region, there was a distinct rise in the density of urns in the central zone of the linear arrangements of graves. Such a situation was most clearly observed in Bielsko and Komarów-Osada, Zamość district, Site 9 (Fig. 3). It probably coincided with the former highest point of culmination of the entire site and can be assumed to have been the sacred

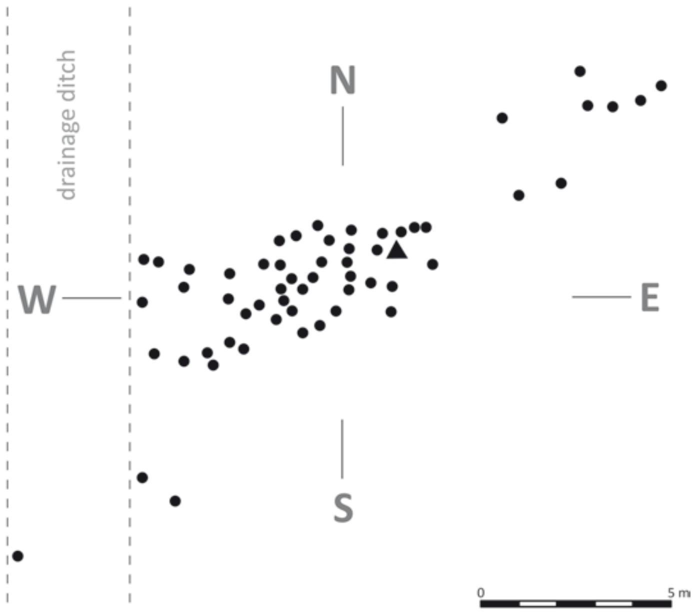

Fig. 3. Komarów-Osada, Site. 9. Overview of the central part of the Bronze Age cemetery. Legend: ● – cremation urn burial; ▲ – cremation pit burial (according to J. Niedźwiedź 1992)

centre of the cemetery and the space closest to the sun in zenith. The sun's highest position is also the middle of the day, midday, when the 'central opening' to the celestial sacrum occurs. It is a time of exceptional clarity, order, and orientation towards life. Magical practices also took effect at this time of day (Kowalski 2007, 460, 464). There may have been two models for the establishment of burial sites in the funerary rituals in the Lublin region. One consisted of locating the first model graves at the eastern edge of the designated cemetery space. This boundary place should be associated with the dawn – the time of mediation. From this point, the cemetery expanded westward, and in this situation, we would be dealing with a chronological succession of graves. An analogous model of cemetery succession was noted within the Tarnobrzeg Lusatian culture (Czopek 1996, 56). At Wołkowiany in the Lublin region, this is how, perhaps, one of the rows of graves was initiated. It 'commenced' from the east with a cremation burial deposited in a Late Trzciniec vessel with a pointed base. This was the oldest grave within this cemetery. It is worth noting that the eastern opening zone of a cemetery may also have coincided with the highest elevation in the field. This was the case in Perespa, where the line of graves sloped gently from east to west along the valley's slope. Another model for the spatial design of a burial site involved the placement of model graves in the central, exposed part of the selected area. This was the 'opening' place, by all means appropriate, as it reflected not only the symbolism of the centre of the world, reshaped for the needs of the dead and their successors, but also the closest point between heaven and earth at midday. This part of the cemetery must have been particularly attractive to its users, which is probably why more and more new urns were placed here. It cannot be ruled out that these urns contained the remains of exceptionally privileged deceased, *such as members of a specific* social microstructure. It is also possible that a so-called cyclic model, identified for some Bronze Age and Early Iron Age cemeteries, existed here, in which the space was extended away from a certain point, and then there was a return movement towards the said point and hence the presence of older and younger graves next to each other (Woźny 2000, 116; 2007, 223, 224). In such clusters, the graves were spaced so close together that the urns even touched each other. The close placement of graves next to each other was especially possible in the necropoleis of the Lublin region, where the urns were most likely visible on the ground surface. This prevented the destruction of older structures when new ones were established. The extremely rare cases of placing one urn on top of another are also worth mentioning, which probably reflected some kind of social or kinship microstructure. Increasing the density within the burial space also had other consequences, for it cannot be ruled out that when the chosen area was filled and with a larger number of dead, new solutions were sought, for example, by occupying a zone with unfavourable characteristics. This was the case with the Kosin necropolis, which, in its youngest stage of use, was expanded to the north (Kostek 1989, 404).

The act of assigning value to the space concerned not only the burial site but also the individual graves and the burials within them. When making the burials, an attempt was made to refer to the positively regarded directions, *i.e.,* east and south. There was a clear astronomical basis for the orientation of the wooden sarcophagi in the cemeteries in Krupy and Jakubowice Murowane (Fig. 4). The long axis of these features ran from south to

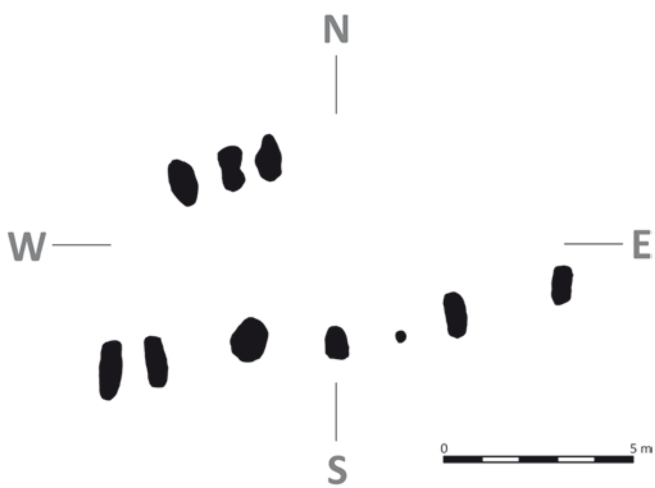

Fig. 4. Jakubowice Murowane, Site 5. Layout of graves within the surveyed part of the Early Iron Age cemetery (according to U. Kurzątkowska and A. Rozwałka 1990)

north. The bodies of the deceased, where the anatomical arrangement of the corpse was preserved, had been arranged with their heads to the south. Such a situation was recorded, for example, in Krupy and Jakubowice Murowane. Inhumation burials in Brodzica, Hrubieszów district, Site 19 (Padło and Ratajczak 2007), Gródek, Hrubieszów district, Site 1C (Kłosińska 2005) and in Strzyżów, Hrubieszów district, Site II (Kietlińska 1936) were also interred with the heads towards the south. This direction, universal for inhumation burials not only within the territory of the Lusatian culture but also in the Wysocka culture, also indicates a distinct value attribution to the human body.

The northern zone of the cemeteries was probably not recognised as positively valued, *e.g.* in Świeciechów Duży. At this cemetery, only pit graves were located within the northern zone. Anthropological analysis showed that these pit graves contained exclusively the remains of deceased children and juveniles. These were probably not fully-fledged members of the local community (who had died, *e.g.*, before their initiation), buried in the part of the cemetery with a negative connotation, which was perceived as such due to the absence of sunlight.

The topic of the spatial arrangement of the cemeteries in the Lublin region is a broad research field. The subject concerning the space within the graves themselves, *e.g.* how bones were placed in the urns themselves and why some urns were tilted or even turned upside down, has already been partly outlined. The question of where animal bone deposits, flints, and belemnites appeared in the graves in the Lublin region was also asked (Kłosińska 2012). Additionally, it is worth mentioning the existence of communication holes in vessels, which were always oriented to the south (Kłosińska and Klisz 2003). This is a fascinating subject matter requiring separate study and elaboration. So is the entirely 'untouched' issue of the distances within the cemeteries, be it between the cemetery lines or the graves themselves. The population of those times used some kind of measurement system, such as on settlements. Exciting and convincing conclusions on this subject have recently been published (Gralak 2009). Finally, another aspect of studying space within cemeteries is outlined, which is both challenging and stimulating. Namely, a question arises as to whether the act of cemetery foundation could have been linked to the astronomical changes of the seasons. This cannot be ruled out, given the probable, powerful experience of natural processes perceived by Bronze Age and Early Iron Age people and the way they shaped their lives.

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BURIAL CUSTOMS AND CULTURAL CHANGE. A CASE STUDY FROM CENTRAL GERMANY DURING THE TRANSITION FROM THE LATE BRONZE AGE TO THE EARLY IRON AGE

ABSTRACT

Korczyńska-Cappenberg M. 2025. Burial Customs and Cultural Change. A Case Study from Central Germany during the Transition from the Late Bronze Age to the Early Iron Age. *Sprawozdania Archeologiczne* 77/1, 21-51.

This paper presents the osteological, taphonomic, and archaeological analysis of a cremation grave from Markranstädt in northwestern Saxony – a region situated at the intersection of three cultural traditions during the final phase of the Late Bronze Age and the older phase of the Early Iron Age. Although the burial lacked distinctive grave goods, typochronological multivariate statistics provided a chronological and cultural framework for interpretation. Osteological analysis identified the deceased as an adult aged 30-40 years, exhibiting a notably tall stature and no pathological alterations in the skeletal remains. Taphonomic evidence reveals a deliberate and structured arrangement of the cremated bones within the urn, including the vertical, antithetical positioning of lower limb epiphyses and the horizontal placement of upper limb elements. These findings enhance our understanding of funerary practices in the region, highlighting the ritual complexity of cremation burials during this period of cultural transition.

Keywords: Late Bronze Age, Early Iron Age, funerary practices, Central Europe, osteological analysis, multivariate statistics
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INTRODUCTION

Robert Hertz, in his seminal 1907 essay 'A Contribution to the Study of the Collective Representation of Death', was among the first to recognise that for indigenous peoples, death is not a discrete event but an extended process of transformation. Subsequently, Arnold van Gennep's groundbreaking work 'Les Rites de Passage' (1909) classified funerary rituals as rites of passage, delineating three fundamental stages within that process: separation (preliminal), liminality (marginal), and aggregation – the reintegration into the social community (postliminal).

While these pioneering studies were based on ethnographic observation and were not contextualised within archaeological data, they addressed the universal, deeply traumatic human experience of death that transcends cultural and temporal boundaries. Notably, no society fails to develop complex and varied practices for engaging with the deceased. From the sociological perspective, death constitutes a transition in which an individual relinquishes social roles and, through ritual performance, is transformed into an ancestor who, in the afterlife, sustains the wellbeing of the living community (*cf.*, van Gennep 2005; Brandt 2011, 71; Gramsch 2010, 141; Hofmann 2008, 369, 370; Korczyńska *et al.* 2016; Veit 2013, 12, 13). Beyond private mourning and transition rites, funerary ritual serves pivotal social functions for the living community by reinforcing kinship bonds, enhancing group cohesion, and facilitating differentiation from external groups (*cf.*, Benz and Gramsch 2006, 430; Hofmann 2008, 369).

Funeral customs generally adhere to clearly articulated regulations; yet, each ritual act exhibits unique variations reflective of individual and local agency. Such variability is manifested in the archaeological record as a diversity of burial customs within and between cemeteries. However, it is imperative to acknowledge that graves rarely offer a direct mirror of social reality. Instead, they encode ideological frameworks – religious, social, and political beliefs and norms (Brandt 2011, 72; Gramsch 2005, 3; 2010, 123-134). Furthermore, interpreting prehistoric funerary customs demands a conscious effort to transcend modern conceptions of death. A task that remains, for us, almost insurmountable due to the substantial cultural and temporal distance separating contemporary perspectives from those of the past.

Within this theoretical framework, the present study turns to a recently investigated singular burial in the scarcely explored region north of Markranstädt, district of Leipzig, northwestern Saxony. Here, archaeological rescue excavations initiated in 2019 by the Saxon State Office for Archaeology shed new light on local settlement dynamics. During the excavations, three new archaeological sites have been uncovered and documented. The present article focuses on an excavation area uncovered in 2020 at activity MS-129, and, more particularly, on the urn grave found there, which was thoroughly examined through micro-excavations (Kretzschmar and Korczyńska-Cappenberg 2024). The core research questions guiding this investigation are as follows: Is it possible to determine an individual's stature and sex from cremated remains when bone fragments are analysed in detail and organised into larger units? Furthermore, have micro-excavations revealed discernible patterns or rules governing the spatial arrangement and deposition of cremated human remains within the urn, reflecting intentionality and thus representing the postliminal transition phase, an integral element of burial customs?

To address these questions, an intensive excavation method was employed, involving meticulous documentation of the position of every individual bone fragment. Such analyses are exceptionally labour- and time-intensive and remain extraordinarily rare within both Late Bronze Age and Early Iron Age contexts. Previous studies in this domain have either failed to reveal consistent patterns in bone placement (*e.g.*, Waltenberger *et al.* 2023), produced limited, albeit groundbreaking, observations (Gramsch 2010), or provided only basic spatial information (Pankowská *et al.* 2017).

The present paper thus contributes novel data, advancing our understanding of at least some urn burial practices in this region and demonstrating the potential of detailed micro-excavation, combined with osteological and taphonomic analyses, as tools for elucidating prehistoric funerary traditions.

MATERIALS AND METHODS

Geographical location of the site and fieldwork

Markranstädt is located in the northwestern part of Saxony, within the Leipzig Basin, a gently undulating loess-loam-covered lowland that forms part of the Central German loess zone. The area lies at an elevation of approximately 120-140 metres above sea level.

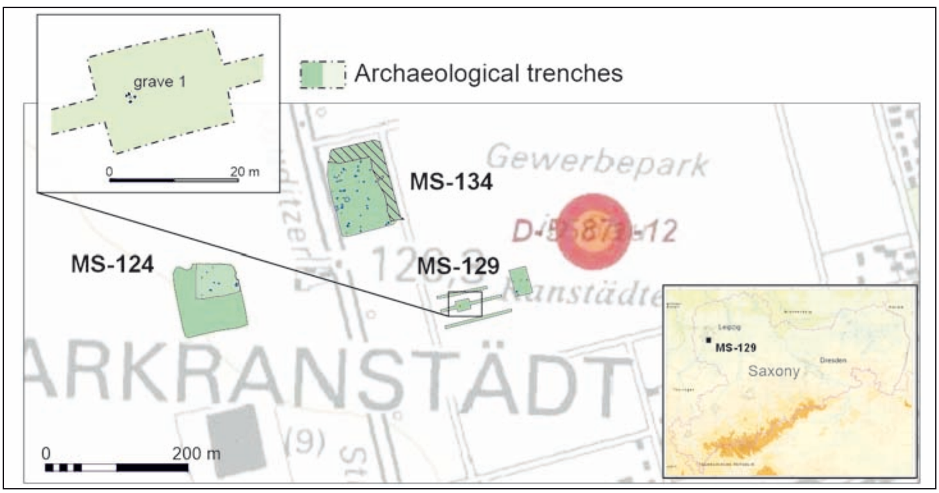

Fig. 1. Location of the grave at Markranstädt-129 (MS-129)

It is characterised by fertile loess soils derivates (German typology: 'Parabraunerde'), with the nearby Saale, Weiße Elster and Luppe rivers forming the current hydrological background (together with some lakes that are remnants of lignite mining in the region).

Before the planned construction work in the northern part of the city, in 2019, the area was archaeologically examined through test trenches (Fig. 1). In the eastern part of the site, several features likely representing settlement remains were documented, while in the central area, an isolated urn grave was identified. Following its discovery, the excavation area surrounding the grave was expanded, but no further graves were found, confirming its singular nature. Four large stones surrounded the urn, but no clear grave pit or indications of a burial mound were detected (Fig. 2: A). The urn was subsequently retrieved using a block recovery and further examined under laboratory conditions.

Cultural background of the study area

The Northwestern Saxony region lies in a border zone where multiple archaeological cultures and groups (in the sense of the cultural-historical approach) intersect. This intricate cultural diversity makes it difficult to assign a precise chronological context and suggests that the burial at Markranstädt may potentially exhibit overlapping influences from adjacent cultural traditions. Understanding these interactions and regional diversity is crucial for interpreting the burial's unique features and assessing its place within broader socio-cultural transformations occurring at the time.

During the final phase of the Late Bronze Age and the transition into the Early Iron Age (Ha B2-Ha B3/Ha C, approx. 900-780 BC), in northwestern Saxony, the horizontally grooved pottery style of the late Lusatian Culture predominated (Fig. 2: A). However, due to its peripheral location, the area also exhibited influences from the so-called Saalemündung group, which originated in eastern Saxony-Anhalt as well as from the Unstrut group

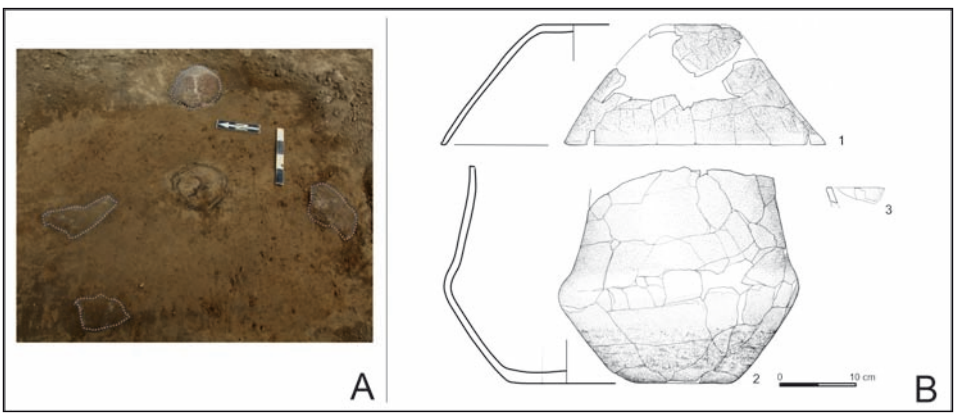

Fig. 2. Markranstädt-129, Grave 1: photographic documentation in the field (A) and pottery inventory (B)

of the northern Thuringian Basin (*e.g.*, Heynowski 2010). The burial customs within the later Lusatian Culture are generally considered comparatively uniform, with quite elaborate urn graves. Also, in both the Saalemündung and Unstrut groups, cremation was the predominant practice. However, within the Unstrut group, several inhumation graves also occur, interpreted as a continuation of older burial traditions. In northwest Saxony during the Late Bronze Age, a moderate variety of grave types can be observed. This ranges from classic urn graves with burial pits and few grave goods, to (presumed) chamber graves, cremation pit graves, and isolated so-called bell-rimmed graves (German: 'Glockengräber', *cf.*, *e.g.*, Battaune; Schmalfuß 2015/2016). This variance reflects the region's peripheral position within the broader Urnfield complex.

In the subsequent phase (Ha C, approx. 780-620 BC), unlike in eastern Saxony, where the Lusatian culture transitioned into the Billendorf culture, the transition from the Late Bronze Age to the Early Iron Age remains unclear (Ender 2009, 158; Döhlert-Albani 2025, 24). There is no evidence of a continuous Billendorf cemetery or settlement to the west of the Elbe River, which spans both the final stage of the Late Bronze Age and the older phase of the Early Iron Age. Instead, in northwestern Saxony, three cultural groups intersected and partially overlapped: the western group of the older Billendorf Culture, which extended along the Elbe corridor; the House Urn Culture between Elbe and Saale rivers and the Thuringian Culture in Thuringia Basin and in Saxony-Anhalt along the Saale, Weiße Elster, and Pleiße rivers (Fig. 3: B; Peschel 1990; Döhlert-Albani 2025; see also further references therein). For this region, R. Heynowski (2007) proposed the existence of an independent Northwestern Saxon Group. Based on analysis of grave characteristics and inventories from the cemetery at Zwenkau-Nord, he concluded that this group cannot be clearly assigned to any of the adjacent Early Iron Age cultural units. However, certain finds and burial customs could be attributed to the styles known from the surrounding regions. In the Billendorf cemetereies an extensive ceramic assemblage – comprising many small

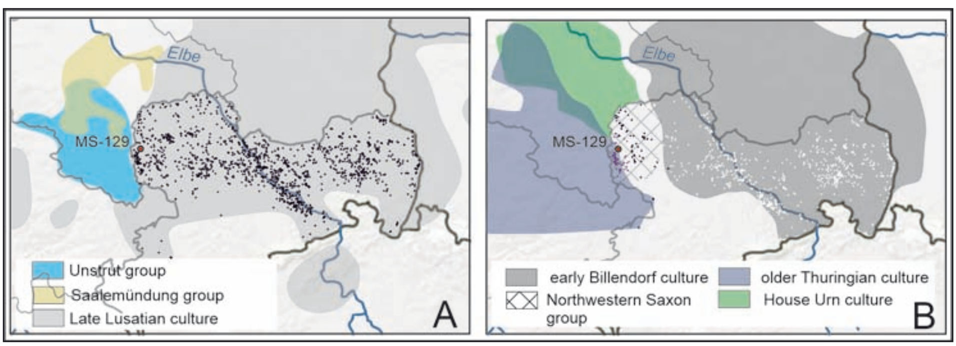

Fig. 3. Extent of the archaeological cultures in Central Germany during the final phase of the Late Bronze Age (A; Ha B2-Ha B3/Ha C, *ca*. 900-750 BC) and older stage of the Early Iron Age (B; Ha C-Ha D1, *ca*. 750-550 BC) (after Buck 1979; Heynowski 2010; Meller 2015; Peschel 1992, modified)

and large vessels – was placed in the grave alongside the urn (*cf.*, Kaiser and Manchus 2017), while Early Iron Age burials of the Northwestern Saxon Group usually consisted of individual urn graves accompanied by one or two additional vessels. This burial custom shows remarkable parallels to the funeral traditions in the areas to the west and northwest. Because of the relatively uniform grave inventories, it might be assumed that generally the community that settled Northwest Saxony at that time might be described as egalitarian. Burials that could be interpreted from our current perspective as rich were only very occasionally found in the Leipzig and Halle regions (*cf.*, Heynowski 2007, 120; Müller 1993). The Northwestern Saxon Group continued to develop in Saxony with those distinctly independent traits throughout the entire Iron Age.

Methods of micro-excavation and documentation of the materials

Following the identification of the urn burial in the field, the grave context, including the urn and its immediate surroundings, was excavated as a single soil block under the supervision of the appointed head of rescue excavation, Sven Kretzschmar. This includes not only the urn itself and its contents, but also the surrounding grave pit and adjoining sediment. This block was subsequently stabilised using a gypsum plaster jacket to preserve the original stratigraphy and spatial relationships of its contents. Such an approach enabled detailed micro-excavation and in-lab analysis of the cremated remains, associated pottery fragments, and sediment layers within the urn, providing a comprehensive starting point for understanding the grave assemblage and for further investigation into individual funerary customs.

The micro-excavation within the urn was conducted following the natural stratigraphy. The urn was filled with a clay-loess sediment that required very careful moistening to allow digging and to enhance the visibility of the bones without compromising the integrity of the fragile bone spongiosa. All bone remains and pottery finds were individually numbered and documented *in situ*. A new layer was excavated whenever several new finds became visible, and the border of the osteological and archaeological material could be recognised. In order to detect possible charred macro remains and/or charcoals, all sediment from the urn and from the grave pit was floated with sieves of 0.5 mm and 1 mm mesh diameter.

Osteological methods

Anatomical and taphonomic analyses were carried out on skeletal and dental fragments larger than 4 mm, which were manually separated during excavation. The smaller fraction (<4 mm) was excluded from further analysis. The anatomical identification of the bone fragments, their state of preservation (maximum length and width, weight), and any pathological changes were determined. Bone fragments with matching fracture edges were refitted and subsequently measured as a unit in order to study taphonomy of the cremated remains and osteological issues.

For complete long bones, unburned metric references were taken from Gonçalves (2011) and Gonçalves *et al.* (2020). Sex estimation was then conducted using the methods proposed by Mall *et al.* (2001). To verify the sex estimations, measurements of calcined remains were compared with experimental data published by Gonçalves (2011) and with sex estimations from cremated remains in Late Bronze Age and Iron Age cemeteries in Italy, as analysed by Cavazzutti *et al.* (2019). In addition, the method developed by Gonçalves *et al.* (2013) was applied to some remains.

To estimate the stature of the individual, a reconstruction of pre-burning bone metrics was carried out using the results of experimental studies by Gonçalves (2011) and Gonçalves *et al.* (2020). Subsequently, the equation proposed by Trotter (1970) and, additionally, the Rösing method (1977) were used.

Methods of the statistical approaches to the typochronological classification of the grave from Markranstädt

The inventory of the Markranstädt grave consisted essentially of two vessels: a biconical vase and a conical bowl. To assess the statistical affiliation of the vessel used as the urn with a formal archaeological group, multivariate statistical analyses were conducted. For this purpose, a reference database of undecorated vases from Saxony, southeastern Saxony-Anhalt, and eastern Thuringia was compiled (51 cases in total; see Table 1 in Suppl. data). In each case, such measurements as:

H1 – Maximum vessel height;
H2 – Height from the rim to the maximum belly width;
H3 – Height from the bottom to the maximum belly width;
H4 – Height of the shoulder zone;
W1 – Rim diameter;
W2 – Maximum vessel width (corresponding to the maximum belly width);
W3 – Bottom diameter;
W4 – Neck diameter just above the shoulder was taken.

From these measurements, the following proportions were calculated: belly position and slenderness → H1/W2, H3/H1; mouth shape → W1/W2, W4/W2; overall appearance → combination of H1/W2, W3/W2, H4/H1. Subsequently, a Principal Component Analysis (PCA) was performed using the Past version 5.2.1 based on a correlation matrix in which variables that showed strong positive correlations were excluded from the analysis to avoid redundancy.

RESULTS

Typo-chronological classification of the grave inventory

The grave inventory comprises two vessels: a large, undecorated vase with a conical neck and a gently curved profile, serving as the container for the cremated remains, and a conical bowl that covered the burial (Fig. 2: B). The urn vessel was tempered with mineral inclusions and fired in an oxidising atmosphere. Both its interior and exterior surfaces were smoothed, with the lower portion of the exterior intentionally left rough. The bowl exhibits comparable technological traits, with its outer surface deliberately roughened by a brush technique extending to approximately one centimetre below the rim.

While conical bowls are present throughout the Late Bronze Age in Central Germany, they notably increase in frequency during the younger phase of the Billendorf Culture (*e.g.*, Buck 1979; 1989; *cf.*, Fig. 2: B). The Markranstädt vessel remains undecorated. Reconstructing the typochronological development of this vessel type solely on the basis of profile features is challenging. Conical-neck vases appear in Central Germany from the Middle Bronze Age onward. In general, their later iterations show a decline in pronounced profiling and a decrease in incised decoration towards the end of the Bronze Age (*cf.*, Buck 1979, 1989). The straightforward comparison of vases resembling the Markranstädt vessel suggests close parallels to pieces found in Middle Saxony, including cemeteries such as Dresden-Stetzsch (Coblenz 1985, pl. 37.10, 40.9, 57.19), Altlommatzsch (Hellström 2005, *e.g.*, Graves 57, 158 and 243), and Liebersee (Bemman and Wesely-Arents 2005, pls 33.20-21, 76.22; Ender 2003, pls 5.7, 12.36, 29.1, 50.5, 71.9). But on the other hand, strong analogies exist with the immediately adjacent western regions as well, particularly with a vessel from an Unstrut group cemetery in Obermöllern (southeast Saxony-Anhalt, Wagner 1992, fig. 53.15; see fig. 5.14). Taken together, neither the urn nor the covering bowl displays distinctive typological features sufficient for precise cultural and chronological attribution.

For that reason, an attempt was made to apply multivariate statistical analysis of the urn for further examination of its typological affinities (Fig. 4). Although it is generally assumed that the proportions of robust, handmade vessels primarily reflect stylistic traditions maintained at the household level by local workshops, it has nevertheless been demonstrated that similarities in vessel form may also reflect continuity or discontinuity in the style development or suggest local network connections (*cf.*, Przybyła and Dzięgielewski eds 2024).

In the case of the urn from Markranstädt, Principal Component 1 (PC1) explains 32.41% of the variance and shows positive correlations with the following vessel ratios: 1) the ratio, showing how high the belly is and 2) the ratio providing insights into the design of the neck/shoulder area, and negative correlations to the ratio, that describes the opening relative to the maximum width. Principal Component 2 (PC2) explains 27.43% of the variance, with positive correlations to 1) the ratio, that shows whether a vessel is tall and slender or squat and 2) the ratio describing whether the vessel is narrow- or wide-mouthed and a negative correlation with neck diameter just above the shoulder/maximum vessel width (the ratio showing if neck is narrow or wide).

Both axes of the plot likely reflect chronological depth, as most of the Early Iron Age vases are clustered right to the PC1 axis of the diagram (Fig. 4: A). The vessel from Markranstädt,

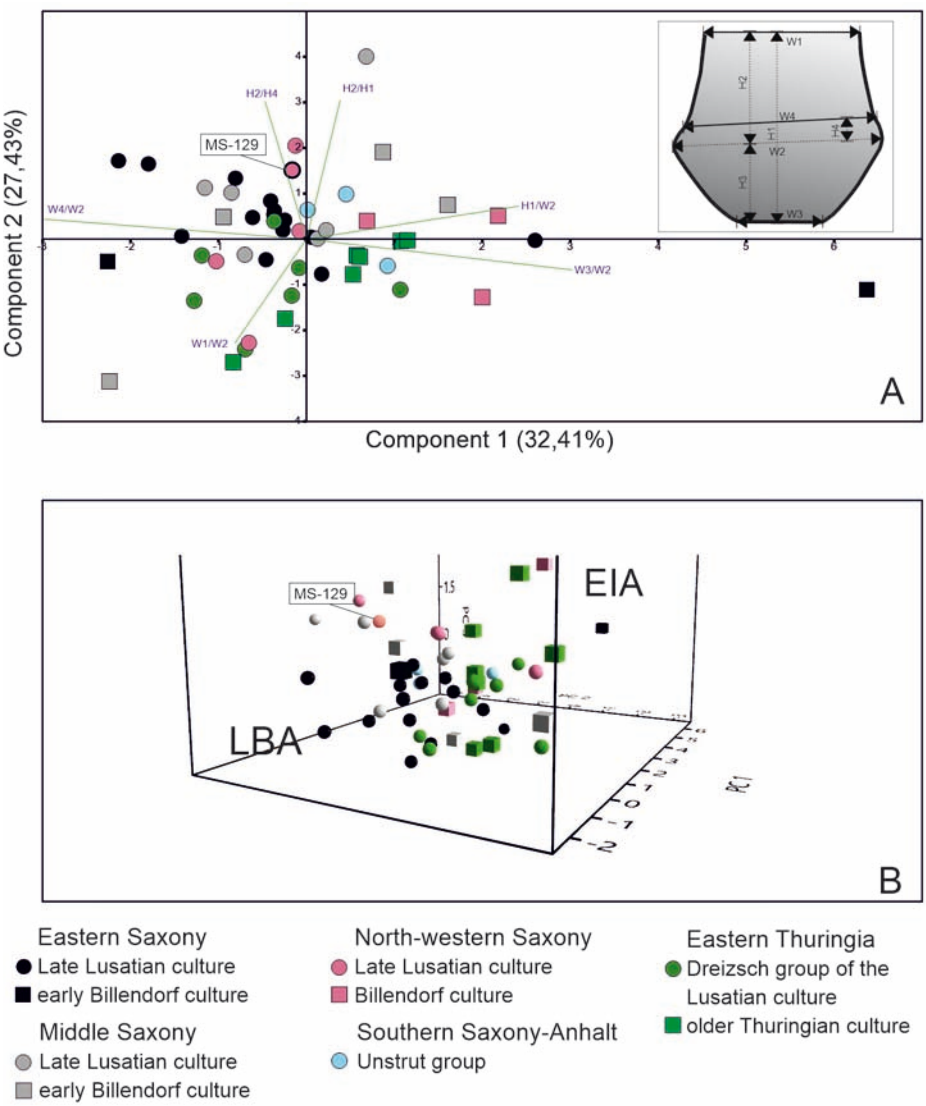

Fig. 4. Plot of the PC1 and PC2 of the Principal Components Analysis (A) and 3D visualisation (B) of undecorated vessels of 'terrine' type from the Late Bronze Age and Early Iron Age sites located in Central Germany

together with Late Bronze Age vessels from northwestern Saxony, is positioned to the left of the PC1 axis and closely clusters with vessels from the Middle Saxony region. This spatial placement indicates that the urn shares the same stylistic tradition with vases from the Late Bronze Age Lusatian culture of Middle Saxony. At the same time, Early Iron Age vessels from eastern Thuringia in both periods form a distinct, separate cluster. This allows the grave to be placed within the Late Bronze Age Lusatian ceramic tradition and indicates a close interaction network within the Saxony region during the Late Bronze Age.

Results of micro-excavation

A total of 15 stratigraphic layers were excavated and documented using orthophotogrammetry based on the Structure from Motion (*SfM*) technique (Fig. 5). The urn's fill containing the cremated remains appears to have been relatively loose, as the burnt bones were embedded in substantial amounts of redeposited loess sediment. In the upper layers of the urn (Layers 1 and 3-5), fragments of the base and rim of a conical bowl were discovered. Additionally, six small pottery sherds were recovered from deeper layers among the bones, attributable to two further Late Bronze Age/Early Iron Age vessels, including a rim fragment with a conical profile (Fig. 2: B) and a body sherd from a thin-walled vessel. The precise timing of these fragments' entry into the urn remains unclear. Since no additional vessels were found in the immediate vicinity of the urn, it is conceivable that the sherds may represent the remains of libation rituals performed during the burial ceremony (*cf.,* Gramsch 2005; Nebelsick 2000; 2018, with further references). However, it cannot be ruled out that the sherds entered the urn post-depositionally through erosion of the surrounding cultural layer or, less likely, through bioturbation. Nevertheless, no settlement remains have been identified in the immediate vicinity of the grave that could have served as the source of these ceramic fragments. For that reason, this question is still open.

Numerous recent seeds of white goosefoot (*Chenopodium album*) were also found inside the urn, probably introduced by bioturbation or via re-deposited sediment. A recent seed of ivy-leaved speedwell (*Veronica hederifolia*) was recovered from Layer 13. Those macroremains should be interpreted as the result of macrofaunal activity, which impacts stratigraphy and sometimes even fragmentation of cremated bones (*e.g.*, Hałuszko *et al.* 2022). In contrast to recent intrusions, four small fragments of charcoal found in direct contact with the bones are plausibly remnants of the pyre. They represent oak (*Quercus* sp.), pine (*Pinus* sp.), hazel (*Corylus avellana*), and an undetermined conifer species. The fact that only four tiny charcoal fragments were recovered suggests that the cremated bones were very carefully collected from the pyre and probably washed afterwards.

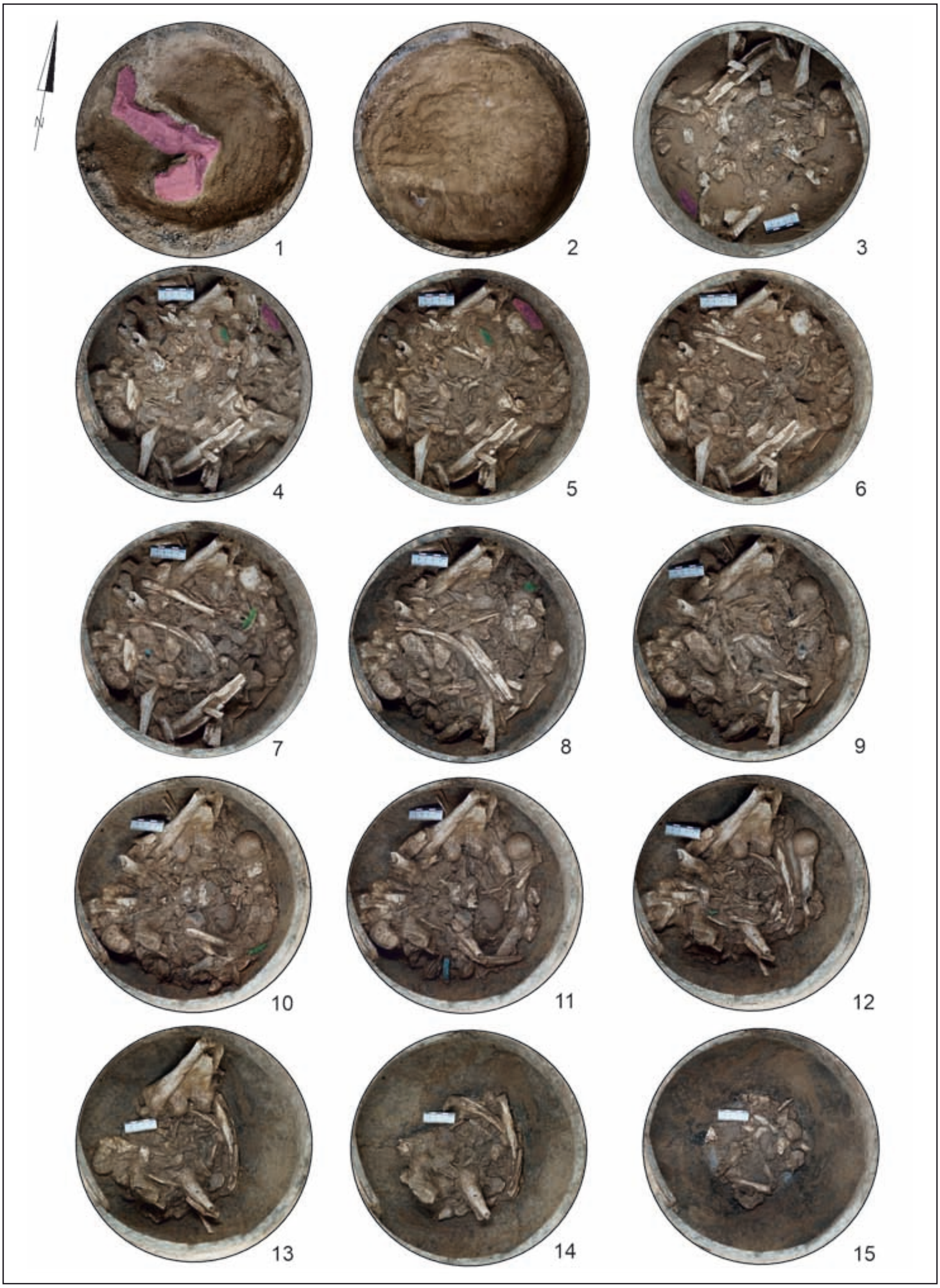

Fig. 5. Assemblage of 15 documentation layers of the micro-excavations of the urn from Markranstädt-129, including sherds of the covering bowl (violet) and other pottery fragments (blue and green)

Osteological analysis – general remarks

The osteological assemblage consisted of 576 three-dimensional measurements of human bone and tooth fragments. The total mass of the cremated remains is 2216 g with no bone elements exceeding the expected count for a single individual. According to experimental studies, the average weight of combusted remains of a male individual ranges from 1842 g (Herrmann 1976, cited in Gonçalves 2011, 29) to 3379 g (Baas and Jantz 2004, Table 4), with a median of 2680 g (based on studies by Bass and Jantz 2004; Chirachariyavej *et al.* 2006; van Deest *et al.* 2011; Herrmann 1976; Malinowski and Porawski 1969; McKinley 1993; Warren and Maples 1997). Such heat-induced weight loss results from the dehydration and decomposition of organic bone components (Hiller *et al.* 2003, 5093 ff.). These comparative data suggest that in the case of the Markranstädt burial, the cremated remains were almost entirely deposited in the urn. However, the osteological identification and cataloguing of the skeletal elements show that the anatomical representation of the cremated remains differs slightly from that of a complete skeleton (Fig. 6). While this discrepancy likely has a primarily taphonomic origin, it is also possible that certain ritual choices influenced the selection and deposition of the cremated remains. Different sequences of burning various body regions on the pyre (Symes *et al.*, 2015, fig. 2.8-2.8), as well as the varied structural composition of bone tissue, may have led to incomplete calcination of some skeletal parts, reducing their preservation potential. For example, under optimal conditions, the ventral side of the distal femur at the knee typically undergoes

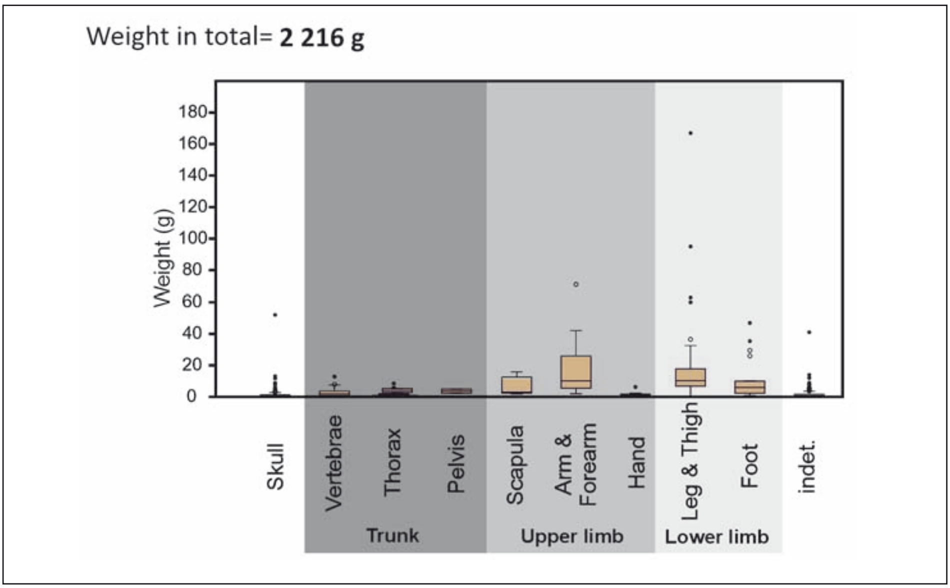

Fig. 6. Distribution of the cremated human remains from the burial at Markranstädt-129

Fig. 7. Selection of bones from the burial at Markranstädt-129:
left humerus (1), right and left radii (2), right and left foot bones (3), right fibula (4), distal epiphysis of the tibia with a marked *facies articularis malleoli medialis* (5), right and left patellae (6), right and left femora, dorsal view (7), left scapula (8), cervical vertebrae (9), thoracic vertebrae (11)

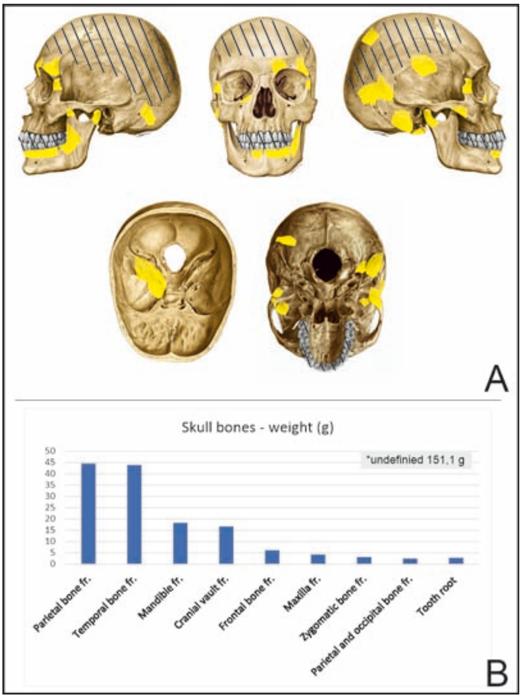

Fig. 8. Cranial element inventory from the burial at Markranstädt-129 (A); weight distribution of the identified cranial fragments (B)

burning in the early stages. In contrast, the proximal femur is affected later in the process (Symes *et al.* 2015, figs 2.8 and 2.9). If this pattern holds in our case, it might explain the absence of proximal femoral epiphyses in the remains from Markranstädt. However, the hypothesis of intentional selection of femoral epiphyses, if preserved, cannot be excluded entirely. Most bone fragments exhibit yellowish to white colouration, indicating – following the combustion stages defined by Herrmann *et al.* (1990, 259) and J. Wahl (1981, table 1) – temperatures exceeding 800°C. A few fragments show grey to bluish-grey colouration, which may point to lower temperatures around 550°C (Wahl 1981, table 1). These colour differences might reflect temperature fluctuations at different stages and locations during cremation, which aligns with the underrepresentation of certain skeletal parts.

The postcranial skeleton accounted for 1931.7 g. Of these, 1391 g belonged to the long bones of the upper and lower limbs, including the humerus (Fig. 7: 1), radius (Fig. 7: 2), ulna, fibula (Fig. 7: 4), tibia (Fig. 7: 5), and femur (Fig. 7: 7). Both patellae (kneecaps, Fig. 7: 6) were also identified, with a total weight of 29.1 g. Foot bones were particularly abundant (Fig. 7: 3), weighing 211.4 g in total. A further 37.1 g were attributed to hand bones, 30.1 g to both scapulae (Fig. 7: 8), and only 7.3 g to the pelvic bones. The trunk is represented by vertebrae weighing a total of 157.2 g (Fig. 7: 9, 10), and 94.5 g of rib fragments.

The skull fragments weighed 284.7 g (Fig. 8). Most fragments were identified as parts of the temporal bone (including both fossae mandibulares, the right mastoid process, and the right petrous part), and the parietal bone. Additionally, parts of the occipital bone, zygomatic bone with both frontal processes, and frontal bone (with the left supraorbital margin) were identified. Several mandibular fragments and one fragment of the maxilla were also present. Nineteen tooth root fragments were documented as well, including roots from five premolars or canines and four molars.

Several skeletal elements from the Markranstädt burial display heat-induced fractures. Most bone fragments exhibit taphonomic alterations consistent with exposure to high temperatures, such as warping (Fig. 7: 4) and thumbnail fractures (Fig. 7: 2). While some bones – such as vertebrae and metacarpal or metatarsal elements – were fully preserved, others, particularly long bones, were found fragmented. Notably, several lower limb bones show very similar fracture patterns (Fig. 7: 5, 7). At present, it remains unclear whether these fractures of the tibia and femur occurred naturally during carbonisation, without deliberate human intervention, or whether they resulted from intentional breakage during collection and placement in the urn. The presence of symmetrical thumbnail fractures could theoretically result from even burns on both sides of the body. However, slight differences in the maximum width of the tibiae (Table 2 in Suppl. data) and in the osteometric values of the tarsal bones (Table 3 in Suppl. data) – which are generally larger on the right side – suggest varying degrees of thermal shrinkage and, consequently, a non-uniform temperature distribution on the pyre.

Table 1. Sex estimation of the individual from the cremation burial MS-129, derived from osteometric measurements of the humerus and radius. Raw and corrected values (after Gonçalves 2011; Gonçalves *et al.* 2020) were evaluated using logistic regression equations for sex determination after Mall *et al.* (2001)

	MS-129 (mm)	**MS-129_burial 1 meassurements after correcture (based on Gonçalves 2011 and Gonçalves *et al.* 2020)**	**Logistic regression equations for sex estimation of unburned modern samples in western Germany (after Mall *et al.* 2001) value D < 0.30 suggest female; value D > 0.30 suggest male**	**MS-129**
Humeral head vertical diameter (HHVD)	44	4.84	D = 0,196 maximum lengt (cm) + 1.962 head diameter (cm) + 1.160 epicondylar width (cm) - 22.608	0.748
Humerus epicondylar width	56	6.16		
Humerus maximal lenght	306	34.262		
Radius distal width	31	3.41	D = 0,484 maximum length (cm) + 4.731 head diameter (cm) + 0.236 distal width (cm) - 21.680	2.431
Radial head dorso-ventral diameter	20	2.2		
Radius maximal lenght	238	26.649		

Table 2. Sex estimation of the individual from the cremation burial MS-129, based on comparative osteo-metric data of selected bones in relation to modern reference populations (after Gonçalves *et al.* 2011; Gonçalves *et al.* 2013) and ancient samples (after Cavazzutti *et al.* 2019)

	Mean rate of dimensional change of calcinated bones (Gonçalves 2011)	**MS-129_ raw data (mm)**		**Sexual differences on calcined bones of modern samples from Portugal (after Gonçalves 2011)**		**Logistic regression equations for sex estimation (after Gonçalves *et al.* 2013). positive values suggest males**		**Cut-of points for osteometric sex estimation based on calcinated bones of ancient Italian populations (after Cavazzutti *et al.* 2019)**
		R	L	Male	Female			
Humeral head transverse diameter (HHTD)	13.45%		40	39.16	33.76	-32.753 + 0.891 * HTTD	2.89	
Humeral head vertical diameter (HHVD)	11.86%		44	43.51	37.74	-26.919 + 0.661 * HHVD	2.17	37.88
Humeral epicondycar breadth (HEB)	9.67%		56	58.32	36.47			
Talus: maximum length A-B (TML)	11.38%	51	50	50.97	45.57	-32.849 + 0.683 * TML	1.94	46.87
Talus: trochlea length C-D (TTL)	14.70%	30	30	31.48	27.71			28.92
Calcaneus maximum length (CML)	11.78%	79		76.92	67.71	-39.628 + 0.549 * CML	3.74	
Calcaneus load arm length (CLAL)	11.95%	47		47.41	40.47			
Calcaneus load arm width (CLAW)	15.39%	38		38.80	34.19			
Cuboid maximum lenght (CL)	15.64%	40	38	33.66	30.24			
Cuboid maximum breadth (CB)	19.23%	30	32	25.23	22.30			
Cuboid maximum heigh (CH)	14.92%	24	22	21.52	21.21			
Navicular maximum lenght (NL)	17.41%		17	18.67	X			13.46
Medial cuneiform lengh (MCL)	15.50%	31		23.23	19.80			
Medial cuneiform lengh heigh (MCH)	13.57%	35	33	29.69	25.36			
Radial head dorso- ventral diameter	no data	20	20	X	X			18.32

Table 3. Estimated living stature of the cremated individual from MS-129, based on corrected long-bone lengths (after Gonçalves 2011; Gonçalves *et al.* 2020). Calculations follow Trotter (1970) and Rösing (1977) equations

	Maximal lenght	**Mean rate of dimensional change of caltinated bones (based on Gonçalves 2011; Gonçalves *et al.* 2020)**	**Maximal lenght after correcture (based on Gonçalves 2011; Gonçalves *et al.* 2020)**	**Equations used to estimate stature (in cm) from long bone lengths (after Trotter 1970)**	**Estimated living stature**	**Estimated living stature (Rösing method)**
Humerus maximal lenght	306 mm	11.97%	34.262 cm	3.08 * Hum + 70.45 ± 4.05	175.97 cm ± 4.05	
Radius maximal lenght	238 mm	11.97%	26.649 cm	3.78 * Rad + 79.01 ±4.32	179.74 cm ± 4.32	
Humeral head transverse diameter	40 mm	10.00%	4.4 cm			*ca* 167.5 cm
Radial head dorso- ventral diameter	20 mm	10.00%	2.2 cm			*ca* 175.5 cm

Table 4. Reconstructed sequence of bone deposition within the urn from the Markranstädt burial (MS-129), indicating intentional arrangement of skeletal elements during interment

Sequence of bone deposition in the urn	
1 – bottom of the vessel	Right patella
2	Right femur and left tibia *placed vertically*
3	Left arm (ulna → radius → humerus) *placed horizontally*
4	Left tibia and right femur *placed vertically*
5	Right humerus
6	Left patella
7	Scapular fragments *centrally placed*
8	Ribs and lumbar vertebrae
9	Foot and hand bones
10	Right and left fibulae and right ulna *placed horizontally*
11	Right radius *placed horizontally*
12	Skull bones and cervical vertebrae

Osteological analysis – anthropological Assessment of Age, Sex, and Stature

The study of skull sutures is a widely used method for estimating the age of unburned skeletons. Burned bones may lead to some misinterpretations due to the heat, which often causes ossified sutures to break apart, thereby giving the impression of belonging to a younger individual (Holck 2008, 64; fig. 8). Fortunately, this misjudgement can be verified by analysing fractal edges and surfaces. In this case, the biological age, based on the degree of cranial suture closure, can be estimated at 30-40 years old (*Adultus*/*Maturus*) (Holck 2008, 63-65; Piontek 1996, 150-152; Fig. 9).

In human skeletal analysis, specific morphological traits and bone measurements are commonly used to estimate biological sex (in adults) and living stature, provided that fragmentation and the absence of key skeletal elements do not prevent such analyses. As already mentioned, during cremation, bones undergo weight loss and shrinkage. Heat-induced dimensional changes have been the focus of numerous experimental studies (*e.g.*, Dokládal 1970; Bradtmiller and Buikstra 1984; Buikstra and Swegle 1989; Hummel and Schutkowski 1986b; Piontek 2007). The degree of shrinkage observed in these experiments varies significantly with factors such as combustion temperature, bone mineral con-

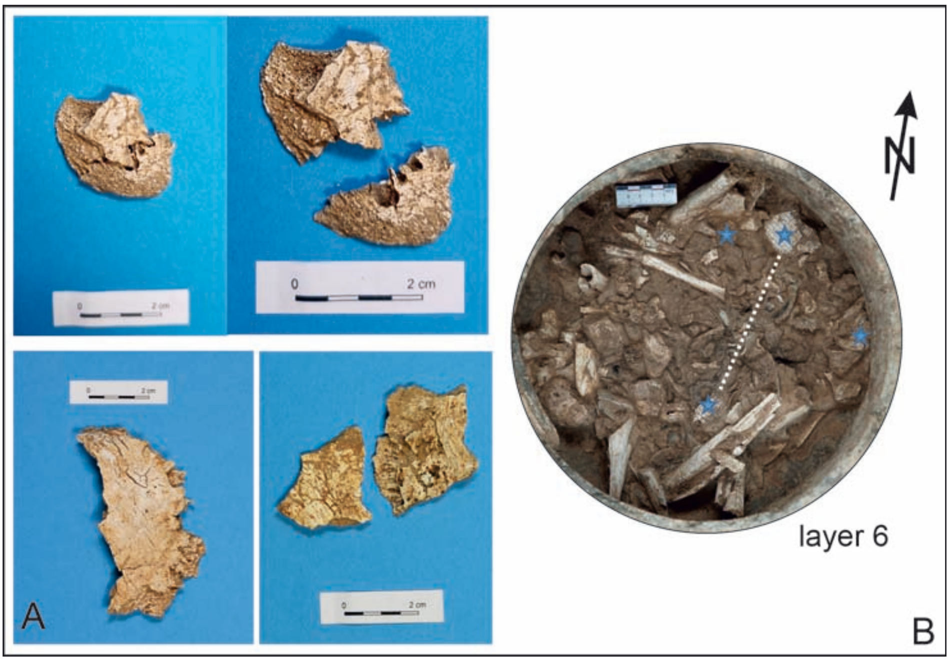

Fig. 9. Fragments of the parietal bone (lower left), and the temporal and occipital bones with an incompletely ossified lambdoid suture (A); position of the latter within the urn (B)

tent, differences between compact and spongy bone, and collagen fibril orientation (Gonçalves 2011 and references therein). Generally, bones heated up to 800°C exhibit relatively moderate shrinkage, while temperatures between 1000 and 1200°C may lead to shrinkage rates of up to 17%, depending on the duration of combustion and the specific bone type (Gonçalves 2011). Despite the unpredictability of dimensional changes in calcined bones, the application of osteometric methods to assess sexual dimorphism remains possible – albeit with certain limitations.

In the case of the individual from Markranstädt, no clear sex-specific morphological traits were preserved. However, the available osteometric data from the humerus and radius (Table 1), along with additional measurements (Table 2), strongly suggest that the individual is male. Furthermore, the estimated living stature of the possibly male individual from Markranstädt – reconstructed using the left humerus and left radius, with appropriate corrections for thermal shrinkage – ranges between 175.9 and 179.7 cm (±4 cm), based on Trotter's equations (1970), or between 167.5 and 175.5 cm according to the Rösing method (1977).

No pathological changes were observed in the osteological material. The pronounced articular surface of the distal tibia, which articulates with the medial surface of the talus, is common in prehistoric societies and is indicative of frequent squatting (Fig. 7: 5).

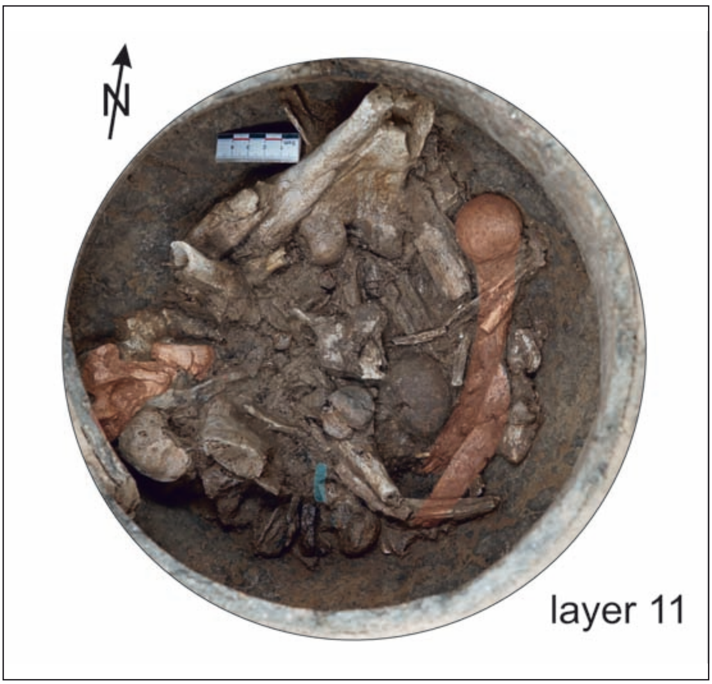

Fig. 10. Markranstädt-129: Position of the humerus (red) within the urn (orthogonal view)

Taphonomic and spatial observations on the deposition of cremated human remains within the urn

Despite the burial's complex taphonomy, several observations regarding the arrangement of bones within the urn can be made. Apart from the concentration of cranial bones and cervical vertebrae in the upper part of the urn, the bones are not anatomically grouped (Table 4).

However, some general patterns are discernible: long bones, particularly those of the lower limbs, tend to be oriented vertically, whereas upper limb bones are predominantly arranged horizontally. Notably, the upper limbs appear to follow a specific pattern (Figs 10 and 11), in which the proximal epiphysis are positioned opposite their respective distal joint ends.

Furthermore, the left and right bones of each pair appear to be in parallel alignment. Particularly striking is the vertical placement of the lower limb diaphysis at the base of the urn, with the left and right femora and tibiae arranged in an antithetical pattern (Figs 12 and 13).

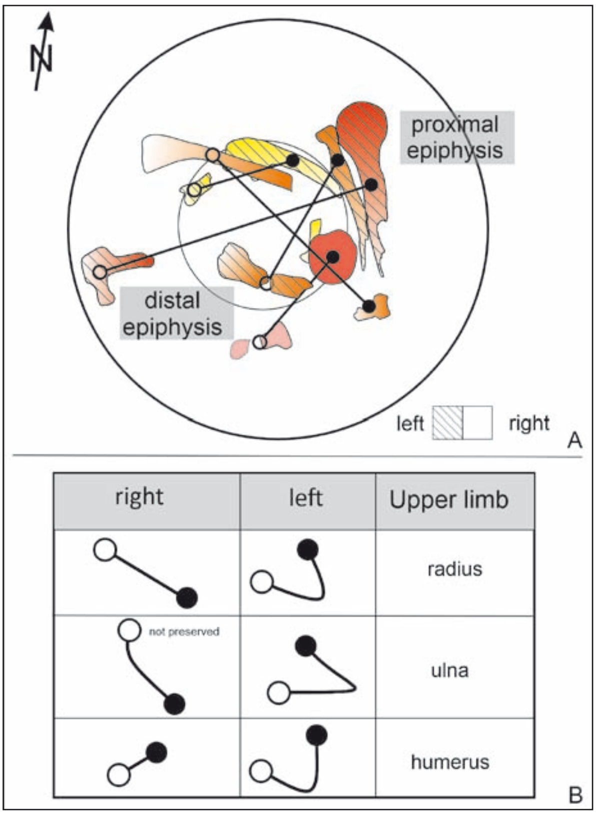

Fig. 11. Markranstädt-129: Arrangement of the upper limb bones within the urn (orthogonal view)

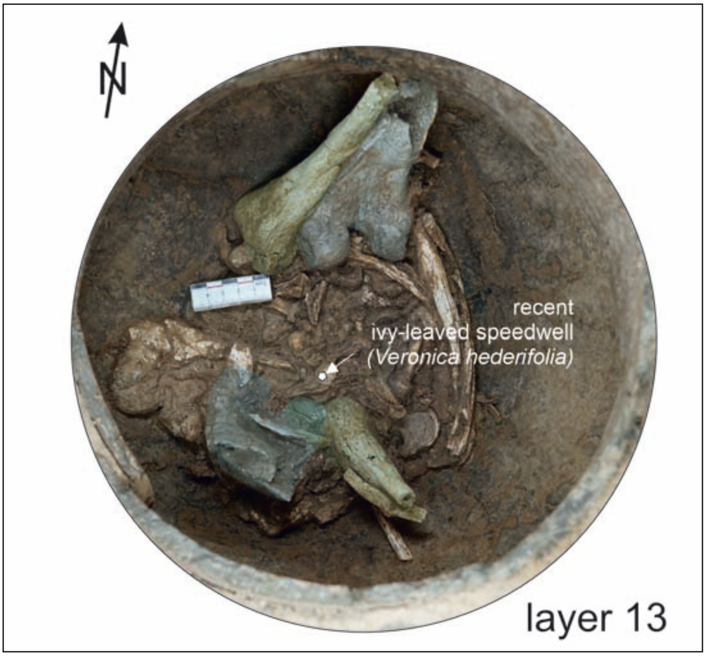

Fig. 12. Markranstädt-129: Position of the femora (orange) and tibiae (yellow) within the urn (orthogonal view)

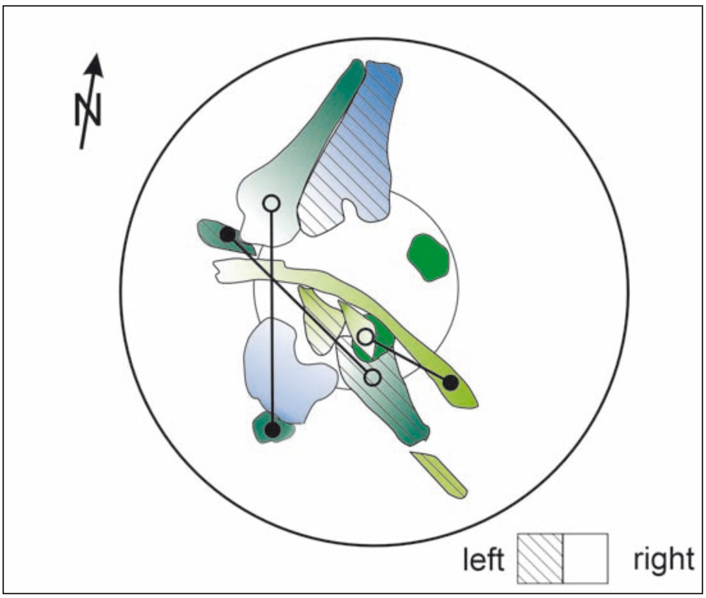

Fig. 13. Markranstädt-129: Arrangement of the lower limb bones within the urn (orthogonal view)

DISCUSSION

The reconstruction of the burial rite based on archaeological sources is a very vague and often misleading challenge. In our case, even the exact dating and cultural attribution of the grave from Markranstädt is not straightforward. It also remains unclear why the grave stands out as a singular feature. Comparable singular graves are known from northwestern Saxony – for example, from the archaeological site in Großlehna, approximately 2 km west of Markranstädt – but they are not a common type of funerary site. The isolated location of the analysed grave may be a result of the current state of research. The grave may be located in a peripheral zone of an as-yet undiscovered Late Bronze Age-Early Iron Age cemetery. The stone arrangement around the urn might reflect an unpreserved construction (barrow?) and may explain its distant localisation.

Another remarkable aspect is the low degree of bone fragmentation observed in the cremated remains. The large size of many bones is generally unusual in Late Bronze Age cremation burials. It is comparable to just a few burials from Late Bronze cemeteries, such as Großlehna in northwestern Saxony (Grave 22), Müllrose in eastern Brandenburg (Tiedke and Storch 2019/2020, Grave 590: 74-79) or Janowice 44 in Lesser Poland (Korczyńska *et al.* 2018, Grave 35). On the other hand, from Ha C/D onwards, a generally significantly low fragmentation of cremated remains can be observed – a trend demonstrated both in the Early Iron Age Pomeranian Culture (*e.g.*, Drozd-Lipińska 2022; Henneberg 1974) and within the Jastorf Culture (Wolska 2021). Also, lower fragmentation appears more frequently in Saxony at the beginning of the Early Iron Age (Schmalfuß *et al.*, in preparation). So, although the urn still resembles the Late Bronze Age pottery style, the degree of fragmentation of the cremated remains in the burial from Markranstädt might already reflect Early Iron Age cremation practices. This could suggest an anachronism in the vessels used (which style would be older) and in the cremation rites, potentially dating the grave to the 7th and 6th century BCE (Ha C).

However, we should also consider the possibility that the Late Bronze Age chronology of the grave is accurate. In such a case, low bone fragmentation might reflect the diversification of cremation traditions within smaller geographical regions (or archaeological cultural groups), as noted in Late Iron Age Southeastern Norway (Holck 2008, 106). This burial type could be interpreted as a variation of the so-called 'special burials' (German: 'Sonderbestattungen'; Veit 2013, with further references). In Central Germany, non-normative burials are typically associated with inhumation remains in settlement pits (German: 'zerrupftete Bestattungen'; Balfanz and Jarecki 2004) and have often been negatively interpreted, particularly within the culture-historical framework, as expressions of ritual, social, or violent contexts. However, this does not appear to be the case for the burial from Markranstädt, as the deceased individual, at least from today's perspective, seems to have been treated with dignified respect. This might suggest that the transitional ritual in the sense of A. van Gennep (1909), which was intended to guide the individual to the ancestral realm, was carried out with care (see below for further discussion). It is important to acknowledge, however, that applying contemporary understandings of 'respect' and 'care' to prehistoric ritual contexts is methodologically problematic and epistemologically fraught. Archaeological interpretation inevitably involves projecting present-day cultural values and emotions onto past societies, risking anachronism, and must therefore be approached with caution. For this reason, the indications presented herein regarding funerary rites, or rather, funeral customs, should be understood as an interpretative heuristic grounded in the available evidence and hypotheses rather than as a specific direct correlation to modern emotional attitudes.

Experimental studies have shown that, following the collapse of the pyre during ongoing combustion, the burnt skeleton generally retains its original anatomical position, despite the typical shrinkage of muscles, tendons, and ligaments and the resulting 'pugilistic posture' – the position in which the body, after exposure to heat, adopts a fist-clenched, arms-flexed stance (McKinley 2015; Piontek 1976; Symes *et al.* 2015). In the postliminal phase, this allows for the collection of bones from the pyre in an intentional order and their placement in a deliberate, structured arrangement in the urn, as determined in Markranstädt, reflecting both ritual intentionality and practical considerations. According to the description in the Iliad (XXIII, 232-241), the funeral pyre on which Patroclus' body was cremated was extinguished with wine the following day, after which the remains of the hero of the battle with the Trojans were collected and placed into an urn. Experimental studies on the cremation process demonstrate that the funeral pyre remains hot for several hours (Leinweber 2002, 168; Wahl 1981, 275), and pouring liquid onto it not only lowers the temperature but also facilitates the differentiation of burned bones from ashes (Pany-Kucera *et al.* 2013, 209). The extremely low number of charcoal fragments in the urn and absence of an ash layer on the bone surfaces suggest that the combusted remains may have been cleaned – possibly even washed – prior to deposition in the urn. Similar observations have been reported from many other Late Bronze Age cemeteries (*cf.*, Hałuszko *et al.* 2015; Korczyńska *et al.* 2018; Wolska *et al.* 2024). Additionally, the low degree of fragmentation observed in Markranstädt indicates that the pyre was at least partially cooled prior to being doused with liquid (*cf.*, Gramsch 2010, 152; Wahl 1981, 276).

In the Markranstädt burial, skull bones and cervical vertebrae appear to have been deposited in the upper parts of the burial, which may reflect the sequence of post-cremation bone sorting. The central placement of scapular fragments could reflect their symbolic role. The conspicuous positioning of skull bones in Late Bronze Age cemeteries across Central Europe has been repeatedly documented through modern, stratified anthropological studies. For instance, in late Lusatian Culture cemeteries in Brandenburg (*e.g.*, Cottbus Alvensleben-Kaserne; Gramsch and Großkopf 2005), Greater Poland (*e.g.*, Wtórek; Hałuszko *et al.* 2022), Silesia (*e.g.*, Rolantowice; Hałuszko *et al.* 2015), and the Świętokrzyskie Voivodeship (*e.g.*, Podlesie 5; Jaskulska 2018), skull fragments are predominantly found in the upper layers of urn deposits. Similarly, in the non-urn cremation grave from the biritual Lusatian Culture cemetery at Opatów, Lesser Poland, cremated skull fragments of a child in the *Infans I* age group were placed in the northern part of the burial pit, with all remains deposited in anatomical order (Szczepanek and Jarosz 2013, 38, 47). The deposition of skull bones as the final element is generally interpreted as evidence of a deliberate ritual act, suggesting an 'anthropomorphisation' of the urn and the symbolic 'reintegration' of the deceased into society (Gramsch 2010).

In the urn from Markranstädt, certain bones show bilateral symmetry in their placement, including both femora, tibiae, and fibulae. Long bones of the lower limbs tended to be placed vertically, whereas upper limb bones were arranged horizontally, perhaps due to their morphology. On the contrary, the spatial division of proximal and distal epiphyses of the upper limbs might be interpreted as part of a ritualised deposition sequence beyond the anthropological order. Similar observations were made from a few burials from Cottbus Alvensleben-Kaserne. At this cemetery, a particular arrangement of bones could occasionally be observed, such as long bones laid parallel to one another or joint heads aligned with opposite sides of the urn or placed parallel to each other (Gramsch and Großkopf 2005, 85). Also, at the Early Iron Age cemeteries in Zapceń, Klukowo, and Lipnica in Pomerania, F. Rożnowski (1995) described several bone-deposition patterns, one of which illustrated the deposition of larger bones at the bottom of the urn.

Altogether, these observations suggest a deliberate and meaningful process of selecting and placing cremated remains, rather than random deposition. However, due to the scarcity of comparative material, it remains unclear whether this pattern represents an individual, isolated act or a recurring practice within a broader cultural or regional funerary tradition. Notably, the urn from Markranstädt displays strong stylistic affinities with the late Lusatian Culture of Middle Saxony. However, the absence of accompanying vessels is atypical for the burial customs of that period and region, which are generally characterised by more complex graves. Conversely, the presence of large stones aligns more closely with the funerary practices of western groups, such as the Saalemündung group in Saxony-Anhalt. Meanwhile, the size and arrangement of cremated bone deposits bear resemblance to customs commonly observed in numerous Early Iron Age cemeteries. Consequently, the Markranstädt grave appears to embody influences from multiple funeral traditions of the surrounding regions.

CONCLUSION

The cremation burial from Markranstädt provides a highly significant and complex case within the archaeological context of the Late Bronze Age and Early Iron Age in Northwestern Saxony. The stone arrangement, potentially indicating the presence of a former barrow or other grave constructions that have since eroded or been destroyed, together with the burial's spatial situation, raises questions about the broader context of the grave, which may in fact be part of a larger, yet undiscovered, cemetery. Based on osteological analysis, archaeological and taphonomic observations, several key aspects emerge that offer valuable insights into burial customs and the social context surrounding the deceased individual.

The biological age estimation of the deceased placed it between 30 and 40 years of age at the time of death, along with the reconstructed relatively high stature. The absence of pathological changes further supports the notion of a probably healthy person, though the distinctiveness of the burial may reflect a special status or role within the community.

One of the most striking features of this burial is the low degree of fragmentation in the cremated remains and their spatial arrangement in the urn. This trait sets the Markranstädt burial apart from most other Late Bronze Age graves, despite the typochronological assignment of the urn to the Late Bronze Age context. The relatively large size of the bone fragments is observed at many Early Iron Age cemeteries. This suggests that Grave 1 may represent a transitional funerary tradition in which cremated remains were deposited within an urn resembling late Lusatian Culture style, while the combusted remains themselves were already being treated in an Early Iron Age manner, though a highly structured and intentional process.

In that sense, the burial at Markranstädt provides significant evidence of the complexity of funerary practices during the transition from the Late Bronze Age to the Early Iron Age. It could illustrate the symbolic transformation of the deceased into an ancestor, as described by van Gennep's concept of *Les Rites de Passage* (1909). The deliberate selection and arrangement of bones, along with the broader stylistic context of the grave vessels, suggest that the burial of this possibly male individual from Markranstädt was part of a ritualised act aimed at ensuring a successful passage into the ancestral realm and further enhancing cohesion of the local community. In this regard, the present study contributes to a deeper understanding of at least one funerary practice in Northwestern Saxony in the Late Bronze Age / Early Iron Age. It highlights the region's cultural or group-specific diversity during this transitional period.

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HOARDED ASSEMBLAGES FROM THE BRONZE AGE AND EARLY IRON AGE BETWEEN THE VISTULA AND THE BUG: STATE OF RESEARCH

ABSTRACT

Taras H. 2025. Hoarded assemblages from the Bronze Age and Early Iron Age between the Vistula and the Bug: state of research. *Sprawozdania Archeologiczne* 77/1, 53-73.

The paper summarises the state of knowledge on hoarded assemblages in central-eastern Poland, covering various research aspects, including the state of laboratory investigation of these assemblages. The reasons for the relatively small number of finds of this type between the Vistula and Bug rivers are analysed, as well as the nature of individual hoards (reasons for deposition), the composition of their assemblage, and chronology. The provenance of metal objects composing the individual hoards, within narrower chronological ranges, is also discussed.

Keywords: Hoards, Bronze Age, Early Iron Age, central-eastern Poland
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1. INTRODUCTION

A review of previous publications devoted to hoards from the metal ages on the territory of Poland emphatically shows that, compared to other regions, in the central-eastern zone (just like in the north-eastern zone), there are significantly fewer finds of this type (see Nosek 1957; Kostrzewski 1964; Blajer 1990; 1999; 2001; 2013; Kłosińska 2010). The

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maps compiled for monographic studies published up to 2013 reveal only 16 hoards of metal objects dated from the Bronze Age to the Early Iron Age, with most of these finds already relating to the Early Iron Age, while two have no established chronology (Nosek 1957, 270, 283; Blajer 2001, 372). This disproportion in comparison to other regions of Poland, especially in the younger phases of the Bronze Age, is particularly incomprehensible, considering the number of metal artefacts revealed so far, mainly as isolated finds, including weapons, tools and ornaments of various provenance (*e.g.*, Kłosińska 2016; 2017; Kłosińska and Sadowski 2017; Taras 2019).

The beginnings of the discovery of such assemblages date to the second half of the 19th century. Deposits were then acquired at Niewiadoma, Sokołów Podlaski District (Nosek 1957, 279; 1960; Węgrzynowicz 1973, 118; Blajer 2001, 364), Skwarne, Mińsk Mazowiecki District (Kostrzewski 1964, 26, 27, 116, pl. 2: 45; Blajer 2001, 366; Kłosińska 2013b) and Wożuczyn, Tomaszów District (Żurowski 1927, 52, 55-56, 59, note 17; Nosek 1957, 279, 280; Kostrzewski 1964, 78-80, fig. 106; Blajer 2001, 369; Kłosińska 2010, 23, photo 7). Further finds, already from the first half of the 20th century, come from Bondyrz, Zamość District (unspecified hoard of bronze objects – Nosek 1957, 283, 285), Góra, Legionowo District (Nosek 1957, 280; Kostrzewski 1964; Blajer 2001, 337), Kiełczew, Ostrów Mazowiecka District (Pasternak 1938; Kostrzewski 1964, 39; Blajer 2001, 361), Hrubieszów, Hrubieszów District (Cichoszewska 1922-1924; Żurowski 1948, 163, 164, *item* 28; Kostrzewski 1964, 34); Proszew, Węgrów District (Kostrzewski 1964, 54; Blajer 2001, 365), Zagłoba-Dratów, Opole Lubelskie District (Gardawski and Wesołowski 1956; Kostrzewski 1964, 32; Blajer 1999, 160, 161), and from Zemborzyce, Lublin District (Gurba 1961; Kostrzewski 1964, 81; Blajer 2001, 370). In the second half of the 20th century, the quantity of data on hoards was enlarged by the assemblages from Wakijów, Tomaszów Lubelski District (Nosek 1957, 279), Kisielsk, Łuków District (Kostrzewski 1964, 39, 40; Blajer 2001, 361, *item* 66), Liszki, Sokołów Podlaski District (Głosik 1993, 218, *item* 41; Blajer 2001, 262), Rzeszotków, Siedlce District (Miśkiewicz 1962; Kostrzewski 1964, 63-65; Blajer 2001, 366), Radecznica, Zamość District (Kłosińska *et al.* 2005) and Warszawa-Zacisze, Warszawa Capital District (Głosik 1983, 255, 256, *item* 135; Blajer 2001, 368; Orlińska 2016).

All discoveries of hoarded assemblages, past and present, are accidental in nature. At the end of the last century and the present one, to a large extent, such finds have been revealed as a result of deliberate searches by amateur detectorists. Most contemporary discoveries come from the south-eastern part of the Lublin region. This group includes finds from the Zamość District – from Deszkowice II (Kuśnierz 1998b; Kuśnierz and Urbański 1998), Szczebrzeszyn (Kuśnierz 2006; 2007; Nosek and Stępiński 2007), 'by the Sieniocha River' ('znad Sieniochy') (Kłosińska and Sadowski 2017) and two deposits from Śniatycze (Kłosińska 2008; Kłosińska and Sadowski 2017), from the Hrubieszów District – from Gródek 1C (Panasiewicz and Taras 2007), Kułakowice II (unpublished, mentioned – Kłosińska 2016, 158, fig. 3), as well as from Podbiel, Otwock District (Narożna-Szamałek 2013; Kurzawska 2013), and Bużyska, Siedlce District (Mogielnicka-Urban 2008, 218).

At the end of the 1990s, another deposit came to the Regional Museum in Biłgoraj. It originated from Majdan Gromadzki in the Biłgoraj District. In this case, however, the find has a precise location. It had been deposited in a small ground recess near a 'pond', which no longer exists but is marked on maps from the 19th century.

In recent years, information has come to light about another hoard from Biłgoraj District, from Czernięcin Poduchowny, dated to the HD, also with a precise location. This deposit includes only ornaments, especially large rings (https://muzeumbilgoraj.pl/skarb-z-czerniecina-poduchownego/; https://archeologia.com.pl/skarb-brazowych-ozdob-sprzed-25-tys-lat-odkryty-na- lubelszczyznie). The hoard is currently being studied by a team of researchers that, in addition to archaeologists, includes representatives from the natural and exact sciences.

Elżbieta M. Kłosińska is currently working on three hoards, excavated by amateur artefact hunters in Opole Lubelskie District, in the settlements of Adelina, Budzyń, and Trzciniec, as well as the deposit from Stara Róża in Łuków District. All these assemblages contain only ornaments, including large rings.

Deposits of non-metallic objects should be added to the collection of hoarded assemblages. These include two alleged Early Bronze Age flint axe deposits from Krasiczyn-Wojciechów, Lublin District (Libera 2003, 45-47, figs 4 and 5) and Złojec, Zamość District (Libera 2003, 45, 46, figs 1-3), as well as one deposit of crescent-shaped flint sickles from Parczew, Parczew District (Żółkowski 1988; Libera 2001, 63). Moreover, it is worth mentioning a unique find of around 1000 faience beads from Horodysko, Chełm District, deposited, together with a copper ornament, *i.e.*, a pendant, and a fragment of another one, *i.e.*, a disc, in a vessel of the Strzyżów culture (Ślusarski 1970; Robinson *et al.* 2004, 84, 104-106), as well as a cache find of 'Lusatian' pottery vessels of a ceremonial nature from Huszczka Duża, Zamość District (Gajewski 1984).

2. ANALYSIS OF CLUSTER FINDS

At present, 38 hoards, *i.e.*, assemblages consisting of at least two objects and apparently deliberately deposited at one place and time, are known from central-eastern Poland (Figs 1 and 2). They include 33 metal assemblages, where metal objects are the primary component (Table 1), and five other deposits (Table 2). It should be mentioned here that with regard to five deposits from the territory in question and dated to the Early Iron Age, doubts have been voiced as to the validity of such a classification of the finds. These included Wakijów (a human sacrifice drowned in a swamp together with ornaments?; Nosek 1957, 279), Wożuczyn (ring ornaments from a barrow?; Żurowski 1927, note 117; Nosek 1957, 279, 280), Radecznica (grave?; Kłosińska *et al.* 2005, 222, 228), Zemborzyce (grave?; Gurba 1961, 105), and Warszawa-Zacisze (grave?; Głosik 1983, 255, 256). Nowadays, as in the past, it is impossible to verify these opinions.

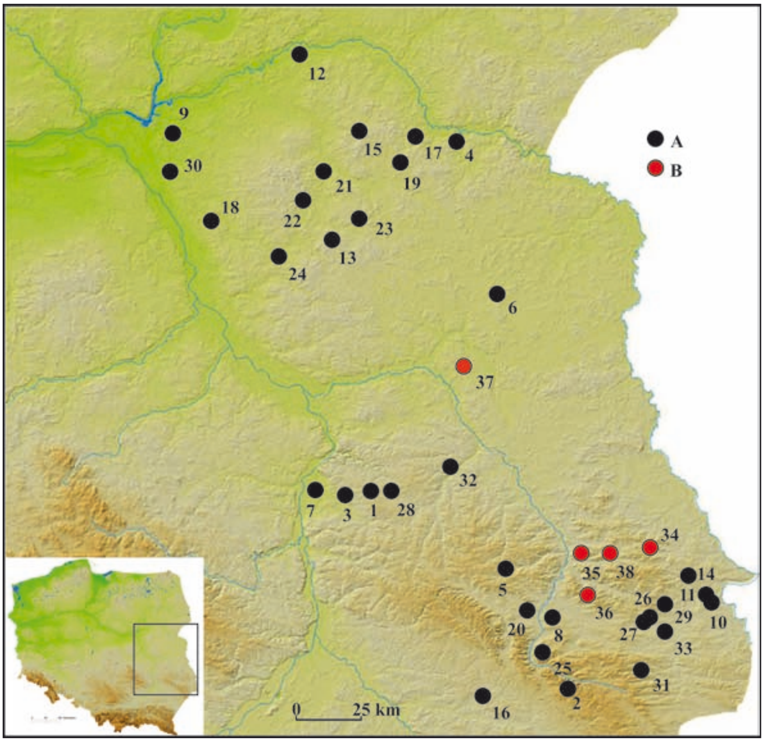

Fig. 1. Location of Bronze Age and Early Iron Age hoards in the area between the Vistula and Bug rivers: A – hoards of metal and mixed objects (predominantly metal); B – hoards of non-metal objects (base map by L. Gawrysiak 2011). The numbering of points on the map is consistent with the numbering in Tables 1 and 2

Apart from detailed classification studies, only a few of the published deposits have undergone fundamental analyses of their chemical composition. They include Zagłoba-Dratów (Gardawski and Wesołowski 1956, 66, 67), Gródek (Panasiewicz and Taras 2007, table 1), Deszkowice II (Kuśnierz 1998b, 47), Śniatycze – two hoards (Kłosińska 2008, 266-272; Kłosińska *et al*. 2017, 65-70), Radecznica (Kłosińska *et al*. 2005, 221-224), Szczebrzeszyn (Nosek and Stempiński 2007), Kułakowice II (unpublished), and Czernięcin Poduchowny (unpublished). Thus, there is an excellent capacity for improvement in this regard, all the more so as the current standards of research procedures for this type of finds far exceed the former requirements (see *e.g*., Bayley *et al*. 2008; Garbacz-Klempka 2018). This can be well exemplified by the long series of well-published hoards, including those from Polish territory (*e.g*., Rząska and Walenta eds 2017; Baron *et al*. 2019; Kaczmarek *et al*. 2021; Blajer *et al*. 2022; Szczurek and Kaczmarek 2022). Archaeometric analyses have been conducted, to some extent, for the deposits from Gródek and Czernięcin Poduchowny. Nevertheless, it is in this area that the hoards from central-eastern Poland need special attention.

Nature of the objects, composition of the hoards

The absolute majority of deposits, comprising exclusively metal and mixed objects, *i.e.*, 23, contain only ornaments, with the number ranging from two to over 100 items (Table 1). The largest hoards, in terms of numbers, are the mixed hoard of bronze ornaments, glass beads and Cypraeidae shells from Podbiel, and the hoard of scrap bronze ornaments from Kułakowice II. It should also be noted that most metal hoards contain 'large bronzes', in this case, a variety of ring ornaments for the neck and/or limbs, and less frequently, large disc-shaped ornaments. The latter, being the main component of two deposits from the Chodel Depression, namely from Adelina and Trzciniec, also appeared within other assemblages (Budzyń, Majdan Gromadzki). There are several deposits of ornaments, among which more than three categories of products have been identified. This applies to the entire period discussed, *i.e.*, both the Bronze Age and the Early Iron Age.

Only five hoard assemblages from the area between the Vistula and Bug rivers were of a different nature. In one case (Śniatycze, Site 89), these elements were part of a harness, and in three cases (Hrubieszów, Śniatycze, Site 94, and Bużyska), they consisted of tools. The assemblage from Szczebrzeszyn proved to be the most diverse in terms of its composition, as it included a wide range of items, such as weapons, tools, ornaments, and harness elements.

Hoards containing bronze raw material, either in the form of raw material bars or scrap metal from various products, mainly ornaments, are among the rare finds in central-eastern Poland. Such assemblages are known from Kułakowice II, as well as Kisielsk, where, apart from undamaged objects, including, *e.g.*, a neck ring, Stanomino-type leg rings, and glass beads, there are deformed multi-scroll ornaments, fragments of tutuli, and wire. Another one was found in Proszew, where, apart from ornaments, there were also pieces of wire. However, the most interesting hoard assemblage of this type originates from the site identified as 'by the Sieniocha River', which indicates a connection with a metalworking workshop. In addition to the raw material (scrap metal and bronze bars), it includes one half of a bronze casting mould for the production of socketed axes. It is the only object of this type known from this area, with distant stylistic references (Kłosińska and Sadowski 2017, 401).

Presumably, in most cases, the deposits were stashed in various containers. Most commonly, these were pottery vessels, mentioned in the case of seven hoards from the area under investigation, *i.e.*, Bużyska, Gródek, Hrubieszów, Kiełczew, Kisielsk, Liszki (?), and Niewiadoma (?). The situation could have been different in the case of assemblages deposited in water, although even this does not necessarily rule out such a procedure (see Śniatycze, Site 94; Kłosińska *et al.* 2017, 54).

More difficult to ascertain is the use of various organic containers, such as wooden boxes (assemblage from Proszew), leather or fur wrappers, or textiles. In the case of the hoard from 'by the Sieniocha River', the set of objects composing it was wrapped tightly in

Table 1. Hoards of metal and mixed objects (predominantly metal) from the Bronze Age and Early Iron Age in the area between the Vistula and Bug rivers. Legend: LB – large bronzes – Objects requiring large amounts of raw material for production (here: particularly large ring ornaments, large discs, and socketed axes); A – amber (amber beads); G – glass (glass beads); I – iron; P – pots (pottery vessels – hoard deposited inside a pottery vessel); Q – quartz (beads); S – shell (beads); BCM – bronze casting mould; BR – bronze raw material; BS – bronze scrap; CW – wooden container (hoard deposited inside a wooden cover); OOP – other organic packaging

No.	Locality	Bronze/copper objects				Other	Nature of the deposit			Chronology	Selected bibliography
		ornaments	tools	weapons	Harness		ritual	'merchant'/ metalsmith	unspecified		
1	**Adelina**, Opole Lubelskie District; **LB**	X (?)	–	–	–	–	–	–	X	IV-V EB	Unpublished – information: E. M. Kłosińska
2	**Bondyrz** – thereabouts, Zamość District	?	?	?	?	?	X?	–	–	?	Nosek 1957, 283; Blajer 2001, 372
3	**Budzyń**, Opole District; **LB**	X (?)	–	–	–	–	–	–	X	?	Unpublished – in development E. M. Kłosińska
4	**Bużyska**, Siedlce District; **LB**	X (10)	–	–	–	P (1), I (axe)	–	–	X	HD	Unpublished – mentioned: Mogielnicka-Urban 2008, 218
5	**Czernięcin Poduchowny**, Biłgoraj District; **LB**	X (14)	–	–	–	–	–	–	X	HD	https://muzeumbilgoraj.pl/skarb-z-czerniecina-poduchownego/*Archeologia Żywa* 3 (89) 2023 https://archeologia.com.pl/skarb-brazowych-ozdob-sprzed-25-tys-lat-odkryty-na-lubelszczyznie/
6	**Derewiczna**, Radzyń Podlaski District; **LB**	X (6)	–	–	–	–	–	–	X	HC-HD	Nosek 1957, 277; Kostrzewski 1964; Węgrzynowicz 1973; Blajer 2001, 370
7	Zagłoba-**Dratów**, Opole Lubelskie District; **LB**	X (23)	–	–	–	–	X?	–	–	BD	Gardawski and Wesołowski 1956; Blajer 1999, 160-161; 2001, 324; Kłosińska 2010, 23-24, photo 1-2, fig. 2
8	**Deszkowice II**, Zamość District; **LB**	X (14)	–	–	–	–	–	–	X	HD	Kuśnierz 1998; Kuśnierz and Urbański 1998; Blajer 2001, 359; Kłosińska 2010, 24, 33, photo 6, fig. 10
9	**Góra**, Legionowo District	X (2)	–	–	–	–	X	–	–	BB2-HA2	Nosek 1957, 280; Kostrzewski 1964; Blajer 2001, 337

10	**Gródek**, Hrubieszów District	X (6)	–	–	–	P (1), S (1), A (1)	–	–	X	BC/BD-BD	Panasiewicz and Taras 2007; Taras 2007, 101-102, photo 7; Kłosińska 2010, 25, photo 3, fig. 4
11	**Hrubieszów** – thereabouts, Hrubieszów District; **LB**	?	X (2+?)	?	?	P (1)	–	–	X	HB1	Cichoszewska 1922-1924; Żurowski 1949, 163-164, *item* 28; Nosek 1957, 276, fig. 36; Blajer 2001, 338; Blajer 2013, 134; Gedl 1995; Kłosińska 2010, 23
12	**Kiełczew**, Ostrów Mazowiecka District; **LB**	X (6)	–	–	–	P (1)	–	X?	X	HD	Pasternak 1938; Kostrzewski 1964, 39; Blajer 2001, 361
13	**Kisielsk**, Łuków District; **LB**	X (>20)	–	–	–	P (1), BS G (39)	–	X?	–	HD	Kostrzewski 1964, 39-40; Blajer 2001, 361, *item* 66
14	**Kułakowice II**, Hrubieszów District	X (>126)	–	–	–	BS	–	X	X	HA1	Unpublished – mentioned: Kłosińska 2016, 158, fig. 3
15	**Liszki**, Sokołów Podlaski District; **LB**	X– 2 (+?)	–	–	–	P?	–	–	X	HD	Głosik 1993, 218; Blajer 2001, 362
16	**Majdan Gromadzki**, Biłgoraj District; **LB**	X (4)	–	–	–	–	X?	–	–	HB1	Unpublished – information: K. Grochecki
17	**Niewiadoma**, Sokołów Podlaski District**; LB**	X (10)	–	–	–	P?	–	–	X	HD	Nosek 1957, 279; 1960; Węgrzynowicz 1973, 118; Blajer 2001, 364
18	**Podbiel**, Otwock District; **LB**	X (>600)	–	–	–	G (> 200), I (1), A (1), Q (>147), S (168), BS	–	X	–	HC-HD	Narożna-Szamałek 2013; Kurzawska 2013
19	**Proszew**, Węgrów District; **LB**	X (2 +?)	–	–	–	CW	–	–	X	HD	Kostrzewski 1964, 54; Blajer 2001, 365
20	**Radecznica**, Zamość District; **LB**	X (2)	–	–	–	–	–	–	X	HD	Kłosińska *et al.* 2005
21	**Rzeszotków**, Siedlce District, **LB**	X (4+?)	–	–	–	G (16+?)	X?	–	–	HD	Miśkiewicz 1962; Kostrzewski 1964, 63-65; Blajer 2001, 366
22	**Skwarne**, Mińsk Mazowiecki District; **LB**	X (4 +?)	–	–	–	–	–	–	X	HD	Kostrzewski 1964, 26, 27, 116, plate 2: 45; Blajer 2001, 366; Kłosińska 2013b

Table 1

No.	Locality	Bronze/copper objects				Other	Nature of the deposit			Chronology	Selected bibliography
		ornaments	tools	weapons	Harness		ritual	'merchant'/ metalsmith	unspecified		
24	**Sulbiny** (?), Garwolin District	X (?)	–	–	–	–	–	–	X	?	Nosek 1957, 270; Blajer 2001, 372
25	**Szczebrzeszyn**, Zamość District; **LB**	X (5)	X (1)	X (4)	X (4)	OOP?	–	X?	–	HB3-HC	Kuśnierz 2006; 2007; Nosek and Stępiński 2007; Kłosińska 2010, 24-25, 28, 30, photo 4, fig. 6-8
26	**Śniatycze, stan. 89**, Zamość District	–	–	–	X (12)	OOP?	–	X	–	HA1-HA2 (earlier HB3)	Kłosińska 2008; 2010, 25, photo 5; Kłosińska and Sadowski 2017, 396-397
27	**Śniatycze, stan. 94**, Zamość District	–	X (3)	–	–	OOP?	X?	–	–	HA2-HB1	Kłosińska and Sadowski 2017, 397-398; Kłosińska *et al*. 2017
28	**Trzciniec**, Opole Lubelskie District; **LB**	X (?)	–	–	–	–	–	–	–	HA2-HB1	Unpublished – information: E. M. Kłosińska
29	**Wakijów**, Tomaszów Lubelski District; L**B**	X (5)	–	–	–	–	X?	–	–	HD	Poklewski 1954; Nosek 1957, 279, fig. 41-44; Blajer 2001, 368; Kłosińska 2010, 34, photo 8, fig. 11
30	**Warszawa-Zacisze**, Warsaw Capital District; **LB**	X (2)	–	–	–	–	X?	–	–	HD	Głosik 1983, 255-256, *item* 135; Blajer 2001, 368; Orlińska 2016
31	**Wożuczyn**, Tomaszów Lubelski District; **LB** .	X (5)	–	–	–	–	X?	–	–	HD	Żurowski 1927, 52, 55, 59; Nosek 1957, 279-280; Kostrzewski 1964 78-80, fig. 106; Blajer 2001, 369; Kłosińska 2010, 23, photo 7
32	**Zemborzyce**, Lublin District; **LB**	X (2)	–	–	–	–	–	–	X	HD	Gurba 1961; Kostrzewski 1964, 81; Blajer 2001, 370
33	by the Sieniocha River (**Znad Sieniochy**), Zamość District; **LB**	X (2)	X	–	–	OOP, BR (2), BCM (1)	–	X	–	HB2-HB3	Kłosińska 2016, 155, fig. 4; Kłosińska and Sadowski 2017

a piece of fur and additionally tied with a string; fragments of organic material were preserved in the patina (Kłosińska *et al.* 2017, 400). The compact arrangement of individual objects sometimes suggests the organic wrapping of the deposit. This is evident in the case of both hoards from Śniatycze, specifically the elements of harness from Site 89 (Kłosińska 2008, 266; 2010, 32) and the hoard of sickles found at Site 94 (Kłosińska *et al.* 2017, 54; Kłosińska and Sadowski 2017, 397). The brown-black patina on the sickles further suggests that they were deposited in a wet environment. Finds of organic, *i.e.*, wooden and leather, cases are scarce, albeit recorded under specific environmental conditions (*e.g.*, Szczurek and Kaczmarek 2022, 137).

It cannot be ruled out that an unspecified wrapping originally surrounded the objects from Szczebrzeszyn, which, 'according to the explorers' accounts (...), lay at a depth of about 15-20 cm forming a compact pile' (Kuśnierz 2006, 215).

The function of the deposits

It is most challenging for researchers to determine, as reliably as possible, the function of the hoards and to explain the reasons for their deposition under specific conditions. This issue has an impressive literature, and the opinions stated vary and may depend on many factors, *e.g.*, the specifics of individual regions, different methodological approaches, and the individual predispositions of the researchers themselves (*e.g.*, Dąbrowski 1979, 300; Rowlands 1984; Bradley 1990; Ostoja-Zagórski 1992; Bukowski 1998, 255-261; Kristiansen 1998, 73-85; Harding 2000, 352-368; Blajer 2001, 25-28; 2010).

In addition to political reasons (social unrest) and economic reasons (hoarding of goods, hoards of so-called 'pre-monetary currency'), the presence of hoards was also explained by the activities of specific 'professional' groups – craftsmen or merchants (hoards on communication routes, deposits of raw material). For a long time, such finds have been viewed primarily in an ideological context, within the realm of spiritual culture, specifically as offerings to deities or the deceased. In these cases, the particular conditions of artefact deposition, especially in aquatic environments, as well as in elevated spots and other locations, are taken into account as arguments. The composition of the hoards and the arrangement of individual objects may also support this ritual interpretation.

The phenomenon of hoard deposition has also been viewed in a sociological context, as prestige competition, where individuals dispose of valuable objects to demonstrate their high social position. More recently, it has been examined in a settlement and cultural context (Maciejewski 2016). In the latter, the places where metal objects were deposited had been chosen according to the 'cultural norms' recognised by a given community and 'were elements of the settlement network' (Maciejewski 2016, 78). Such a perception of hoards presupposes the selection of a deposition site by recognising the relationship between the concepts of 'metal' and the 'boundary' of the known world.

Only concerning some of the deposits from central-eastern Poland, it is possible, based on their composition and location, to attempt to determine their function. A few of them are located along communication routes, so it can be assumed that they were hidden with the intention of recovering them later. This may be the case with the deposit from Szczebrzeszyn, located in a dry place on the edge of the loess plateau above the Wieprz valley (Kuśnierz 2006, 215), the one from Kiełczew, found on the bank of the Bug river (Pasternak 1938, 287), as well as the one from Podbiel, hidden on the Vistula river route (Narożna-Szamałek 2013, 210). The hoards containing raw materials (bars and scrap), *i.e.*, material intended to be melted down, could also represent caches that had been deposited temporarily. Such a type of deposit is exemplified by the large cache from Kułakowice II, Kisielsk, and possibly also the set of finds from 'by the Sieniocha River' which was hidden near a small cluster of Lusatian culture sites (Kłosińska and Sadowski 2017, 400). It should also be noted that in this area, sections of routes leading from the Dniestr region in a north-western direction intersected with routes running from the west and south-west to the east (see Kośko and Klochko 2009; Czopek 2011; Taras 2016 – for an extensive literature review).

The hoard of faience beads from Horodysko is also interpreted as a 'merchant' deposit (Robinson *et al.* 2004, 104-106).

The set of some elements of a horse harness from Site 89 at Śniatycze may have been hidden only ad hoc, although in this case a ritual sacrifice cannot be ruled out either, as the deposit was located on a small hill near a river 'and it should not be ruled out that this place was originally adjacent to a body of water of some sort, or was surrounded by wetlands' (Kłosińska and Sadowski 2017, 397). In a similar terrain configuration, namely, on a sandy hill in the middle of what was once a marshy depression, the hoard from Warsaw-Zacisze was hidden (Głosik 1983, 255, 256), as were the bronze ornaments from Wożuczyn ('in a barrow'). This may indicate both their sacrificial nature and the intention to recover the valuable objects, which were placed in a location that was easy to remember.

The unusual composition of the deposit from Zagłoba-Dratów, *i.e.*, a large quantity of raw material, large ring ornaments, and especially the presence of a tall diadem with solar symbols, as well as the location of this assemblage, may point to its ritual connotation. However, other interpretations of this find have also been proposed (Kłosińska 2010, 27).

The finds from wet environments, in our case the set of ornaments from Wakijów (deposited in the peat in the Huczwa river valley), as well as the second hoard from Śniatycze, Site 94 (consisting of sickles arranged peculiarly, wrapped with unspecified organic material and deposited within the Sieniocha river valley), most likely are of a sacrificial nature. The circumstances of the discovery of the hoard from Bondyrz, viz., during the drainage of meadows in the Wieprz valley (Nosek 1957, 283), may indicate that it was a sacrificial deposit. The ornaments from Rzeszotków (Blajer 2001, 366) and Góra (Nosek 1957, 280) were also deposited in a wet environment, namely peat meadows. Most likely, the find from Majdan Gromadzki, where metal objects were deposited in a slight depression of land that used to be a natural water reservoir, still marked on 19th-century maps, should also be included among the deposits originating from a wet environment (Heldensfeld 1801-1804, sheet 179).

An analogous deposit, although not containing metal, is the set of two small pottery vessels from Huszczka Duża, found in a swampy depression, a former small lake, connected with the Wolica River (Gajewski 1981, 241).

Provenance of the bronze objects and chronology of the hoards (Fig. 2)

Analysis of the bronze objects constituting the hoards from the area between the Vistula and Bug rivers shows a diversity of provenance. At the same time, the variety of bronze-working traditions partly coincides with the chronology of the deposits.

In the discussed area of central-eastern Poland, there is a complete absence of hoards of bronze objects dating to the Early Bronze Age. However, a highly original deposit of faience beads, enriched with small copper objects, was discovered in Horodysko, Chełm District. It had been deposited in a vessel of the Strzyżów culture. This deposit is unlike any other, and grouped finds of metal or flint objects are scarce within this cultural circle (Sveshnikov 1974, 128; 1990, 70).

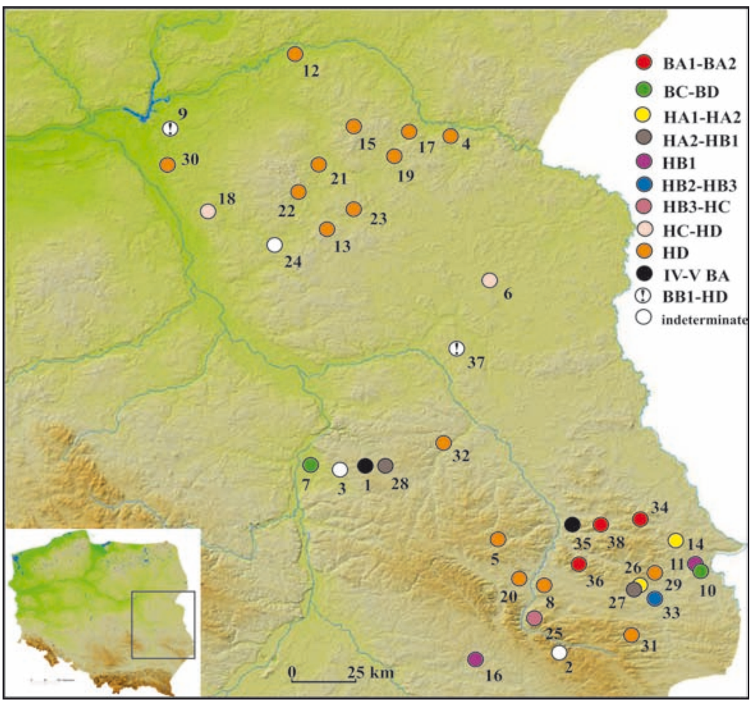

Fig. 2. Chronology of Bronze Age and Early Iron Age hoards in the area between the Vistula and Bug rivers (base map by L. Gawrysiak 2011). The numbering of points on the map is consistent with the numbering in Tables 1 and 2

Table 2. Hoards of non-metal objects from the Bronze Age and Early Iron Age in the area between the Vistula and Bug rivers

No.	Locality	Faience	Flint			stone	Copper ornaments	pottery	nature		Chronology	Selected bibliography
			axes	sickles	Projectile points				ritual	unspecified		
34	**Horodysko**, Chełm District	F (> 1000)	–	–	–	–	X (2)	X (1)	–	X	BA2	Ślusarski 1970; Robinson *et al*. 2004, 84, 104-106
35	**Huszczka Duża**, Zamość District	–	–	–	–	–	–	X (2+?)	X	–	IV-V EB	Gajewski 1984 (miniature pottery vessels)
36	**Krasiczyn-Wojciechów**, Lublin District	–	X (3 +?0	–	?	?	–	–	–	X	B A 1 - BA2	Libera 2003, 45-46, 47, fig. 4-5
37	**Parczew**, Parczew District	–	–	X (8)	–	–	–	–	–	**X**	BB1-HD	Żółkowski 1988; Libera 2001, 63
38	**Złojec**, Zamość District	–	X (3)	–	–	–	–	–	–	X	B A 1 - BA2	Libera 2003, 45-46, fig. 1-3

Two deposits of flint axes (Table 2) from Krasiczyn-Wojciechów, Lublin District, and Złojec, Zamość District, probably also date to the Early Bronze Age. The third deposit of flint objects from the discussed area, viz. the deposit of flint sickles from Parczew, does not have such a clear affiliation, as crescent-shaped sickles are typical of the Trzciniec and Lusatian cultures, and in the Polish lands such finds occur over a long period of time, from the Early Bronze Age to the Early Iron Age (Libera 2001, 119, 120 and fig. 39).

The two oldest hoards of bronze objects in the area between the Vistula and the Bug rivers are correlated with the final phase of the Trzciniec culture, and are dated to the Bronze Age (phases C/D-D) at the earliest. The first of these, from Gródek, does not stylistically indicate a clear source of origin. Spiral ornaments of this type have a wide territorial and chronological range. The earliest ones are known from the Eneolithic (Adamczak *et al.* 2015; Kowalski *et al.* 2019). During the Bronze Age, they are commonly found on both sides of the Carpathian Mountains in a variety of cultural settings, especially in the Tumulus and Urnfield cultures (Mozsolics 1973, 53, 54, Taf. 50: 22; 51: 12; 76: 17; Blajer 1999, 92-94). In the case of the hoard from Gródek, the atypical chemical composition for that time is noteworthy, namely copper with a small admixture of arsenic and trace amounts of other metals and non-metals. In this context, it cannot be ruled out that older, Eneolithic, ornaments were redeposited in the Bronze Age vessel. The rich hoard from Zagłoba-Dratów represents a continuation of the metallurgical traditions of the Barrow cultures in the Trzciniec culture environment (Blajer and Szpunar 1982, 312; Blajer 1984, 48; 1999, 118-119).

The next phase of hoard deposition in the area falls within the HA1-HB1. Three assemblages mark this stage. The first of them, the most numerous and also the oldest, is the deposit of bronze scrap from Kułakowice II. It contains, among other things, a ring-shaped ornament, which (especially in terms of its ornamentation), recalls the Sieniawa-type products of the Tarnobrzeg Lusatian culture, dated to the BD/HA1-HA1 period (Blajer 1999, 124, 125). In the Lublin area, a similar ornament (isolated find) appeared in Modryniec (Kokowski 1993). A hoard of knobbed sickles from Śniatycze, Site 94, is slightly later and dated to the HA2-HB1 (Kłosińska and Sadowski 2017, 397, 398; Kłosińska *et al.* 2017). Elżbieta M. Kłosińska has recently verified the dating of a second hoard from Śniatycze, Site 89, containing elements of a horse harness. She now links his assemblage, initially dated to HB3 (2008, 290), with the impacts from the Carpathian Basin during the HA2-HB1 (Kłosińska and Sadowski 2017, 397). It should be noted that the original dating proposal has already been accepted by other researchers (*cf.*, Blajer *et al.* 2022, 52-58).

The deposits from Trzciniec and Majdan Gromadzki are most probably associated with the same chronological interval. The hoard from Trzciniec (and possibly also from Adelina – both unpublished – I owe the information to E. M. Kłosińska) contained, among other things, belt fittings consisting of large repoussé discs. The hoard from Majdan Gromadzki, also unpublished, contained six objects: two undecorated ring-shaped ornaments (a massive neck-ring made from a round-section rod with hammered ends bent into loops, and an open ring – either a neck-ring or a leg-ring – with tapered terminals); three undecorated discs or bosses with single loops; and an undecorated socketed axe, similar to variant K of Przedmieście type (Kuśnierz 1998a, 40, 41, figs 14 and 15). This assemblage can be seen as chronologically inconsistent, as the neck-ring represents an archaic type in the context of discs/bosses, and especially in the context of the socketed axe, which can be dated to the HB1 at the earliest (Blajer 2001, 82, 83). Nevertheless, such neck ornaments, although characteristic of the Early Bronze Age episode, still appear in the Bronze Age phases B1-B2, and are exceptionally mentioned even in later hoards (see Szafrański 1955, pl. 13; Durczewski 1961, 33, 34; Blajer 1990, 40, 41). The undecorated, slightly conical discs with single loops are dated mainly within Bronze Age phase C – HA2 (Blajer 1999, 98, 99), although they are also found later, in HA2-HB1 (Blajer 2013, 74, 75). The youngest element in this assemblage is therefore the axe, which may date this entire assemblage to the HB1. The hoard from the Hrubieszów area is dated similarly (Blajer 2001, 338). Most of the objects from the deposits mentioned here are referenced in both the Lusatian Urnfield milieu (discs, sickles) and the Danubian zone (especially the axe, but also the sickles and discs) (Blajer 1999, *passim*; 2001, *passim*; 2013, *passim*).

The hoard from 'by the Sieniocha River' should be dated to the Late Bronze Age period (HB2-HB3). It is a peculiar find also due to the origin of the bronze casting mould (Kłosińska 2026, 158; Kłosińska and Sadowski 2017, 400), which is presumably an import from the Volga-Kama zone or central Sweden.

Jerzy Kuśnierz (2006, 220; 2007, 383) associates a multi-element hoard of ornaments, tools, weapons, and horse harness from Szczebrzeszyn with the beginning of the Iron Age (HC). According to Elżbieta M. Kłosińska (2010, 30), however, this hoard may be older and still correlate with the final phase of the Bronze Age, *i.e.*, HB3. According to the latter researcher, the controversy is also aroused by the incorrect, in her opinion, classification of some elements of this deposit (*ibid.*). It should be noted that this morphologically diverse composition is equally complex in terms of the origin of the individual objects, which find analogies in both the environment of the Lusatian Urnfield culture and in the North, specifically in the Baltic milieu, as well as in the Carpathian Basin and western Ukraine. The eastern direction of the influx of bronzes, especially weapons and elements of the horse harness, of Thraco-Cimmerian, and later Scythian origin (Chochorowski 1993; 1999; Kłosińska and Sadowski 2017, 398-400), coincides at this time with a new political situation caused by the pressure from nomads from the Pontic steppes. At this time, in the Lublin region (Kłosińska 2007; 2013a), as well as along the Middle San and Wisłok rivers (*e.g.*, Czopek 2008; 2019; Trybała-Zawiślak 2019, *passim*), a peculiar cultural change is observed. It is evident in the artefact inventories, the settlement model, funerary rites, and the intensification of hoarding during the HD period.

Seventeen hoards are associated with this period, *i.e.*, the HD, representing approximately half of all known deposits from the area between the Vistula and Bug rivers. This group includes exclusively deposits of ornaments, most of which were produced in the metallurgical workshops of the western territorial groups of the Lusatian Urnfield culture. Only in one hoard, from Bużyska, ornaments were accompanied by a socketed axe (Mogielnicka-Urban 2008, 218). In the group of ornaments, large ring-shaped ornaments (twisted neck-rings, leg-rings and arm-rings) are notable, found, for example, in Radecznica, Deszkowice, Zemborzyce, and other localities. With the quantitative decline of metal imports from the south at that time, the deposit from Wakijów is a good example of bronzes with such provenance, as it is associated with the Hallstatt cultural milieu. In the Early Iron Age, the majority of metal objects flowed into this region of Poland from workshops in Greater Poland and Kuyavia (*e.g.*, leg-rings), although some of the items were likely produced in local Masovian-Podlasie workshops (Mogielnicka-Urban 2008, 220; Orlińska and Kaczmarek 2010, 92).

Henceforth, the conclusions formulated by Wojciech Blajer a quarter of a century ago, relating to the nature of hoarding in the Early Iron Age (2001, 65-71), remain valid in light of more recent finds from the area between the Vistula and Bug rivers.

3. CONCLUSIONS

The present distribution of hoards within the area between the Vistula and Bug rivers likely does not accurately reflect their actual spread during the Bronze Age and Early Iron Age. The clusters visible in the Chodel Depression and the south-eastern part of the Lublin region may be partly related to the activities of local amateur metal detectorists. This is not the only reason for their existence, though, given the location of these deposits within the areas of increased settlement activity and the fact that transport routes run through these areas. The clustering of Early Iron Age hoards in south-eastern Masovia and western Podlasie documents the relationship between these areas and the Kuyavian metallurgical centre/or the potential formation of a secondary bronze-working centre in this region.

The few hoards from the early phase of the Bronze Age consisted primarily of bifacial flint tools, with faience beads appearing only exceptionally. The beginnings of valuable bronze object deposition are associated with the community of the late Trzciniec culture. During the early phase of the Lusatian Urnfield culture, bronze artefacts from various regions made their way to the Lublin region, especially its southern part. The main direction of this influx was from the south, although only a portion of these imports were deposited. The nature of such hoards still requires further study, and a promising line of research may be the investigation of their placement in relation to settlement microregions. It also seems necessary to re-examine hoards that have long been known, in order to subject them to comprehensive – and in some cases repeated – laboratory analyses, now made possible by advances in the hard sciences. The chronological framework of these hoards also seems to remain an open question.

The unveiling of new discoveries remains a matter of time. It is only to be hoped that the monitoring of amateur artefact hunting will be better and... that the effectiveness of obtaining funds for future analyses will increase.

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THE MISSING LINK – LATE BRONZE AND EARLY IRON AGES SETTLEMENTS IN THE VICINITY OF THE GOGOLEWO HOARD DISCOVERY SITE

ABSTRACT

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The Gogolewo hoard is one of many assemblages of metal objects from the Late Bronze and Early Iron Ages that have been discovered in western Poland. Its composition is unremarkable, consisting of two sickles and a spear- or javelinhead, with no imports or unusual objects. Although it has been mentioned in several publications, it has never been thoroughly studied. This text focuses on this deposit because, according to archival information, it was discovered in a 'pile of stones'. For this reason, it was included in studies conducted as part of a project examining hoards found in such contexts. The article explores the relationship between Late Bronze and Early Iron Ages settlements and the cultural significance of the hoard's deposition site during this period.

Keywords: Late Bronze Age and Early Iron Age, Lusatian Urnfield cultures, settlement studies, cultural landscape, metal object hoards

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INTRODUCTION

The Gogolewo hoard was discovered in 1876 or 1877 on the slope of a hill in a 'pile of stones' by Stanislaw Czarnecki or, more precisely, on his estate (Waga 1933, 242). File 483, preserved in the Archiwum Naukowym Muzeum Archeologicznego w Poznaniu (Scientific Archives of the Archaeological Museum in Poznań), notes that the hill was the site of a windmill. Additionally, Szafrański (1955, 163) records that the hoard was found on the eastern slope of this elevation. The deposit included three artefacts: two sickles and a head of a javelin or spear, which Blajer (2001, 328) dates to HaA2 (*c.* 1100-1050 BCE).

The most intriguing detail about this hoard is that it was discovered in a 'pile of stones'. Metal object hoards from the Bronze Age and Early Iron Age are often associated with stones. These may be large boulders (*e.g.*, the Granówko hoard – Archiwum Działu Archeologii Muzeum Narodowego w Szczecinie (Archives of the Archaeology Department of the National Museum in Szczecin), File 182; Rosko Site 5 hoard – Cofcianka 1949) or stone pavings on which metal objects were deposited (*e.g.,* the Gdynia-Karwiny hoard – Dzięgielewski *et al.* 2019). Frequently, specific details are absent, with reports merely noting the presence of stones in the context of the hoard. It is not always clear whether these stones were placed there intentionally (*cf.*, Blajer 2001, 256, fig. 42, 311-374). Even when stones are a natural feature of the environment, their recurrent occurrence suggests a significant role in the deposition process, a detail that is often overlooked. The Rosko Site 47 hoard was discovered in a particularly unusual context, having been deposited within a stone and earthwork structure reminiscent of a megalith or barrow. However, no definitive dating of this structure has been provided beyond its apparent contemporaneity with the hoard (*cf.*, Maciejewski 2019). The Gogolewo hoard was selected for research in a project funded by the National Science Centre, Poland: 'A Biography of Late Bronze and Early Iron Age Hoards. A Multi-Faceted Analysis of Metal Objects Related to Monumental Constructions in Poland' (2021/41/B/HS3/00038), which is associated with studies on the phenomenon of such structures. Simply put, the project aims to determine whether the Rosko site 47 hoard is unique or represents a broader cultural phenomenon.

Information about stone structures or 'stone piles' and the details enabling the identification of hoard locations were essential for typifying cases for detailed research within the project (Fig. 1). The Kaliszany hoard, discovered in a stone and earthen structure. The Stołężyn hoard, also reportedly found in a 'pile of stones', was chosen for study. Another case is the Uścikówiec hoard, which, although not discovered in a stone structure (or at least with no record of it), shares several characteristics with Rosko, Kaliszany, and Stołężyn hoards. All these hoards are dated to HaB2-HaB3 (*c.* 950-800/750 BCE), originate from northern Greater Poland, and are large assemblages containing numerous artefacts in both Greater Poland's and Pomeranian styles. Additionally, they were all deposited on the borders of the ecumene or between areas of intense settlement (*cf.*, Maciejewski 2016). The Gogolewo hoard, in contrast, differs in several respects: it is smaller, was deposited more than 200 years earlier, and comes from southern Greater Poland. Moreover, its relationship with the local settlement is not well understood. This article seeks to address this gap.

The exact discovery site of the metal objects from the Gogolewo hoard is unknown. Attempts to pinpoint the location relied on the aforementioned archival records and an analysis of historical maps (a fuller account is provided in another publication – Maciejewski *et al.* in press). Information from the Special-Karte von Südpreussen confirms that the windmill in Gogolewo was located on a hill south of the village. Similarly, the *Urmesstischblatt* Map of 1826, at a scale of approximately 1:25,000, shows the windmill's position south of the village and the land use surrounding it in the 1830s. By the time the hoard was discovered, the windmill no longer existed, though archival records suggest it remained a distinctive landmark. Analysis of Airborne Laser Scanning data and metal detector surveys did not reveal any relics of the structure, although two potential sites where the windmill may have stood were identified. Despite the lack of detailed information, this approximate location

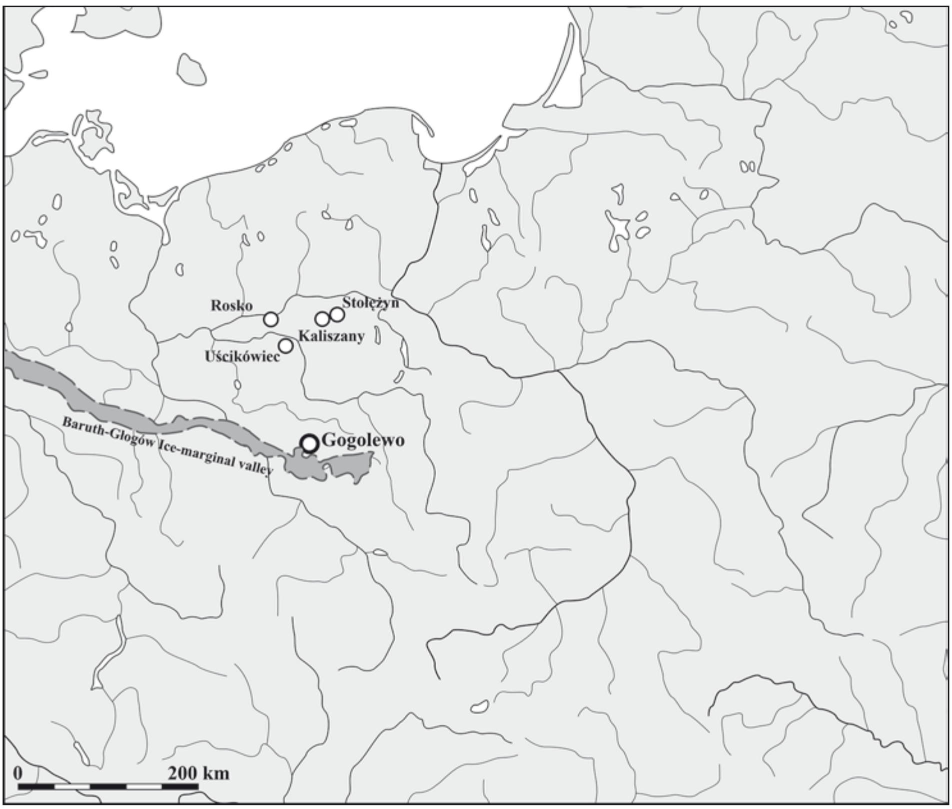

Fig. 1. Location of the Gogolewo hoard and other hoards investigated in the project and the Baruth-Głogów Ice-Marginal valley referred to in the text, according to Kondracki 2002. By the author

provides a basis for investigating the relationship between the site (or area) and Late Bronze and Early Iron Ages (LBA-EIA) settlement. It also allows assessing the hoard's significance within the local cultural landscape.

SOURCES AND METHODS

The research utilised publicly available resources for both archaeological and related environmental data. No field archaeological investigations (*e.g.*, non-invasive surveys or landscape-related studies) or palaeoenvironmental analyses were conducted. The aim was to identify settlement patterns around the hoard deposition site, comparable to studies of other hoards analysed in the project. The research relied on reference information about archaeological sites dated to the LBA-EIA and, more generally, the prehistoric period (PP). Information on generally defined PP archaeological sites was included, as it is highly likely that some may relate to the period under study. In addition, these sites reveal areas that may have been inhabited by communities from various prehistoric periods, suggesting the potential for different areas to have been settled by human groups operating within an archaic economic system. Moreover, they demonstrate that certain areas were surveyed by fieldwalking. The settlement points described primarily derive from the research of the Polish Archaeological Record (Archaeologiczne Zdjęcie Polski – AZP), supplemented by information from various publications presenting the so-called archival finds (*e.g.,* Jażdżewski 1926; Rajewski 1932; Durczewski and Śmigielski 1966). The studied zone is unevenly covered, with the northern part, belonging to the Gostyń district (in the pre-1975 administrative division), being much better explored. An additional search was conducted to supplement the catalogue with settlement points recognised after the AZP survey, obviously based on published information (for a complete list of source data, see: https://zenodo.org/uploads/14680958).

The survey covered nine AZP zones, from 66-27 in the north-west to 68-29 in the south-east. The zone where the hoard was most likely discovered lies in the centrally located zone 67-28. In total, it is approximately 3,600 km^2 (Fig. 2). Data provided by the National Institute of Cultural Heritage (Narodowy Instytut Dziedzictwa – NID) in .shp file format (case number: DDC.441.1.2023.BN) and information available on the institution's map portal (https://mapy.zabytek.gov.pl/nid/) were used. Extensive evaluation of the reliability and suitability of these resources is planned for the future. According to the information provided, the validity of the file mentioned above is 10 July 2023. The AZP surveys were conducted in 1980, 1982, 1983, and 1994, with six zones surveyed by the same team, ensuring a relatively homogeneous dataset regarding fieldwork methodology, the delimitation of archaeological sites, and the chronological classification of retrieved artefacts. Additionally, most of the site was theoretically available for fieldwalking survey, apart from relatively large woodland areas in the north-west of the study zone (Fig. 3).

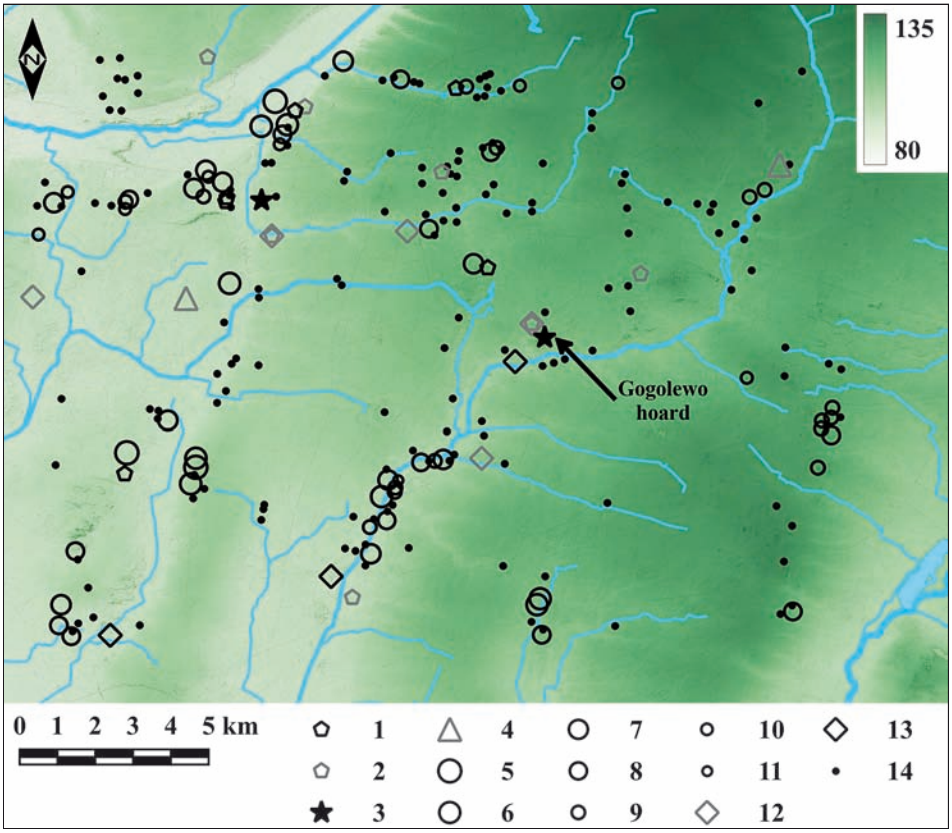

Fig. 2. Late Bronze and Early Iron Age settlement around the Goglewo hoard discovery area. Legend: 1 – cemeteries of known location, 2 – cemeteries of unknown location, point in the centre of the village, 3 – hoards, 4 – probable cemeteries of unknown location, 5 – settlement points known from fieldwalking surveys, over 50 potsherds, 6 – settlement points known from fieldwalking surveys, 21–50 potsherds, 7 – settlement points known from fieldwalking surveys, 11–20 potsherds, 8 – settlement points known from fieldwalking surveys, 6–10 potsherds, 9 – settlement points known from fieldwalking surveys, 4-5 potsherds, 10 – settlement points known from fieldwalking surveys, 2-3 potsherds, 11 – settlement points known from fieldwalking surveys, 1 potsherd, 12 – settlement points known from archival records and literature, with unknown function and location, 13 – settlement points known from archival records and literature, with known location and unknown function, 14 – settlement points dated to prehistory. By the author

Neither resource contained records (so-called KEZAL cards – Karta Ewidencji Zabytku Archeologicznego Lądowego – Record Card of an Inland Archaeological Site) of surveys conducted after the completion of the AZP programme. The absence of more recent cards may suggest that either no significant construction project has occurred in the zone in recent years, they have fortuitously bypassed archaeological sites or have gone unreported, or entries have not been added to the NID databases. Regardless of the underlying reason, the collected dataset was considered representative of settlement trends during the study period. On the other hand, it is virtually impossible to create a complete source record corresponding to any sphere of human activity in prehistory (*cf.*, Urbańczyk 1981). Information on the number of settlement points, their basic statistics, and the results of the nearest neighbour analysis are presented in Table 1.

Table 1. Number of analysed settlement points divided by methods of obtaining information on them. data necessary for nearest neighbour analysis and their occurrence density

Settlement points	No	Observed average distance (m)	Expected average distance (m)	Nearest neighbour indicator	Settlement points / m^2
all	246	-	-	-	0.068
exact location known	228	427.200	597.184	0.715	0.063
fieldwalking surveys	216	446.397	613.548	0.728	0.06
fieldwalking surveys: LBA-EIA archaeological sites	59	688.359	1163.240	0.592	0.016
fieldwalking surveys: PP archaeological sites	157	542.693	716.655	0.757	0.044

The research methodology was tailored to the specifics of the available source material, not only concerning the Gogolewo hoard site but also addressing broader settlement analyses from the LBA-EIA, primarily based on fieldwalking survey results. For such sources, the AZP survey results enable the outlining of general settlement processes and preferences in the selection of settlement sites. However, it is challenging to accurately present the dynamics of these processes. This difficulty arises partly from the inability to precisely date artefacts recorded during fieldwalking surveys. Even when dating is feasible, assuming that a few potsherds from the surface – some of which may lack distinctive characteristics – represent the entire assemblage risks overinterpretation. Additionally, although the number of archaeological sites from the described period is considerable, only a small proportion have been methodologically investigated, and even fewer have undergone rigorous scientific analysis. Consequently, definitions found in various catalogues cannot always be regarded as reliable. A more extensive critical analysis of the sources documented in the AZP, with references to discussions in numerous other scientific publications, has been presented previously (Maciejewski 2016, 24-26; Baron *et al.* 2019, 104-108; Stolarczyk *et al.* 2020, 248-260).

The proposed analytical framework includes analyses of the relationship between the settlements and relevant environmental elements, as well as geostatistical analyses utilising Geographic Information System (GIS) tools. These analyses comprise Kernel Density Estimation (KDE), performed using the heatmap algorithm in QGIS, nearest neighbour analysis (also employing the relevant QGIS function), and visibility analysis (using the Visibility analysis plug-in – Čučković 2016). The effectiveness of this methodological set has been demonstrated in several publications (Maciejewski 2016; 2017; Baron *et al.* 2019; Stolarczyk *et al.* 2020; Blajer *et al.* 2022) and has since been further refined and developed.

As described in numerous papers and books, a crucial part of the reasoning is the state of the research on general settlement trends in the LBA-EIA. This includes critiques of particular perspectives on the topic and reflections on the importance and specificity of the landscape within the humanities, particularly in archaeological research (summarised and organised in Maciejewski 2016, 51-72).

Among the sources used to outline natural landscape, the following were particularly important: terrain relief (visualised using the most up-to-date data provided by the Head Office of Geodesy and Cartography – GUGiK with a resolution of at least 1 m (obtained using the Pobieracz danych GUGiK plug-in for QGIS); hydrological network (visualised using data provided by the Wody Polskie baza WMS plug-in for QGIS and the 'Mapa podziału hydrograficznego Polski w skali 1:10 000' (the Map of hydrographic division of Poland in the scale 1: 10 000), as well as generalised vector maps of potential natural vegetation (Matuszkiewicz and Wolski 2023). Additionally, the division into geographical mesoregions proposed by Kondracki (2002) was considered, with corrections, and presented in digital format (Solon *et al.* 2018).

Regarding palynological studies, the analysed area and most of southwestern Poland are, unfortunately, a true *terra incognita* (Nalepka 2004, 417-421, fig. 107). Isopod maps and other broader findings are a good reference point in this case. These indicate that the areas of southern Greater Poland were thickly populated during the LBA-EIA (Ralska-Jasiewiczowa 2004, 407). Notably, during the so-called Late Holocene (between 5000 and 2500 BP), forest complexes resembling contemporary ones were established, while the range of various species has remained relatively unchanged since then (Ralska-Jasiewiczowa 2004, 407). Similarly, the soils have not undergone significant changes over the last 3,000 years, either (Mierzwiński 1994, 46). The studied zone lies beyond the range of the last glaciation, outside the area where numerous lakes exist today and were located in prehistory; thus, the processes of their disappearance did not significantly impact settlement (Kalinowska 1961).

Notably, the data concerning the relief, water network and Kondracki's regionalisation (2002) remain up-to-date, requiring no further commentary. By contrast, the map of potential natural vegetation not only corresponds to contemporary conditions (for both soil and climate) but is also idealised, as it assumes no human influence. Hence, its validity for representing different periods in prehistory is somewhat questionable. These maps do, however, offer the advantage of presenting information in a way accessible to traditional communities – for instance, indicating that deciduous forests with rich undergrowth signify fertile soils, regardless of how these soils are classified today. Moreover, in other areas, comparisons between pollen profile analyses and maps of potential natural vegetation show a convergence of results (for example, in the Carpathian Foothills – Blajer *et al.* 2022, 172-182). Therefore, it is worthwhile to use such maps, albeit with appropriate caution.

NATURAL LANDSCAPE

There are practically no lakes in the analysed zone. At the same time, the river network is quite dense and consists of smaller watercourses and larger rivers: the Rów Polski (which was initially a natural watercourse), Masłówka, Dąbroczna, and Orla (Fig. 4). They all belong to the Barycz River basin and flow south or south-west towards the terrain depressions associated with the Głogów-Baruth Ice-Marginal Valley (Fig. 1). The Digital Elevation Model (DEM) suggests that many more similar small watercourses may have existed initially (Fig. 4).

Most of the analysed zone falls within the Kalisz Heights, with a smaller portion located in the Leszczyńska Heights. Both regions are part of a belt of uplands characterised by an undifferentiated landscape and favourable conditions for agriculture. To the south lies the aforementioned ice-marginal valley, with a significant terrain depression – the Żmigród Basin (Kondracki 2002, 156-158, 165). In prehistory, this area was swampy and

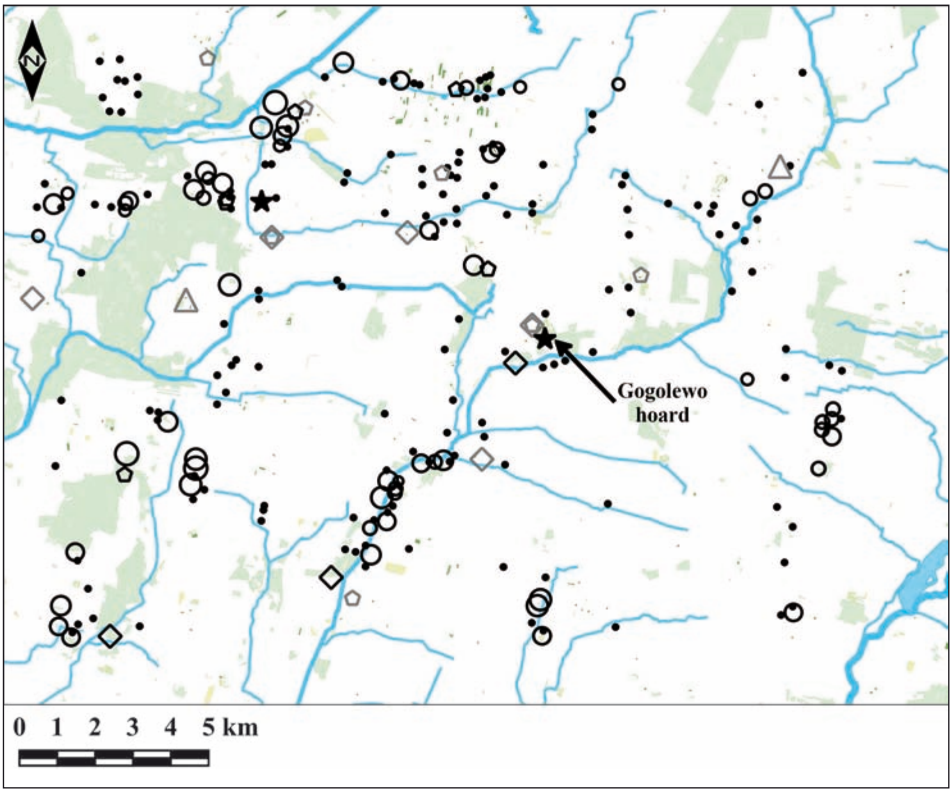

Fig. 3. Forests and wetlands – unavailable for fieldwalking surveys. Based on the Database of Topographic Objects – BDOT10k – www.geoportal.gov.pl. By author

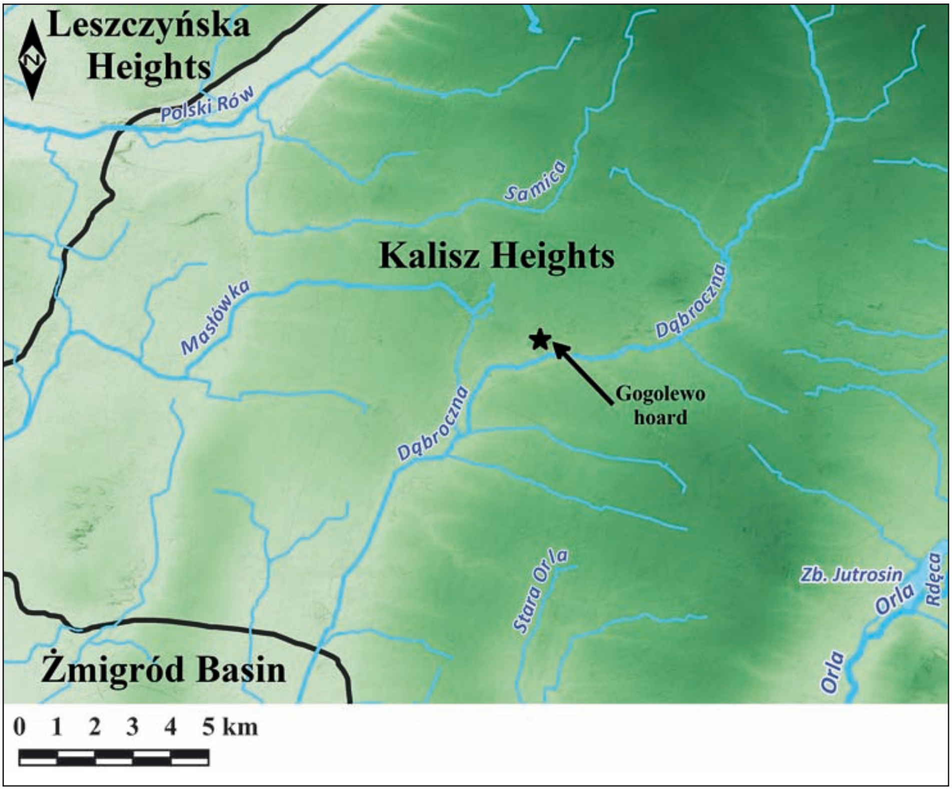

Fig. 4. Physical-geographical mesoregions based on Kondracki 2002 with corrections by Solon *et al.* 2017, featuring the most prominent watercourses and localities mentioned in the text. By the author

likely posed a barrier to settlement and communication (*cf.*, Baron *et al.* 2019). To the north of the upland area lies a region shaped by the last glaciation, characterised by an area of lake districts (Kondracki 2002, 156).

The map of potential natural vegetation (Fig. 5) has been simplified to highlight areas of high value for horticultural crops (*e.g.*, riparian and alder forests) and more extensive crops, such as cereals (*e.g.*, various oak-hornbeam forests). It also shows areas of lesser value for such crops (*e.g.*, fertile beech forests), which are not present in the analysed zone, and areas of low suitability for crops (*e.g.*, pine forests) (for a discussion of forest complexes, see Maciejewski 2016, 177-180). Good agricultural conditions are a notable feature of this area, as it might have been dominated by oak-hornbeam forests and riparian forests, with alder forests in the river valleys. Small areas may have been covered by forests growing on soils of low agricultural value, located in the west and associated with the Rów Polski valley. The soils in this region provide evidence of fluvioglacial processes (Kondracki 2002, 157).

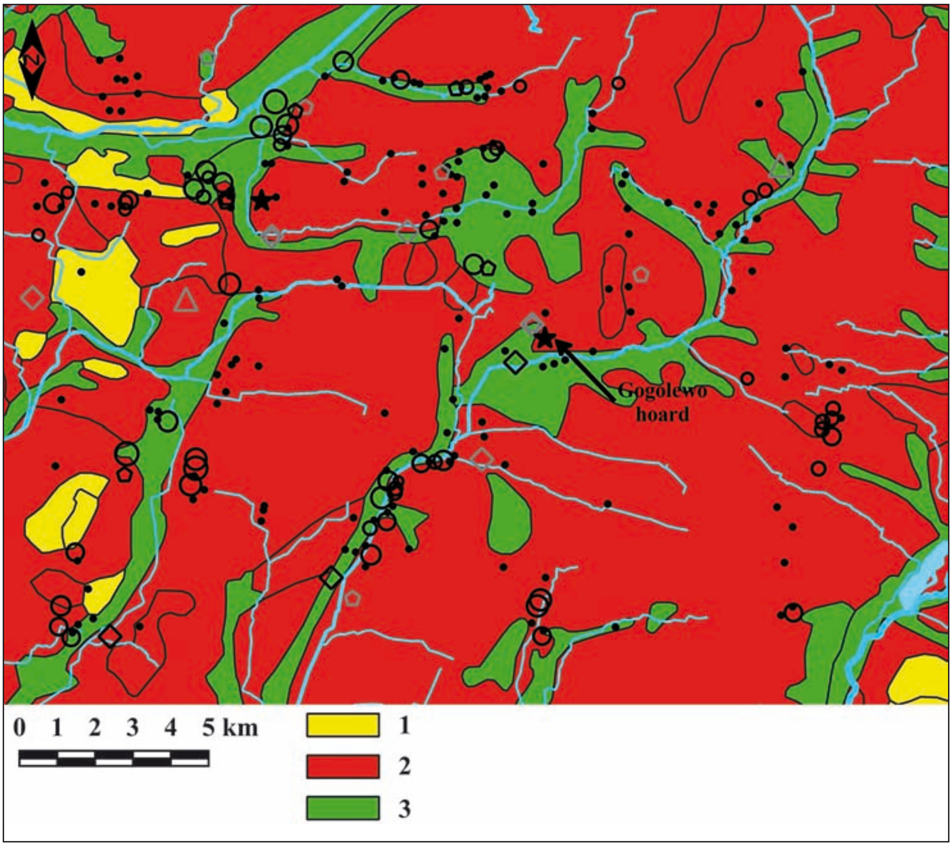

Fig. 5. Simplified map of potential natural vegetation based on Matuszkiewicz and Wolski 2023. Legend: 1 – forest complexes growing on soils of low agricultural value (*e.g.*, pine forests), 2 – forest complexes growing on soils of high value for extensive cultivation (*e.g.*, oak-hornbeam forests), 3 – forest complexes growing on areas of high value for intensive cultivation (*e.g.*, riparian forests). By the author

SETTLEMENT

The settlement points are visualised in the subsequent cartograms (Figs 2-3 and 5-15) with a division into sites known from fieldwalking surveys. The cartograms also include settlement points with an assigned function (*e.g.,* cemeteries) or those whose function is unknown, where the information – usually very scarce – originates from archives or pre-AZP publications. For example, a cemetery identified through an accidental discovery, later verified during the AZP survey, where 12 potsherds were found, is marked in the same way as other sites known only from fieldwalking surveys where 11 to 20 potsherds were discovered (Fig. 2 – legend). In this case, the categorisation does not fully reflect the scientific value of the settlement point but aligns better with the visualisation of the KDE analysis results.

Cemeteries hold the most significant scientific value for the analysed period, as they were central to local communities in various ways (*cf.*, Mierzwiński 1994, 17). There are at least 15 cemeteries and four presumed cemeteries within the study zone. Two of these were identified through fieldwalking surveys, revealing burnt bones and potsherds. The two necropolises at Karzec Sites 2 and 8 are located so close to each other that they are likely remnants of a single cemetery. In addition to the two probable cemeteries identified during the AZP survey and the two necropolises in Karzec, five more cemeteries have been located, one of which is associated with the Pomeranian culture. Most of these necropolises are situated in the northern part of the analysed zone, which may reflect a higher settlement intensity during the analysed period, a greater familiarity with the archival data from this area, and the current state of research. The cemetery at Rogowo Site 1, investigated during rescue excavations in 1959 and 1962, received a more detailed study. However, the research and its subsequent publication notably covered only a small part of

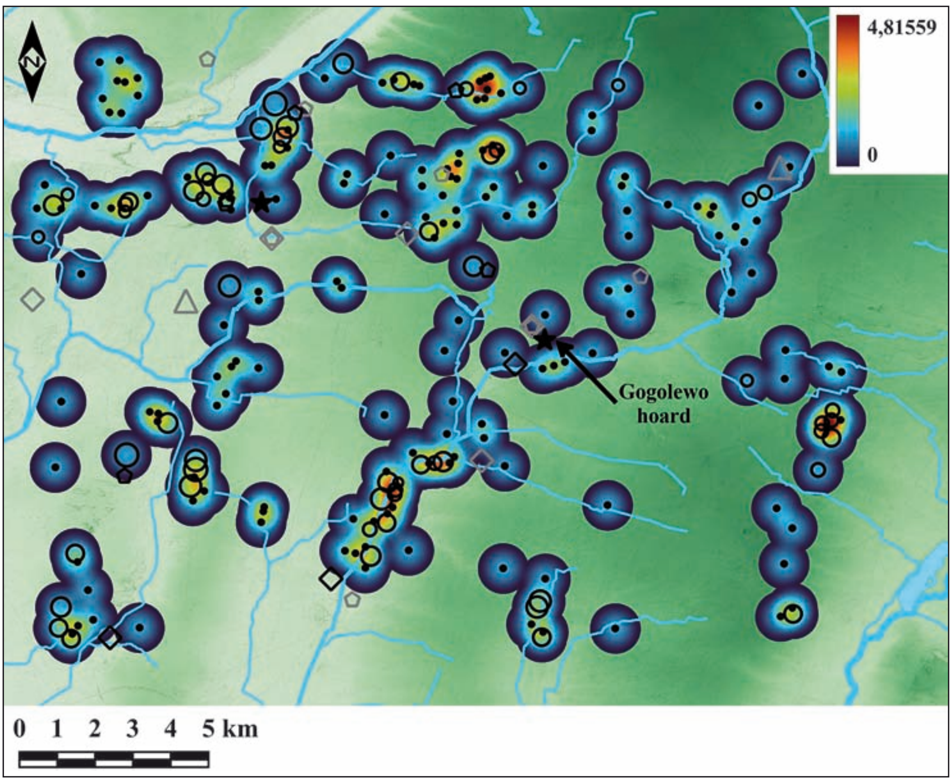

Fig. 6. Visualisation of the Kernel Density Estimation analysis results for all settlement points known from the fieldwalking survey, circle radius 669.5955 m, weights not considered. By the author

the cemetery (Durczewski 1961; 1963). Similarly, part of the evidence from Karzec Site 2 was published, but the article was labelled ‘Part I’, lacked analysis and summary, and the remaining parts were never printed (Śmigielski 1965). The Pomeranian culture cemetery at Pudliszki Site 3 was fully described, including all discovered graves. At the same site, settlement features associated with this taxon were identified, but these remained unpublished despite the author’s declaration (Lipińska 1967). The Lusatian Urnfield cultures (LUC) cemetery investigated by Kostrzewski during the interwar period (Pudliszki Site 10) was described in a lengthy article in the popular science magazine ‘Z otchłani wieków’ (Nowak 1935). Still, its exact location cannot be determined today. For other cemeteries, only very general information is available, and their dating cannot be regarded as reliable.

Three settlements are known from the surveyed zone. One presumed settlement is associated with an early medieval hillfort (Pudliszki Site 1). Previous test excavations have not confirmed the presence of a fortified LUC settlement at this location (‘Atlas Grodzisk’). A second settlement has also been identified in this locality (Pudliszki Site 5). In earlier literature, the site was associated with LUC based on fieldwalking surveys (Malinowski

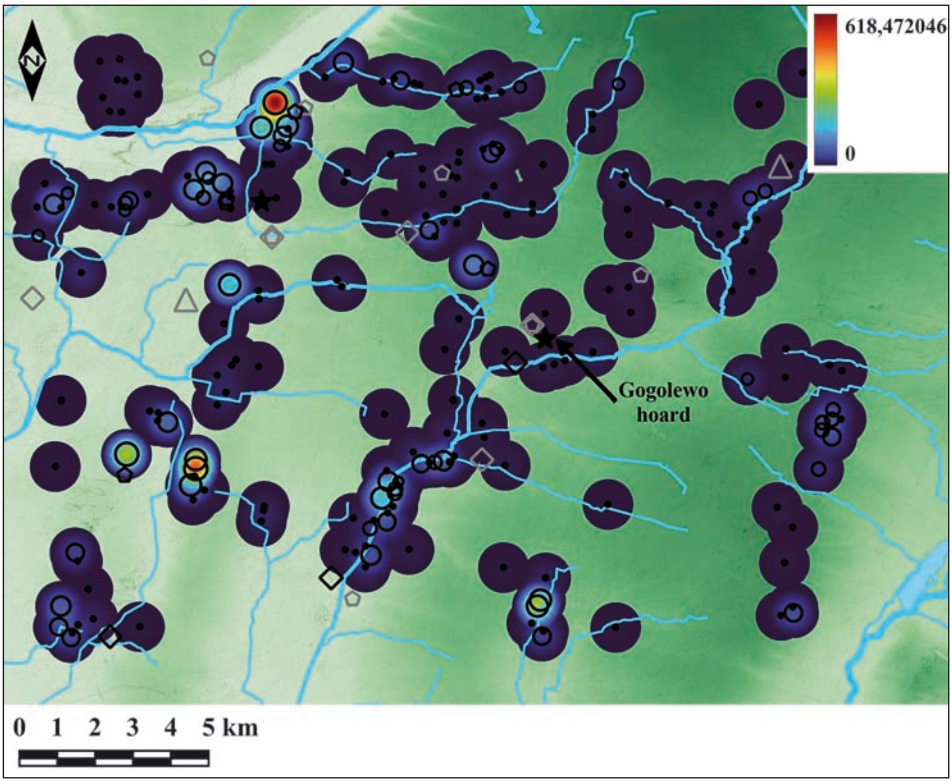

Fig. 7. Visualisation of Kernel Density Estimation analysis results for all settlement points known from fieldwalking surveys, circle radius of 669.5955 m, weights considered. By the author

1955, 17-18). However, Durczewski (1977) attributed the pottery discovered during the 1973 test excavations to the Tumulus culture, thereby dating the entire complex accordingly. Another excavation conducted in 1993 covered a larger zone, and this time, the study's author linked the pottery to the HaC phase and possibly even the final phase of the Bronze Age. These findings were supported by radiocarbon dating (Lasak 1995). It should be noted that the pottery manufacturing technology of the Middle Bronze Age (MBA) and the LBA–EIA did not differ significantly. Therefore, it is likely that the site was also used during the MBA, as the Pudliszki site is known for its graves from this period (Kowiańska-Piaszykowa 1966). The last settlement is the aforementioned Pomeranian culture settlement, also located in Pudliszki.

Another category of highly valuable archaeological finds, particularly in the study of settlements, consists of hoards. Alongside the Gogolewo hoard, the Ziemlin hoard is also known from the analysed zone. It comprises three artefacts and is dated to HaB2–HaB3 (Durczewski and Śmigielski 1966, 110; Blajer 2001, 354). Notably, the detailed deposit location of this hoard is known.

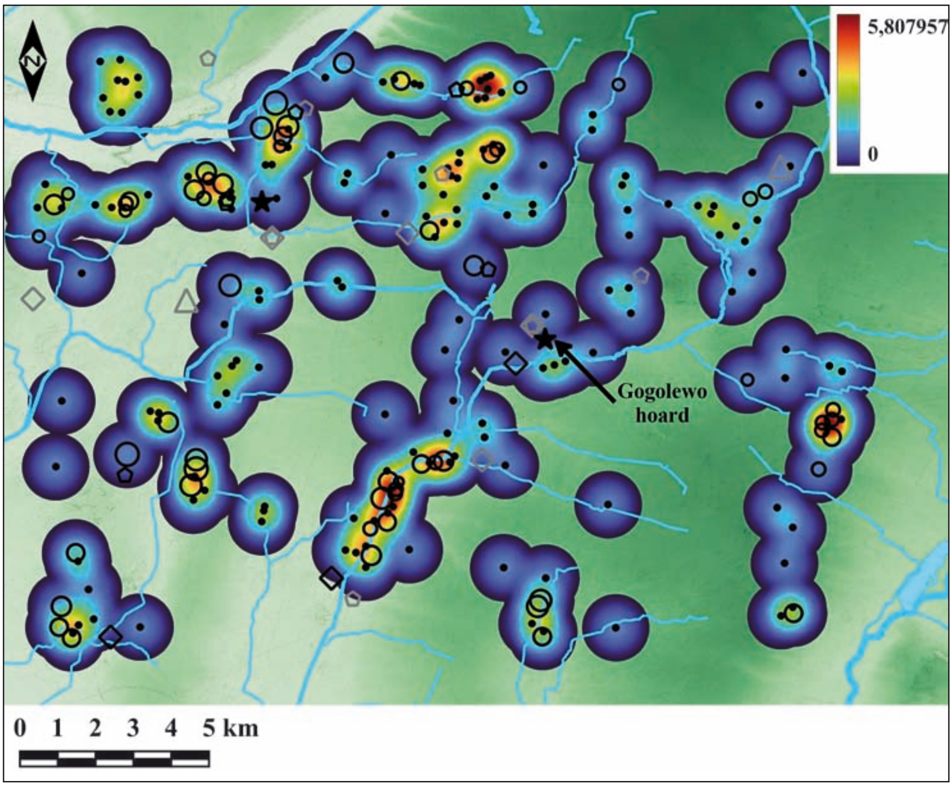

Fig. 8. Visualisation of Kernel Density Estimation analysis results for all settlement points known from fieldwalking surveys, circle radius of 892.794 m, weights not considered. By the author

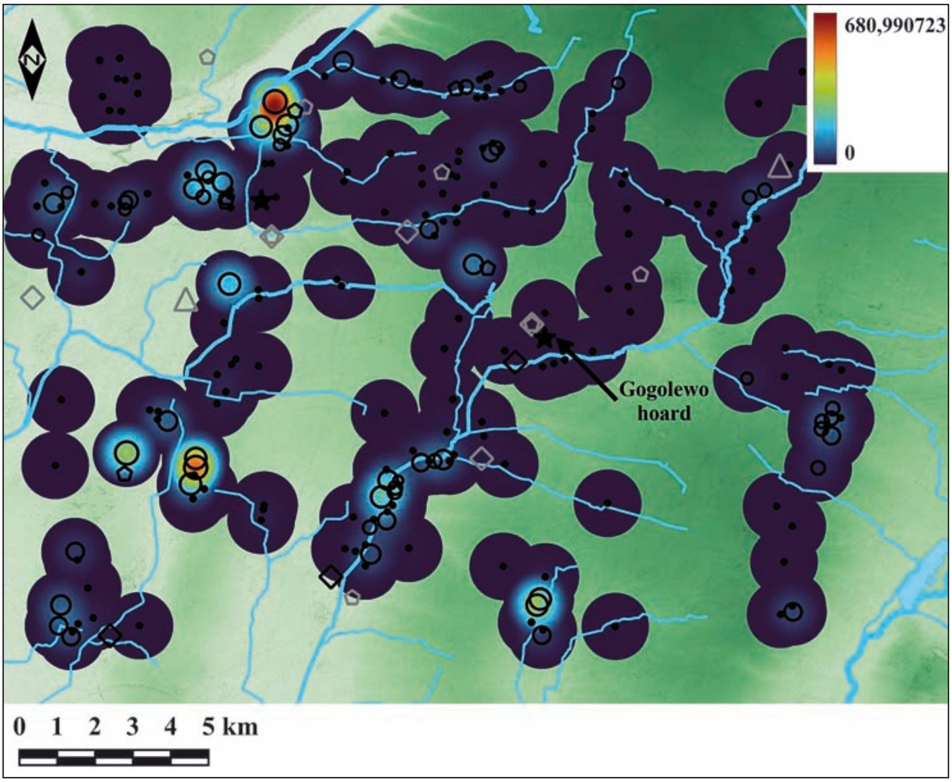

Fig. 9. Visualisation of Kernel Density Estimation analysis results for all settlement points known from fieldwalking surveys, circle radius of 892.794 m, weights considered. By the author

Settlement points identified or verified during the AZP fieldwalking surveys constitute the most numerous group. They are mostly generally dated to the PP (Table 1) and are marked with the same symbols on the settlement maps (Figs 2, 3 and 5-15). Sites identified through fieldwalking surveys and dated to the LBA-EIA were visually differentiated. The size of the symbol corresponds to the number of discovered potsherds.

In summary, few settlement points have a known function, and no more detailed information about them is available. Their distribution across the study zone appears random, with more sites likely located in areas that have been researched more intensively. This may be the case for the Pudliszki area, where several barrow cemeteries are known. At least some of them can be dated to the MBA (Kowiańska-Piaszykowa 1966). Numerous settlement points associated with the LBA-EIA are also found there, including settlements, fortified settlements, and those linked to the Pomeranian culture.

Both LBA-EIA and PP settlements are located along watercourses (Fig. 2). Notably, LBA-EIA settlement points are concentrated in several areas. Firstly, along the tributaries of the Rów Polski, including the Samica, approximately in the vicinity of Pudliszki. Three additional agglomerations are located in the south of the analysed zone. Settlement points are concentrated on the Dąbroczna River north of Miejska Górka up to Gostkowo; further west on to the Zakrzewski Rów and the smallest agglomeration, furthest to the east, along the Stara Orla River near Konary. A final, relatively small complex is located in the east of the analysed zone, near the village of Płaczkowo and is not associated with any contemporary watercourse or reservoir.

These observations, combined with the map of potential natural vegetation, clearly show that most settlement points dated to both the LBA-EIA and PP are situated at intersections of areas covered by multi-layered, multi-species broadleaf forests (oak-hornbeam) and riparian forests (of various compositions) occurring in watercourse valleys. The exception is the aforementioned agglomeration near Płaczkowo. The LBA-EIA settlement avoided more extensive areas potentially overgrown by riparian forests, such as those along the Dąbroczna River near Gogolewo and the Samica River near Chwałkowo. However, PP settlements are marked in these areas, indicating that they were accessible for field walking (Figs 4 and 5).

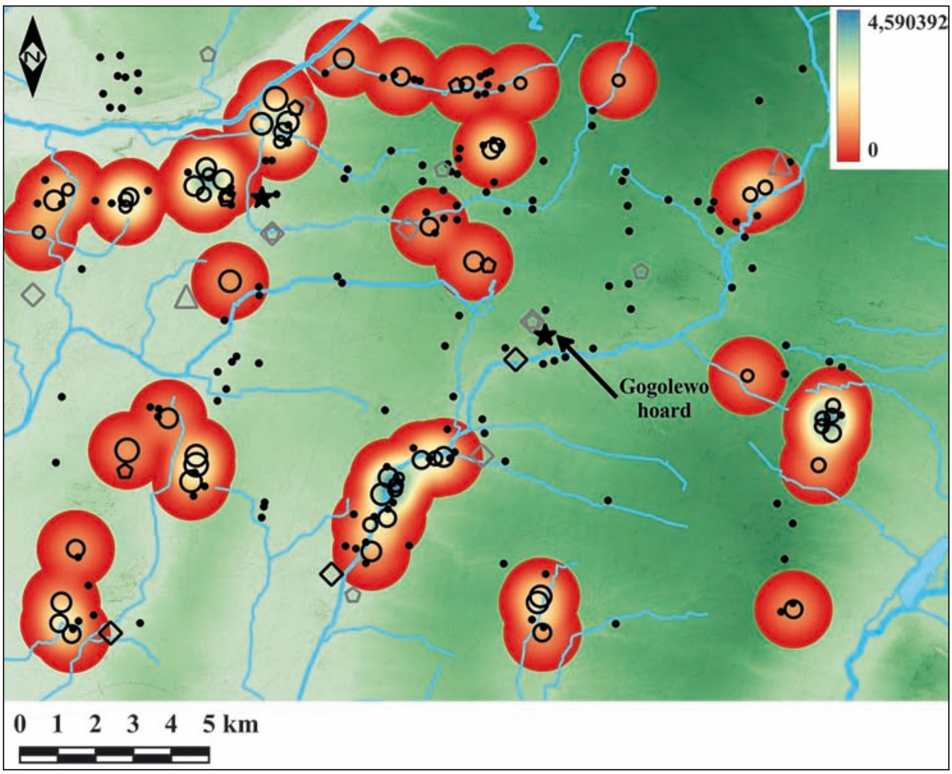

Fig. 10. Visualisation of Kernel Density Estimation analysis results for Late Bronze Age and Early Iron Age dated settlement points known from fieldwalking surveys, circle radius of 1032.5385 m, weights not considered. By the author

GEOSTATISTICAL ANALYSES

KDE analyses can be described as statistical-graphical methods. They are based on the nearest-neighbour principle but allow for more complex studies. KDE is a non-parametric method used to estimate population distribution (not just the dispersion of points on a plane but also other data) and is employed across different scientific disciplines. Additionally, KDE analysis allows for the continuous examination of relationships between data points. The most critical parameter is the search radius around each data point, within which values are assigned to individual grid squares. These squares, which divide the entire study zone, receive higher values the closer they are to the centre(s) of the circle(s). These squares can be compared to the pixels on a screen, and their size also affects the analysis results, which are represented as coloured patches. Another critical factor is the shape of the curve describing the decrease in values assigned to grid squares as the distance from the centre of the circle increases (Jażdżewska 2011, 8, 9; Żurkiewicz 2015, 123; geodose). The analysis

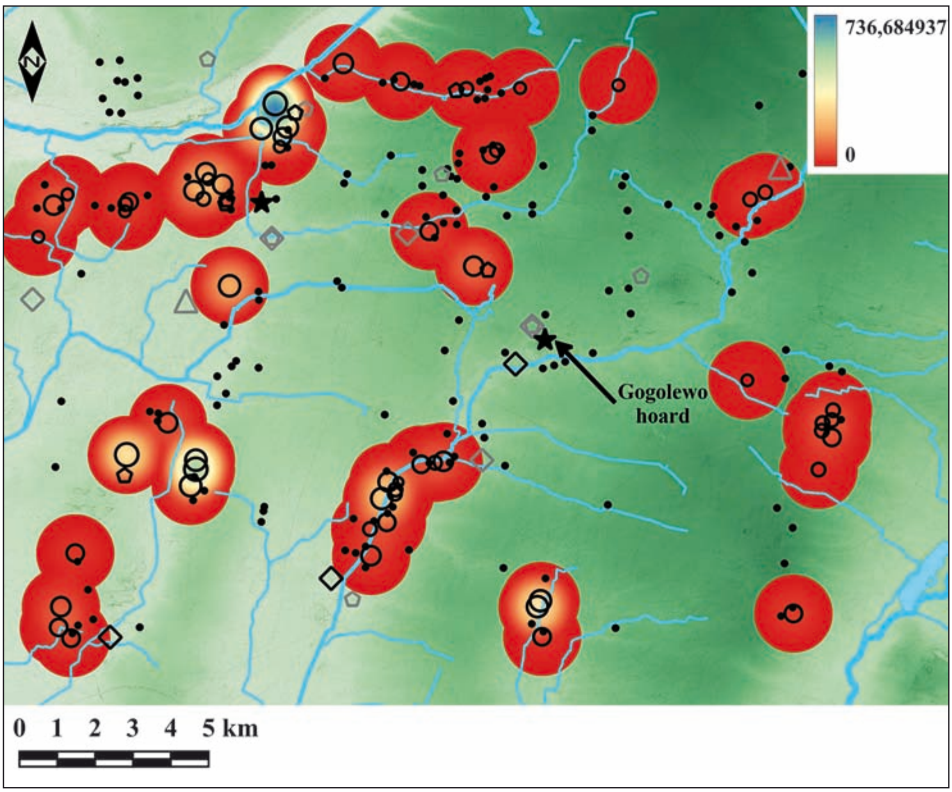

Fig. 11. Visualisation of Kernel Density Estimation results for Late Bronze Age and Early Iron Age settlement points known from fieldwalking surveys, radius of circle 1032.5385 m, weights considered. By the author

was conducted using QGIS software and the Heatmap algorithm. The search radius was set to 1.5 to 2 times the mean observed distance between the data points. Surveys were carried out for all archaeological sites known from fieldwalking surveys (radii: 669.5955 m and 892.794 m) and for LBA-EIA-dated archaeological sites known from fieldwalking surveys (radii: 1032.5385 m and 1376.718 m). The grid square size was 1 m, and the curve used was Quartic (a fourth-degree polynomial).

Analyses were performed both without weights and with weights. The weights were calculated as the product of the number of potshards found at a given archaeological site and an information value assigned according to dating: 5 for LBA-EIA, 3 for probable LBA-EIA, and 1 for PP. The weights for sites with assemblages of different dates were summed (*e.g.*, 3 LBA-EIA potsherds and 6 PP potsherds yield a weight of 3*5 + 6*1 = 21). These approaches enable the observation of different relationships: visualisations without weights reflect the density of settlement points, while those using weights (as products of

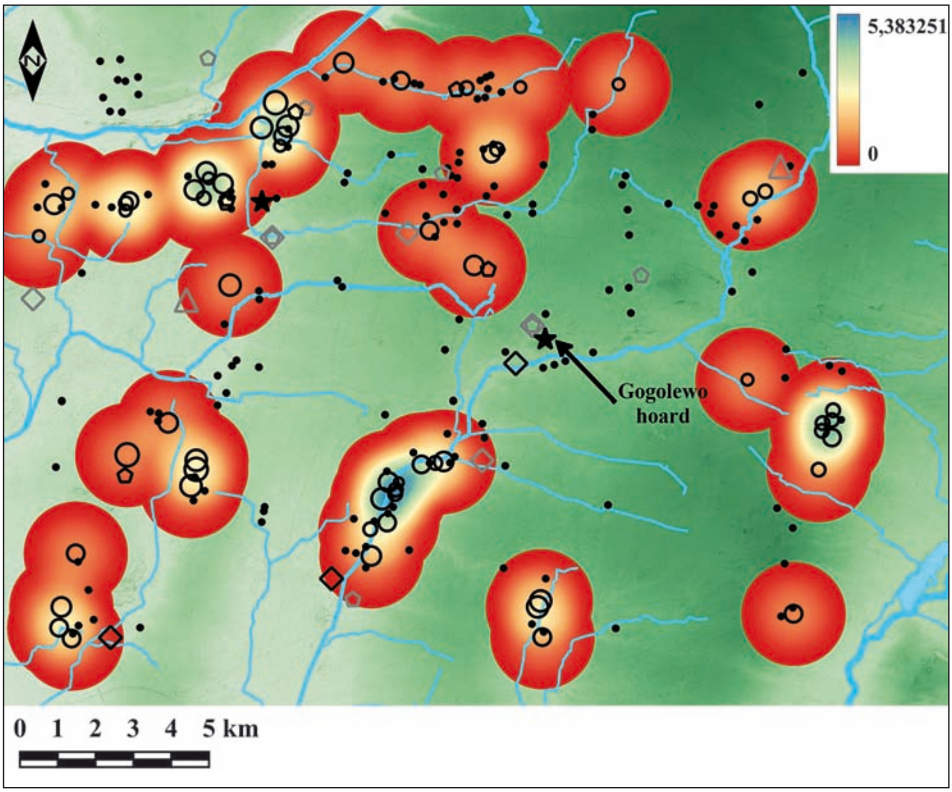

Fig. 12. Visualisation of Kernel Density Estimation analysis results for Late Bronze and Early Iron Age settlement points known from fieldwalking surveys, circle radius of 1376.718 m, weights not considered. By the author

artefact numbers and information value) incorporate information on the frequency of discovered sources (pottery fragments) and their dating.

The results of the KDE analyses (Figs 6-13) confirm the previously described clusters of settlement points associated with the LBA-EIA and provide a more detailed picture. The sites along the Zakrzewski Rów are distinctly divided into two agglomerations. In all analyses, the application of weights significantly emphasises the importance of the settlement cluster near Pudliszki. Interestingly, the cluster along the Dobroczna River is very prominent in the visualisations of the KDE analyses without weights, but does not exhibit high KDE index values when weights are applied. Conversely, the two clusters along the Zakrzewski Rów are equivalent in the unweighted analyses but diverge when weights are introduced, with higher values observed for the northern agglomeration.

Additionally, the results of the nearest-neighbour analysis (Table 1; for a description of the method, see, *e.g.*, Maciejewski 2016, 135, 136) consistently show a tendency towards settlement clustering. This tendency is strongest for settlement points dating to the LBA-EIA rather than for those dated to both the LBA-EIA and the PP.

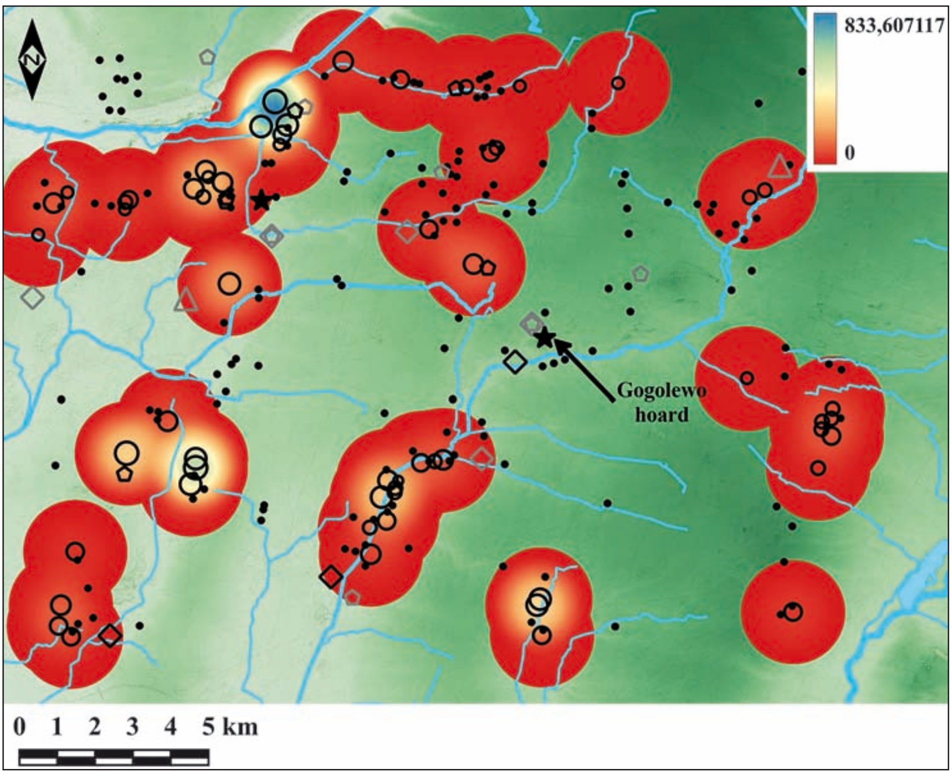

Fig. 13. Visualisation of Kernel Density Estimation analysis results for Late Bronze Age and Early Iron Age settlement points known from fieldwalking surveys, circle radius of 1376.718 m, weights considered. By the author

POTENTIAL VISIBILITY ANALYSES

Potential visibility tests are a method with notable limitations, which have been thoroughly discussed in prior studies (Wheatley and Gillings 2000; Zapłata 2011, 298, 299). A key drawback of these tests is their reliance on contemporary data. The accuracy of the digital elevation model is also critical. While the model is highly accurate in this case, the automatic removal of buildings, plants, and other features may introduce distortions in certain areas. From a survey methodology perspective, the high variability of results depending on the analysed location must also be considered. Sometimes, shifting the point where the potential observer is assumed to stand by only a few metres can significantly impact the analysis results. When conducting visibility analyses, it is essential to remember that the calculations are based solely on the terrain's relief. As a result, the study does not account for numerous natural (*e.g.*, forests, scrub) and cultural (*e.g.*, prehistoric buildings) landscape elements. Reconstructing vegetation from 3,000 years ago would, of course, be problematic, yet its substantial impact on visibility from a site is undeniable.

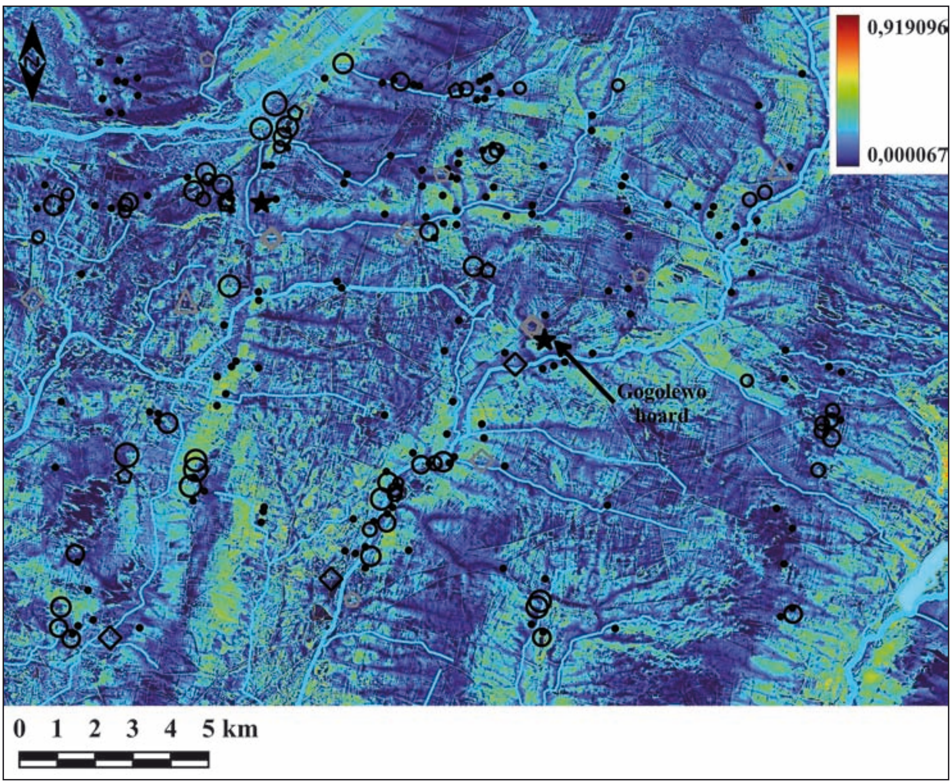

Fig. 14. Visualisation of the potential visibility analysis results, incoming views variant. By the author

The same applies to man-made landscape elements from that period. Achieving accurate results would require detailed documentation from field surveys of all sites within the study zone. Moreover, the fact that an algorithm indicates a site was once visible does not guarantee that an observer would have noticed it. Furthermore, the analysis inherently assumes optimal weather conditions – no rain, fog, darkness, or glare from the sun. All these factors underscore that, in archaeology, we can only refer to such analyses as potential visibility tests.

Visibility analyses were performed in QGIS software using the Visibility Analysis plug-in and the Visibility Index module – Čučković 2016; zoran-cuckovic). Calculations were based on a Digital Elevation Model (DEM) with a 10 × 10 m grid. Other available modules were not utilised due to the uncertain location of the hoard, which does not influence the results for the Visibility Index. The analysis involved calculating two coefficients: the number of points from which a given location is visible (incoming views) and the number of points visible from that location (outgoing views). Here, a 'point' is defined as a 10 × 10 m square, represented as one pixel in the visualisation. Key parameters included the radius

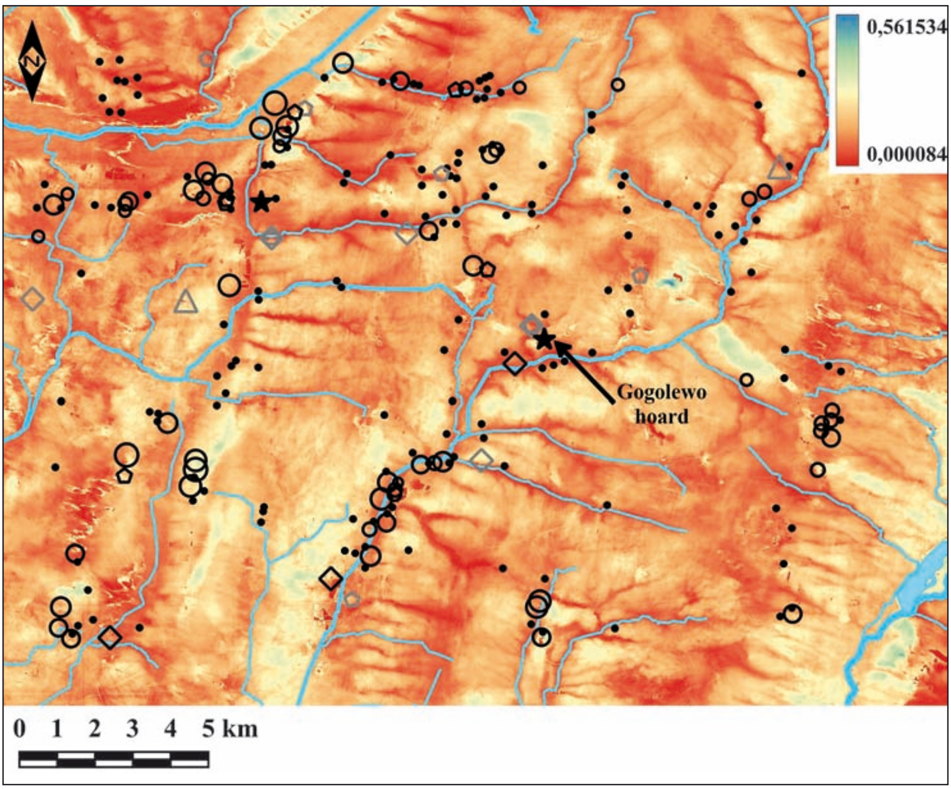

Fig. 15. Visualisation of the potential visibility analysis results, outgoing views variant. By the author

of analysis (set to 3 km, considering that human vision can discern shapes up to approximately 1.6 km) and the observer's height, set at 1.6 m.

The results (Figs 14-16) reveal that both the windmill elevation and the slope where the hoard was deposited were prominent vantage points, clearly visible from the surrounding landscape.

THE MISSING LINK – THE GOGOLEWO HOARD IN THE LANDSCAPE

The research presented here is another attempt to embed hoards of metal objects in the LBA-EIA landscape. It contributes to understanding settlement preferences, available resource usage, and how communities imbue places and areas with meaning – goals central to settlement and landscape studies. In this context, this research has an advantage. Of the discovered hoards, which, after all, are the potential study cases, only a small proportion (around 20%, *cf.*, Maciejewski 2016) can be precisely located in the field. As a result, research into hoards often alternates between thickly populated areas and peripheral areas. The settlements in the analysed zone can unequivocally be classified as peripheral. To the south, settlement activity associated with the Barycz River was notably more intensive, particularly during the Bronze Age and probably in the Early Iron Age. Similarly, more

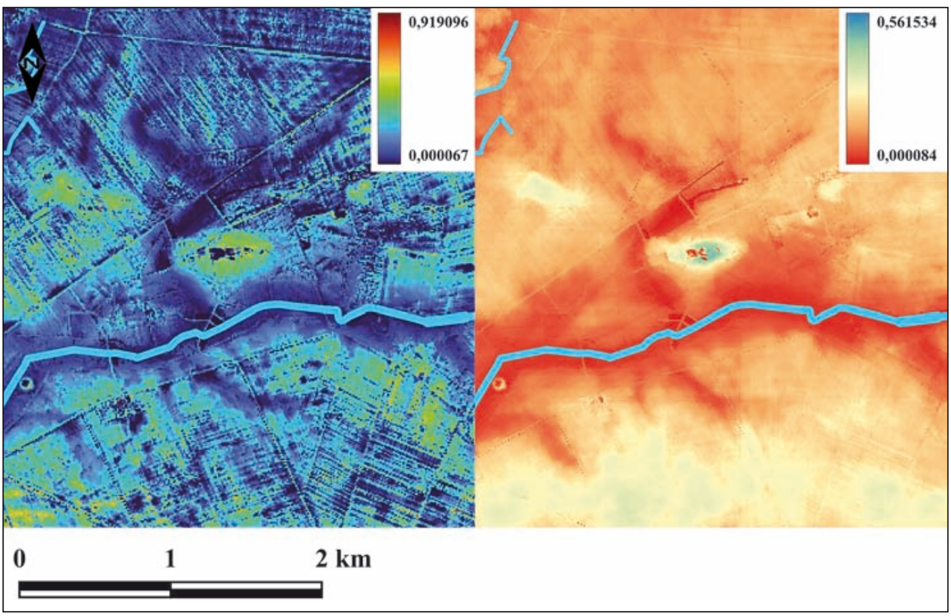

Fig. 16. Visualisation of the potential visibility analysis results for the elevation, where the Gogolewo hoard was discovered, incoming views variant on the left, outgoing views variant on the right. By the author

settlement points are recorded in the north. A glance at the map published by Lasak (1996, map 1; 2001, 384-414) clearly illustrates this pattern.

Settlement studies based on fieldwalking survey results typically reflect the peak demographic and cultural development period of the studied communities, in this case, HaB and HaC. The Pudliszki area, in particular, was densely populated during the MBA. Indeed, defining a separate 'Pudliszki culture' has even been proposed, highlighting the specificity of Greater Poland's MBA sources (Gardawski 1979, 47-49). However, the studied zone lacks settlement points from the early LUC, corresponding to BrD and HaA1, unless the dating of the Kawcze cemetery – about which information is very general – is considered reliable (Malinowski 1961b, 277). Kurnatowski (1966) mentions two archaeological sites, Rawicz and Wymysłów, among the few settlement points located near the zone under analysis. Additionally, remains of a settlement were discovered during rescue excavations along the planned route of the S5 expressway. Pottery from this site exhibits characteristics of both the Tumulus culture and the early LUC (Anioła *et al.* 2018). Archaeological sites in the study zone dating to a later period, corresponding to the chronology of the hoard, are scarce, and those identified lack reliable chronological data.

A review of the cartograms (Figs 2-15) indicates that the hoard was deposited along a boundary running roughly from west to east. This observation aligns with findings in other regions (Maciejewski 2016; 2017; Baron *et al.* 2019; Stolarczyk *et al.* 2020; Blajer *et al.* 2022) and across Europe more broadly (Bradley 2017). Notably, there are some LBA-EIA archaeological sites within Gogolewo, including a cemetery, though its precise location remains unknown. PP settlement points have also been discovered in the area. Furthermore, the AZP for Zone 67-28, where Gogolewo is situated, was conducted by a different research team compared to most zones analysed in this paper. However, as no significant discrepancies are evident, it isn't easy to attribute the current state of the source base to this difference in survey teams.

The examination of the second hoard found in the zone – the Ziemlin hoard – suggests that it was also deposited along the boundary of the densely populated area around Pudliszki. Its deposition site is adjacent to other archaeological sites from the studied period. A similar yet clearer example is the Granówko hoard (Maciejewski 2016, 110-112). This indicates that archaeological sites within a single locality do not preclude the possibility that the hoard was placed at the edge of a populated area.

It is worth noting that the map of potential natural vegetation for this site points to a relatively extensive area covered by riparian trees, suggesting a wetland environment. Similar areas, such as those along the Samica River, also remained unpopulated during the LBA-EIA.

The so-called 'state of the research' often serves as a convenient rationale for archaeologists to support or dismiss arguments. This reasoning also applies here, allowing us to propose that, based on the current research stage, the Gogolewo hoard was likely deposited between two emerging settlement areas of LUC communities. However, it is challenging to determine whether the hoard is more closely associated with the northern or southern group of these settlements. The interpretation of such a location should consider the potential cultural significance attributed to boundaries and metal objects (Maciejewski 2016, 155-172).

The topographical distinctiveness of the hoard's location, combined with its proximity to an elevation overlooking the river and its likely expansive floodplains, appears highly significant. This terrain feature was visible from many points in the surrounding area, potentially serving as a landmark and vantage point. The choice of location was likely deliberate. An intriguing question arises as to whether the hoard site was associated with an earlier structure, such as an MBA grave, or whether the 'pile of stones' was intentionally created to emphasise the site's uniqueness. Unfortunately, this question remains unanswered, as determining the exact location of the former stone structure and its investigations would be necessary. This location could not be identified despite extensive desk research and fieldwork.

This study expands our understanding of hoards deposited within monumental stone structures. It also adds to the record of hoards placed within the physical landscape. By comparing known settlement data from the LBA-EIA with information on the potential natural environment and considering the cultural significance of space, this site can be interpreted within the broader context of the cultural landscape.

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BURYING IRON AT TYNIEC, MASZKOWICE, AND ELSEWHERE: DISTINCT REGIONAL PATTERNS OF METAL DEPOSITION IN THE EARLY IRON AGE OF SOUTHERN POLAND

ABSTRACT

Dzięgielewski K., Markiewicz J. A., Przybyła M. S., Brzeska-Zastawna A., Zastawny A. and Rąpała J. 2025. Burying iron at Tyniec, Maszkowice, and elsewhere: distinct regional patterns of metal deposition in the Early Iron Age of Southern Poland. *Sprawozdania Archeologiczne* 77/1, 101-139.

Recent discoveries of hoards composed of iron objects in Lesser Poland suggest the existence of a specific cultural norm of deposition and a high valorisation of this metal at the onset of the Early Iron Age (750-550 BC). By broadening the scope of analysis to include single finds of 'large irons' and comparing them with burial assemblages, a contrasting picture of regional dichotomy emerges. It is manifested in differing practices of iron deposition among related communities of the period. Those inhabiting the mountainous zone (extending as far as the Vistula valley) buried iron as single depositions or in hoards placed in selected locations within the landscape. Those living in the upland areas to the north of the Vistula, on the other hand, deposited iron exclusively in graves. After presenting two hoards from Kraków-Tyniec and a group of artefacts from Maszkowice, we examine the broader context of these finds along with patterns in the distribution of hoards within the landscape.

Keywords: hoards, iron, Hallstatt C-D1, Lusatian culture, Lesser Poland, fragmentation
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INTRODUCTION, MATERIALS AND METHODS

According to the 'pendulum model' presented by K. Kristiansen (1998), the pattern of exclusion of goods from circulation, mainly metal items, in Bronze Age and Early Iron Age Europe (2300-450 BC) can be characterized in general outline as an alternating dominance of their deposition in the ground as grave furnishings or as so-called hoards, *i.e.*, mass deposits of metal objects outside the sepulchral context. In this model, the Early Iron Age (800-450 BC), especially in Central Europe, where the Hallstatt culture was either present or significantly influenced local cultures, is a period of a distinct shift towards the deposition of metals in the form of personal grave goods. In the Circum-Alpine Region, Bohemia, and southern Moravia, this tendency sometimes manifested itself in lavish furnishings in barrow burials. It was undoubtedly related to changes in the social structure towards a higher degree of hierarchy compared to the Urnfield societies of the Late Bronze Age. In many regions, especially within the Western Hallstatt culture, the practice of hoard deposition largely disappeared, but at the same time, in the peripheries of this cultural

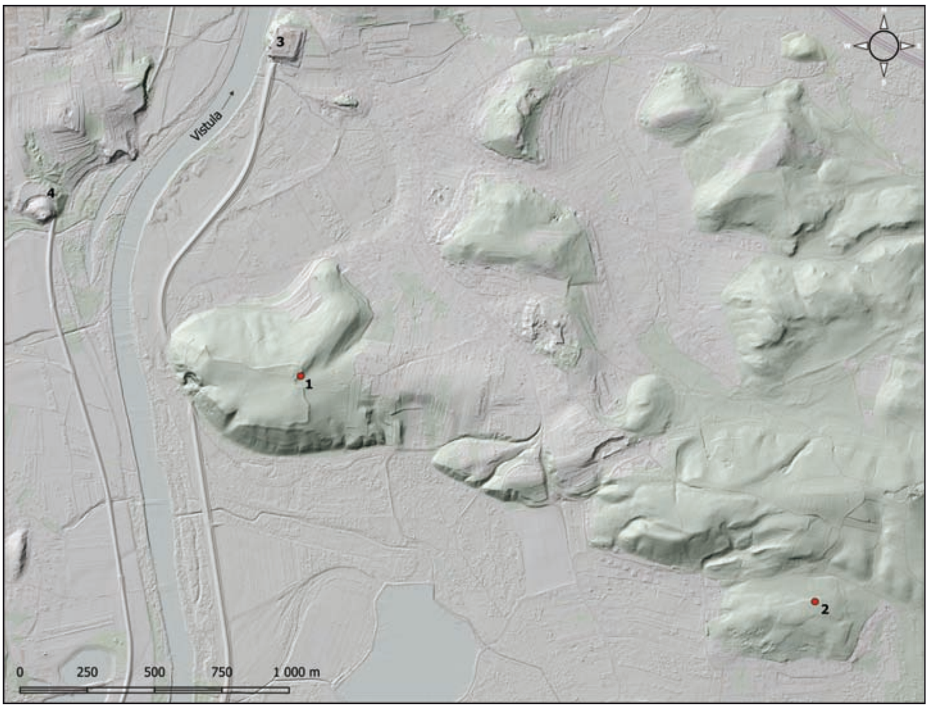


Fig. 1. Location of the hoards of iron ring ornaments from Kraków-Tyniec (red dots). 1 – Kraków-Tyniec 'Grodzisko', Site 1 (Early Iron Age hillfort), 2 – Kraków-Tyniec 'Wielogóra', Site 10. For orientation purposes, and also due to the presence of open hilltop settlements from the Early Iron Age, two distinctive points of the cultural landscape have been marked: the Benedictine abbey in Tyniec (3) and the medieval motte-and-bailey fort in Piekary (4). Developed by K. Dzięgielewski

circle, the custom continued (Westhausen 2019; Golec *et al.* 2023, 16). This was noted for the territory of Poland, where the 'Hallstatt norm' (rich grave furnishings, disappearance of hoards) was evident in the areas of Silesia and southern Greater Poland, covered by strong Hallstatt influences (Gedl 1991; Blajer 1992; 2001), or – according to some approaches – even representing a regional variety of this cultural circle (Gediga 2011). Outside this area, *e.g.*, in Lesser Poland (Małopolska), where local communities preserved the Urnfield traditions to a greater extent, the practice of depositing hoards continued. At the same time, the standard of richer burials with metal items (so-called 'large bronzes' and especially 'large irons') was adopted to varying degrees (Dzięgielewski *et al.* 2020). In recent years, the growing number of discoveries of single iron objects and deposits in Lesser Poland, especially in the Polish Western Carpathians, has allowed us to notice regional differences in the reception of both the discussed deposition patterns and the new metal – iron – itself.

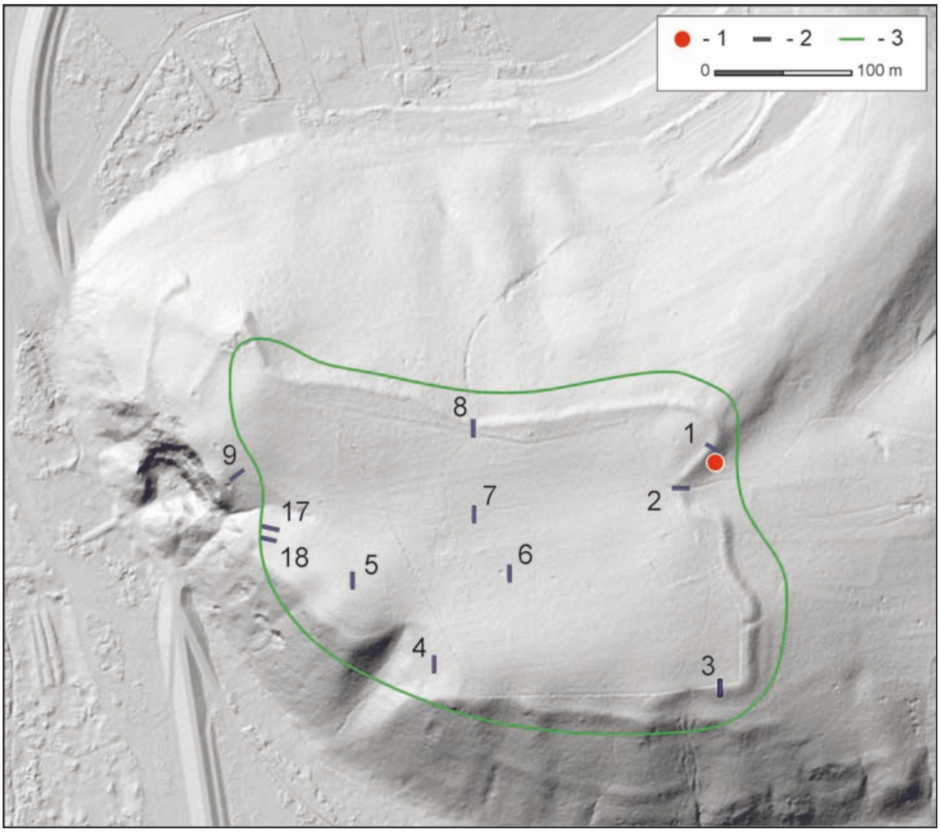


Fig. 2. Kraków-Tyniec 'Grodzisko' with prehistoric defensive ramparts visible from the north and east. Indicated: 1 – findspot of the iron hoard, 2 – test trenches from 1948 and 1951, 3 – extent of archaeological site no. 1 according to the Polish Archaeological Record (AZP). Developed by A. Brzeska-Zastawna and A. Zastawny

Starting from the presentation of two new hoards from Kraków-Tyniec (Fig. 1) and a group of artefacts from Zyndram's Hill in Maszkowice (partly known from the literature but never presented in a contextual approach; *cf.*, Cabalska 1970), we would like to draw attention to the presence of a regional cultural dichotomy, manifested in the different ways of depositing massive iron objects by culturally related communities of the period between 750 and 550 BC. The presentation of the sources is followed by an analysis of the artefacts using the typological method and dating based on the comparative method. Two recently published groups of 'purely' iron deposits, from the Kraków area (Dzięgielewski *et al.* 2020) and the Bielsko-Biała area (Chorąży and Chorąży 2022), constitute a special reference group at the regional scale. However, due to the supra-local typological nature of the metal items, the areas of reference are primarily Silesia and Greater Poland and the early Hallstatt (Ha C-D1) cemeteries of these regions, richly furnished with such objects – including mainly Świbie, Gliwice District, for which a relative periodisation was developed (Michnik and Dzięgielewski 2022). Next, we will examine the regional context of these finds, paying attention to the aforementioned dichotomy in the manner of deposition of 'large irons,' as well as to trends in the location of hoards within the settlement network and landscape. In the context of the finds from Maszkowice, we will also consider the previously rarely described phenomenon of intentional fragmentation of iron objects.

NEW OR VERIFIED SOURCES

Kraków-Tyniec 'Grodzisko', Site 1

In 2025, in the area of Grodzisko Hill in Kraków-Tyniec, a hilly and forested southwestern district of Kraków (Figs 1 and 2), an iron hoard was accidentally discovered, consisting of five ring ornaments of varying sizes (Figs 3 and 4). The items were abandoned by metal detectorists who were illegally searching the area. They probably considered the iron finds uninteresting and left them at the discovery site, hiding them under a rotten tree root (Fig. 3: a). According to the accounts of the finders of the hoard – Beata Grabowska and Wiesława Kruczek – the rings were lying next to each other in a loose arrangement. Agnieszka Brzeska-Zastawna from the Institute of Archaeology of the Jagiellonian University and Albert Zastawny from the Archaeological Museum in Kraków were informed about the discovery, and the artefacts were transferred to them. Archaeologists, along with the finders, conducted field verification, during which the discovery site was identified and marked on a map. It is situated on the main forest path, crossing the Grodzisko Hill on the east-west axis, at 272 m a.s.l., where the remains of an earthen rampart are clearly visible. The iron objects were discovered on the external slope of the eastern section of the rampart, slightly below its crown (Fig. 2). During the on-site inspection, it was found that this area bears traces of repeated searches by metal detectorists. Numerous pits disturbed not only areas covered with humus but also stone structures, as evidenced by limestone scattered on the surface.

Fig. 3. Kraków-Tyniec ‘Grodzisko’: a – moment of re-discovery of the finds discarded by metal detector users, b – iron rings immediately after recovery. Photos: A. Zastawny

Fig. 4. Kraków-Tyniec ‘Grodzisko’. Iron rings after preliminary cleaning (collection of the Archaeological Museum in Kraków). Photo: A. Susuł

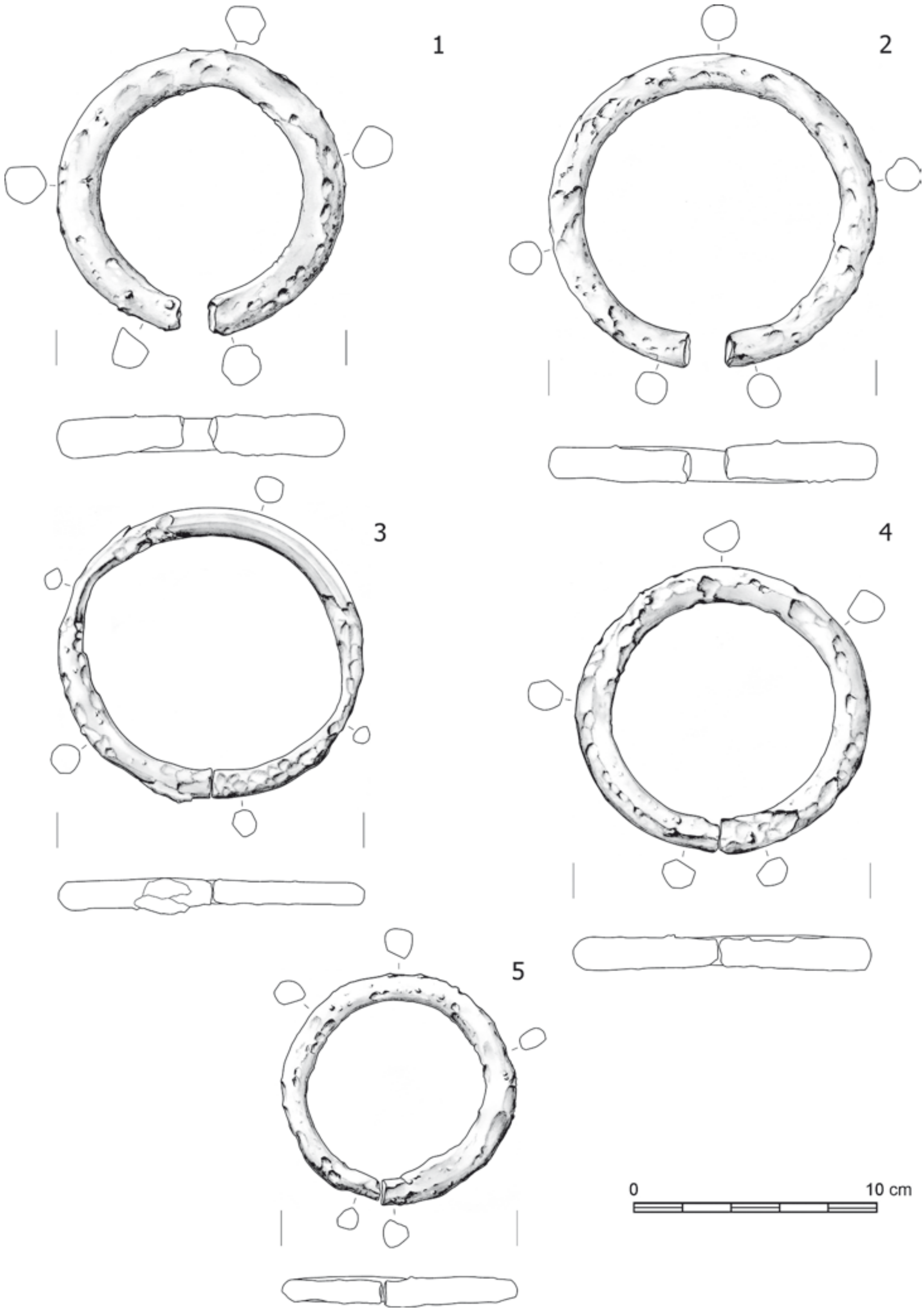


Fig. 5. Kraków-Tyniec 'Grodzisko'. Hoard of iron rings.
Drawing: A. Zastawny

It was determined that the place of discovery is located in the eastern, peripheral part of the archaeological site 1 in Kraków-Tyniec (AZP 103-55/17), entered into the register of archaeological monuments in 1968 under no. 1058. It is a multicultural site with traces of settlement from the Neolithic to the early Middle Ages, known primarily for the relics of an Early Iron Age defensive settlement of the Lusatian culture. In 1948 and 1951, excavations were carried out here by Gabriel Leńczyk from the Archaeological Museum in Kraków, who opened 18 test trenches on the ramparts and the courtyard of the hillfort (Leńczyk 1955). The place where the iron hoard was found is located between Trench 1 (rampart) and Trench 2 (gate) from 1948 (Fig. 2).

Hoard composition (Fig. 4):

1. Iron ankle ring – open, with straight-cut, almost touching ends, circular in shape, made of a massive bar of circular cross-section, partly hammered flat from the 'lower' side. At one end, there is a defect, resembling flaking, caused by chiselling; on the opposite side, from the inside, there is a similar thinning of the bar, caused by hammering. Dimensions: diameter 11.5 cm, bar diameter 1.6-1.7 cm, distance between ends 1.2 cm, weight 424 g (Fig. 5: 1).

2. Iron ankle ring – open, with straight-cut, almost touching ends, oval (originally circular?) in shape, made of a massive bar of circular cross-section. Dimensions: diameter 12.6-13.1 m, bar diameter 1.3-1.4 cm, distance between ends 1.5 cm, weight 355 g (Fig. 5: 2).

3. Iron ankle ring – open, with straight-cut, touching ends, oval in shape, made of a bar of circular/oval cross-section (originally of partly polygonal cross-section – well-preserved fragments of the ring show traces of 'faceting' – *cf.*, Fig. 13: b). In two opposite parts of the ring, there is a pronounced narrowing of the cross-section, made by hammering mainly from the inner side (*cf.*, Fig. 13: a). Dimensions: diameter 11.7-12.2 cm, bar diameter 1.0-1.1 cm (at the narrowings 0.6-0.9 cm), weight 198 g (Fig. 5: 3).

4. Iron ankle ring – open, with straight-cut, touching ends, almost circular in shape, made of a massive bar of circular cross-section, diagonally hammered from the 'lower' side towards the inside of the ring along the entire circumference. Dimensions: diameter 11.6-11.8 cm, bar diameter 1.2-1.3 cm, weight 299 g (Fig. 5: 4).

5. Iron bracelet/ankle ring – open, with straight-cut, touching ends, almost circular in shape, made of a massive bar of semicircular cross-section, diagonally hammered from the 'lower' side towards the outside of the ring along the entire circumference. Dimensions: diameter 9.1-9.4 cm, bar diameter 0.9-1.1 cm, weight 126 g (Fig. 5: 5).

Kraków-Tyniec 'Wielogóra', Site 10

A hoard of two iron ring ornaments was found in 2023 on a small hill called Wielogóra (257 m a.s.l.), located in the southern part of the Tyniec Forests (Fig. 1). The discovery was made by Jakub Rąpała and Lucjan Michalik during searches with a metal detector, carried out under permit no. 164/23, issued by the Municipal Conservator of Monuments in

Kraków. The hoard was deposited in the northern part of the flattened top of the hill, near a wide pass separating the elevation from the neighbouring hills. Two iron ring ornaments were discovered in a small trench. They were located at a depth of about 35 cm below ground level, in a light brown sandy layer containing small stones up to 10 cm in size. The rings lay horizontally, one on top of the other, with a slight shift. In both cases, their ends point west, which may indicate a deliberate arrangement of the objects (Fig. 6). No other metal or ceramic artefacts were found in the trench. The place where the iron rings were discovered is about 2 km away from the hillfort at Kraków-Tyniec, Site 1 (see above). Pottery fragments of the Lusatian culture were also found near the western slopes of the Wielogóra hill, within the settlement at Kraków-Tyniec, Site 10 (Fraś and Olszowski 1971, 89).

Hoard composition (Fig. 7):

1. Iron ankle ring – open, with tapering, pointed ends, overlapping by ¼ of the circumference; circular in shape, made of a bar of circular cross-section. Dimensions: diameter 11.2-11.4 cm, bar diameter in the central part 1 cm, at the ends 0.4 cm, the ends overlap by 8 cm, running exactly parallel at a distance of approx. 0.15 cm, weight 139 g (Fig. 8: 1).

2. Iron ankle ring – open, with bluntly rounded, touching ends, circular in shape, made of a bar of circular cross-section. The ends are not on the same plane (they could partially overlap), but they show no signs of secondary damage (unbending or flexing). Dimensions: diameter 11.3-11.5 cm, bar diameter 0.7-0.8 cm, weight 95 g (Fig. 8: 2).

Maszkowice 'Góra Zyndrama', Site 1

From the area of the hillfort on Zyndram's Hill in Maszkowice, Nowy Sącz District, comes a collection of iron objects, including 20 rings of various sizes, three bars or fragments, two axes, and a sickle. Most of these artefacts were found at shallow depth (usually 20-25 cm) in the upper layers of the younger settlement phase of this site, dating to the Early Iron Age (Przybyła 2024a). Due to the homogeneity of the Iron Age layer, the high degree of erosion of its upper parts, and the methodological shortcomings of the excavations in the 1960s and 1970s, it is not possible to determine the chronology of the iron objects from Maszkowice solely based on context. The typological dating of this group of artefacts from southern Poland adopted in this article, however, allows for their confident assignment to the building phase V-VI of the site on Zyndram's Hill, which, based on a large collection of pottery and radiocarbon dates, can be synchronised with the Ha C-D1 phases (Markiewicz 2024, 573).

The locations of all iron artefacts, both those recovered during old excavations (1959-1975) and those discovered during new fieldwork (2010-2024), were precisely measured within the trenches. This made it possible to trace their distribution against the background of documented layers (Fig. 9) and the density map of the Early Iron Age pottery (Ha C-D periods) (Fig. 10). This procedure allows several observations regarding the circumstances of deposition of the analysed objects:

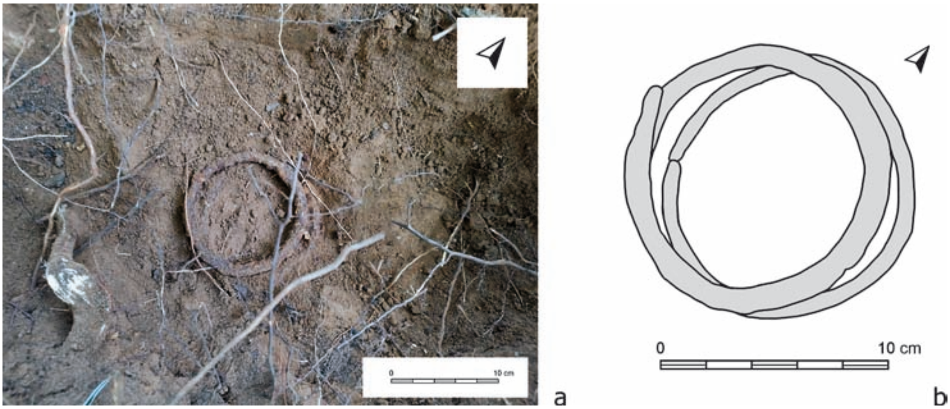


Fig. 6. Kraków-Tyniec 'Wielogóra': a – hoard of iron objects in situ, b – arrangement of the rings. Photo and drawing: J. Rąpała

Fig. 7. Kraków-Tyniec 'Wielogóra'. Iron rings after conservation (collection of the Institute of Archaeology and Ethnology, Polish Academy of Sciences, Kraków branch, Igołomia Archaeological Laboratory). Photo: K. Dzięgielewski

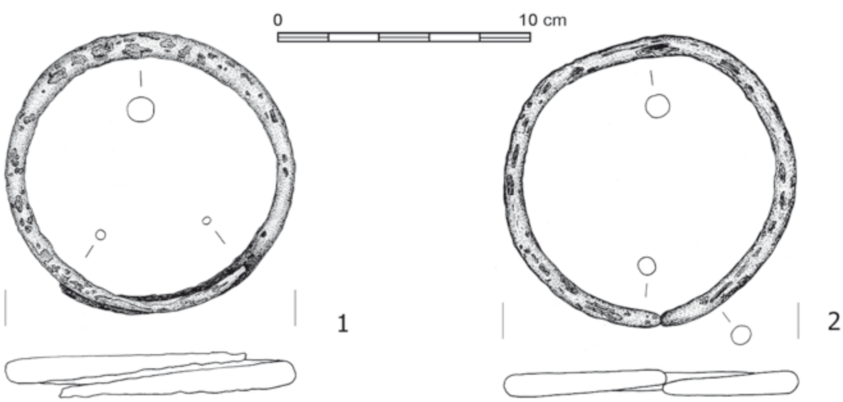


Fig. 8. Kraków-Tyniec 'Wielogóra'. Hoard of iron rings. Drawing: J. Rąpała

Fig. 9. Maszkowice 'Góra Zyndrama'. Distribution of iron objects against the background of documented structures associated with Iron Age settlements. a – fragment of a ring, b – complete ring, c – axe, d – bipyramidal bar, e – sickle; 1 – undocumented, 2 – range of pebble pavements, 3 – pavements displaced by slope erosion, 4 – area devoid of Iron Age layers, 5 – Iron Age cultural layer, 6 – cultural layer displaced by slope erosion, 7 – pits, 8 – certain and presumed postholes, 9 – certain and presumed course of the rampart from the Early La Tène period (drawn by J. A. Markiewicz and M. S. Przybyła)

Fig. 10. Maszkowice 'Góra Zyndrama'. Distribution of iron objects against the background of the density map of the Early Iron Age pottery (Ha C-D). a – fragment of a ring, b – complete ring, c – axe, d – bipyramidal bar, e – sickle (drawn by J. A. Markiewicz and M. S. Przybyła)

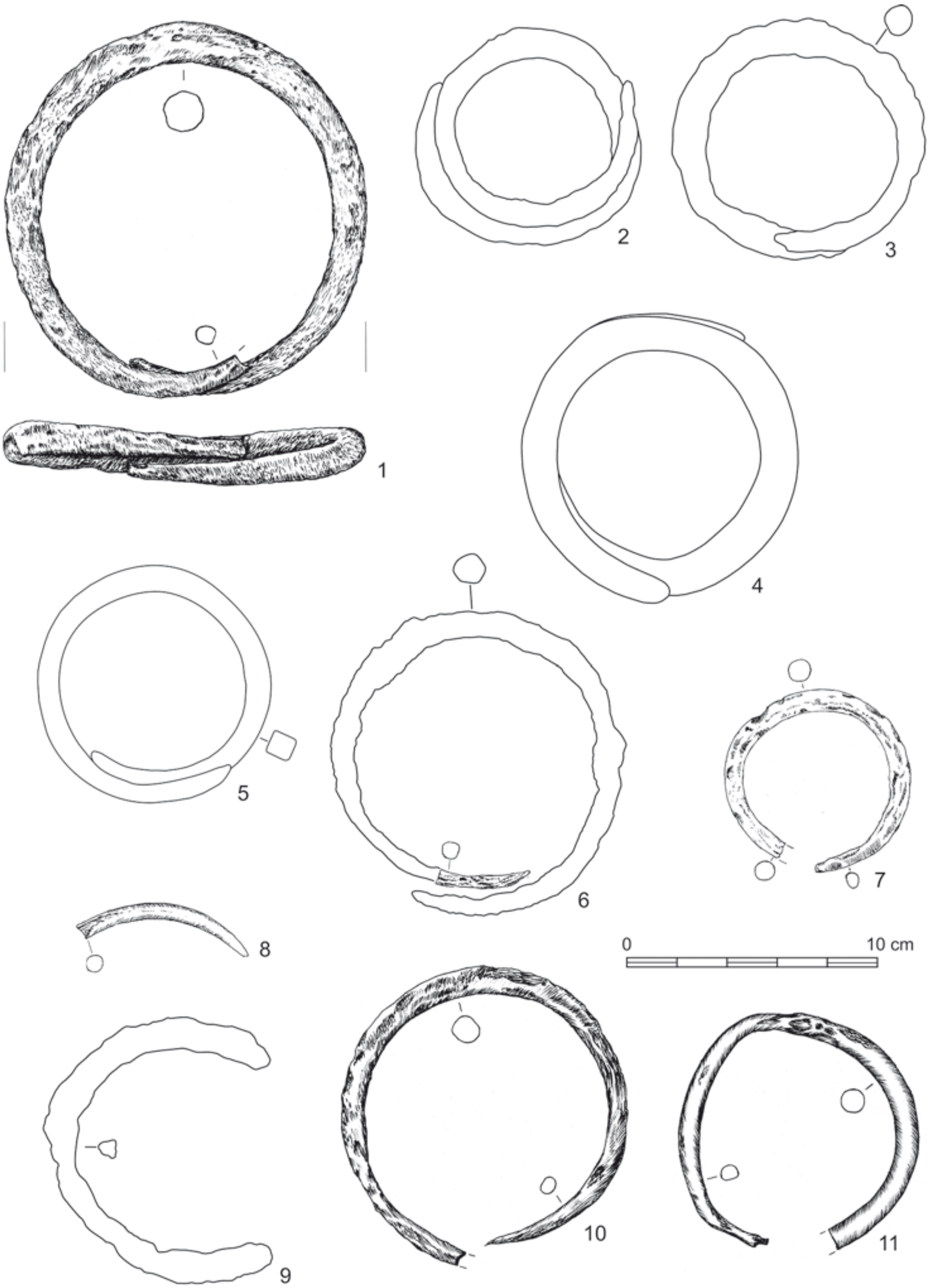


Fig. 11. Maszkowice 'Góra Zyndrama'. 1-7, 9-10 – iron rings, 8 – fragment of an iron ring (1, 7-8, 10-11 – drawn by J. A. Markiewicz and M. S. Przybyła; 2-5, 9 – based on field documentation from the 1960s and 1970s; 6 – drawn by M. S. Przybyła, partially redrawn based on field documentation from 1968)

(1) The distribution of iron artefacts is not uniform at the site. On the contrary, they show a general tendency to group in the northern part of the examined area, in the highest part of the top plateau, creating several smaller concentrations there. These clusters do not coincide with places where pottery fragments are concentrated. This means that the more frequent occurrence of iron objects is not related to the intensity of settlement processes or the scale of post-depositional processes (erosion and layer accumulation).

(2) In the zone with the highest density of iron rings, within the trenches from 1968, two rings were found less than 20 cm apart, while two further pairs were found less than 2 m apart. It can be stated that the iron rings closest together were located along the north-south axis. Considering the shallow depth at which these artefacts were deposited, it can be assumed that this is the result of some of them being displaced during agricultural work. Although the hillfort area was used as a meadow at the beginning of the research (1959), it is known to have been ploughed earlier. A German aerial photograph from 1944 shows that the ploughing furrows were arranged roughly along a north-south line (kind information from D. Golik).

(3) The above observations allow us to formulate a hypothesis that at least some of the iron artefacts from the hillfort on Zyndram's Hill originally formed deposits (possibly small, numbering up to two rings), which were disturbed by ploughing before the mid-20th century. These objects were deposited outside the zone of the greatest settlement intensity (Fig. 10). The two subsequent Iron Age settlements on Zyndram's Hill essentially replicated the spatial layout developed during the Early Bronze Age (ca. 1725-1500 BC). That is, the buildings were densely arranged along the edge of the promontory plateau, where the Bronze Age fortifications were partially preserved, surrounding an open space in the centre (Przybyła 2024a, 270-279; 2024b, 903, 904). Most of the iron objects are located on the approximate boundary between these two zones – the built-up and the open.

Hoard composition (the items 20 cm apart):

1. Fragment of an iron ring – open, made of a bar of circular cross-section. A tapered end with a pointed tip has been preserved; at the other end, a visible mark from cutting during metallurgical analysis in the second half of the 20th century is visible (in the drawing in the field documentation, the artefact is 2 cm longer). Dimensions: preserved length 7.5 cm, original diameter about 11 cm, bar diameter 0.3-0.5 cm, weight 12 g (Fig. 11: 8).

2. Iron ring – open, with tapering ends, initially overlapping; circular in shape, made of a bar of circular cross-section. One end is pointed, the other was cut off during metallurgical analysis in the second half of the 20th century. Dimensions: diameter 9.5 cm, bar diameter in the central part 0.9 cm, weight: 89 g (Fig. 11: 11).

Other objects:

3. Iron (ankle) ring – open, with tapering, overlapping ends, circular in shape, made of a bar of circular cross-section. One end is preserved, straight-cut; the other was cut off

during metallurgical analysis in the second half of the 20th century. Dimensions: diameter 14.5-15 cm, bar diameter in the central part 1.6 cm, at the ends 0.6-0.7 cm; the ends are poorly fitted, overlapping by approx. 5 cm; weight 428 g (Fig. 11: 1).

4. Iron ring – open, with tapering, pointed ends, overlapping by ½ of the circumference; circular in shape. Dimensions: diameter 8.5-9 cm, bar thickness in the central part approx. 1.2 cm, at the ends approx. 0.7 cm. The artefact was lost (redrawn here, based on field documentation from 1972: Fig. 11: 2).

5. Iron ring – open, with slightly tapering, overlapping ends, circular in shape, made of a bar of circular cross-section. Dimensions: diameter 9.5-10 cm, bar diameter 1.1-1.2 cm. The artefact was lost (redrawn from field documentation from 1975; Fig. 11: 3).

6. Iron ring – open, with bluntly rounded ends, overlapping by ½ of the circumference; circular in shape. Dimensions: diameter 11-11.5 cm, bar thickness approx. 1.3 cm. The artefact was lost (redrawn here, based on field documentation from 1962: Fig. 11: 4).

7. Iron ring – open, with bluntly rounded, overlapping ends, circular in shape, made of a bar of rectangular (?) cross-section. Dimensions: diameter 9.3 cm, bar thickness approx. 1 cm. The artefact was lost (redrawn here, based on field documentation from 1963: Fig. 11: 5).

8. Iron (ankle) ring – open, with tapering, overlapping ends, circular in shape, made of a bar of circular cross-section. Originally complete, cut during metallurgical analysis in the second half of the 20th century – one pointed end was preserved, the rest was lost. Dimensions of the preserved part: length 3.5 cm, maximum bar diameter 0.6 cm, weight 4 g. Original dimensions (according to the drawing in the field documentation from 1968): diameter 11.6-12 cm, bar diameter in the central part 1.1-1.2 cm (Fig. 11: 6).

9. Iron ring – open, with tapering, initially touching or slightly overlapping ends, circular in shape, made of a bar of circular cross-section. One end was cut off during metallurgical analysis in the second half of the 20th century. Dimensions: diameter 7.3-7.5 cm, bar diameter in the central part 0.9 cm, at the ends 0.5-0.6 cm, weight 41 g (Fig. 11: 7).

10. Iron ring – open, with bluntly rounded ends (?), circular in shape (according to the drawing in the field documentation preserved in ¾ of the circumference), made of a bar of triangular (?) cross-section. Dimensions: diameter approx. 10.5 cm, minimum bar thickness 0.7 cm, distance between ends (?): 7 cm. The artefact was lost (redrawn from field documentation from 1963; Fig. 11: 9).

11. Iron ring – open, with tapering, initially overlapping ends, circular in shape, made of a bar of circular cross-section. One end is pointed, the other was cut off during metallurgical analysis in the second half of the 20th century. Dimensions: diameter 11.4-12 cm, bar diameter in the central part 1-1.1 cm, weight 107 g (Fig. 11: 10).

12. Fragment of an iron neck-ring of the Maszków type – made of a twisted bar of rectangular cross-section, with one end preserved, hammered flat and rolled up into an eye (looped). The state of preservation hardly allows for determining whether the twisting direction has changed. Secondarily reworked into a bracelet, circular in shape, with unevenly

overlapping ends. Dimensions: diameter 8.2-8.4 cm, bar cross-section 0.3 × 0.4 cm, ends overlapping by 3.5 cm, weight 32 g (Fig. 12: 1).

13. Fragment of an iron neck-ring (?) – made of a twisted bar of rectangular cross-section, with unpreserved ends. There is no change in the twisting direction on the preserved section. Secondarily reworked into a bracelet, circular in shape, with overlapping ends. Dimensions: diameter 6.5 cm, bar cross-section 0.4 × 0.5 cm, ends overlapping by 3 cm, weight 21 g (Fig. 12: 2).

14. Fragment of an iron neck-ring (?) – made of a twisted bar of rectangular cross-section, with unpreserved ends; one end was cut off during metallurgical analysis in the second half of the 20th century. There is no change in the twisting direction on the preserved section. Secondarily reworked into a bracelet or ankle ring, circular in shape, with an incomplete circumference. Dimensions: diameter 8.5 cm, bar cross-section 0.7 × 0.7 cm, distance between ends approx. 6 cm, weight 53 g (Fig. 12: 3).

15. Fragment of an iron ring (less than ½ of the circumference). Dimensions: original diameter approx. 10 cm, bar thickness approx. 1.1 cm. The artefact was lost (redrawn here, based on field documentation from 1961: Fig. 12: 4).

16. Fragment of an iron ring (approx. ½ of the circumference). Dimensions: original diameter approx. 7.5 cm, bar thickness approx. 0.9 cm. The artefact was lost (redrawn here, based on field documentation from 1965: Fig. 12: 5).

17. Fragment of an iron ring – made of a bar of circular cross-section. Dimensions: preserved length 8.5 cm, original diameter approx. 11 cm, bar thickness approx. 1.4 cm. The artefact was lost (redrawn here, based on field documentation from 1972: Fig. 12: 6).

18. Fragment of an iron ring – made of a bar of circular cross-section. Dimensions: preserved length 11 cm, original diameter approx. 12 cm, bar thickness approx. 1.7 cm. The artefact was lost (redrawn here, based on field documentation from 1975: Fig. 12: 7).

19. Fragment of an iron ring – made of a bar of circular cross-section. Both ends show traces of having been secondary cut off in prehistoric times (*cf.*, Fig. 14: 1). Dimensions: preserved length 7.5 cm, original diameter approx. 11 cm, bar diameter 0.9-1 cm, weight 28 g (Fig. 12: 8).

20. Fragment of an iron ring – made of a bar of circular cross-section. Both ends show traces of having been secondary cut off in prehistoric times; one of them was additionally cut during metallurgical analysis in the second half of the 20th century (*cf.*, Fig. 14: 2). Dimensions: preserved length 7.5 cm, original diameter approx. 11 cm, bar diameter 1.1-1.3 cm, weight 55 g (Fig. 12: 9).

21. Fragment of an iron socketed axe with a socket of rectangular cross-section – preserved socket with a part narrowing towards the blade. Dimensions: preserved length 7 cm, socket cross-section 3.5 × 4.5 cm. The artefact was lost (Fig. 12: 10 after Gedl 2004).

22. Fragment of an iron socketed axe with a socket of rectangular cross-section – preserved blade with a part of the socket. Dimensions: preserved length 8.4 cm, blade width 5.5 cm. The artefact was lost (Fig. 12: 12 after Gedl 2004).

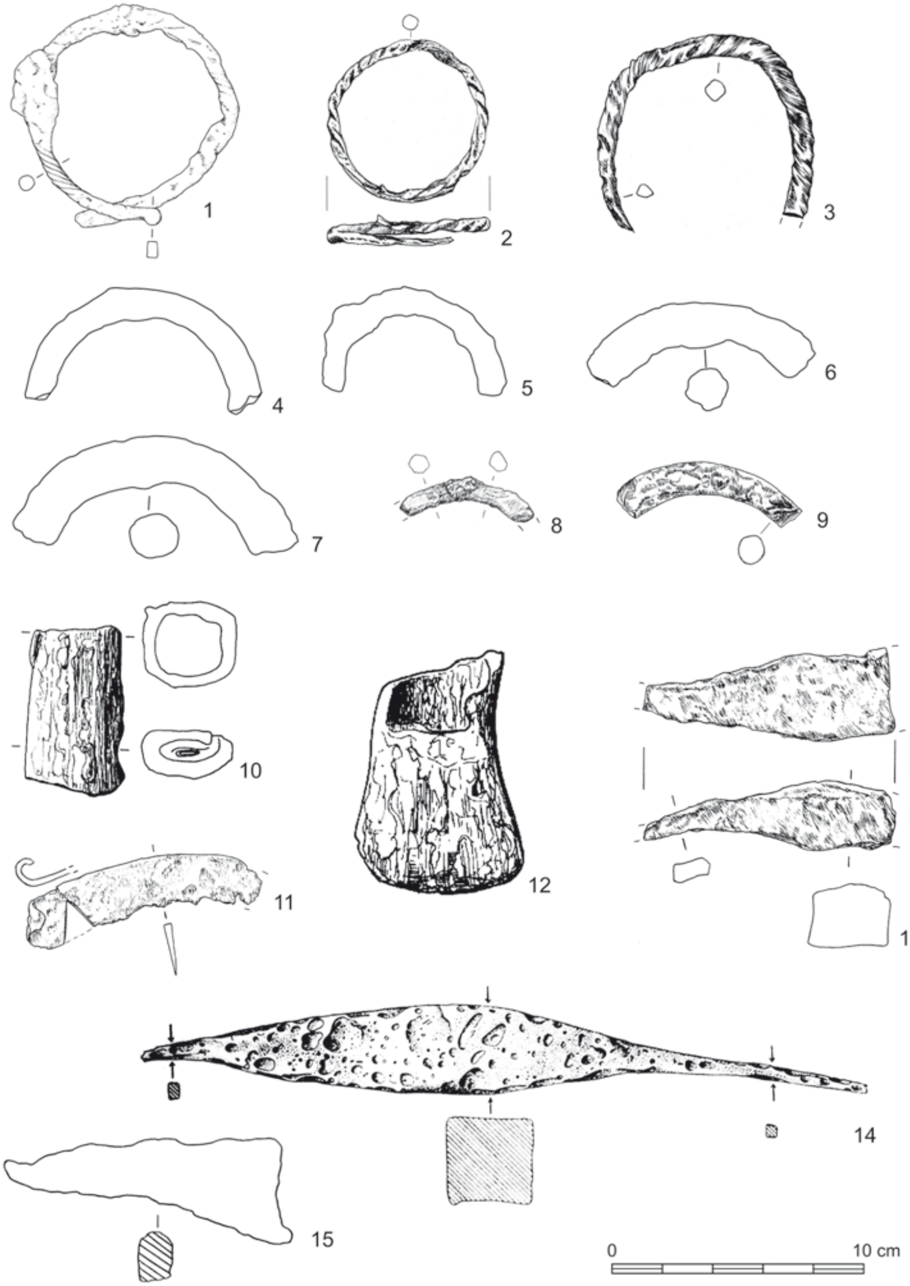


Fig. 12. Maszkowice 'Góra Zyndrama'. 1-3 – fragments of neck-rings made of twisted iron bar; 4-9 – fragments of iron rings; 10, 12 – iron socketed axes; 11 – iron sickle; 13-15 – iron bipyramidal bars (1-3, 8-9, 11, 13 – drawn by J. A. Markiewicz, M. S. Przybyła and E. Rydzewska; 10, 12 – after Gedl 2004; 14 – after Cabalska 1964; 4-7, 15 – based on field documentation from the 1960s and 1970s)

23. Fragment of an iron sickle with a perpendicular projection at the base – designed for left-handed people; slightly arched blade, heavily corroded in the tip part and with traces of modern cutting. A sample was cut out from part of the blade at the base for metallurgical analysis in the second half of the 20th century. Dimensions: preserved length 9.5 cm, maximum blade width 2.1 cm, thickness 0.2 cm, weight 20 g (Fig. 12: 11).

24. Fragment of an iron bipyramidal bar – the wider part shows traces of being cut off in prehistoric times (*cf*., Fig. 16), the narrower part was cut off during metallurgical analysis in the second half of the 20th century. Dimensions: preserved length 9.7 cm, cross-section of the broadest part 3.2 × 2.3 cm, the narrowest part 1 × 0.5 cm; weight 227 g (Fig. 12: 13).

25. Iron bipyramidal bar. Dimensions: length approx. 30 cm, cross-section of the broadest part approx. 3.6 × 3.6 cm, the ends approx. 0.6 × 0.8 cm, weight: 875.5 g. The artefact was lost (data and Fig. 12: 14 after Cabalska 1964).

26. Fragment of an iron bipyramidal bar. Dimensions: preserved length 11 cm, thickness at the widest part 4 cm. The artefact was lost (redrawn here, based on field documentation from 1975; Fig. 12: 15).

TYPOLOGICAL AND CHRONOLOGICAL ANALYSIS

Bracelets and ankle rings

The massive arm and leg ornaments from the analysed deposits represent two types. The first of them is distinguished by tapered, overlapping ends, which can be pointed (Tyniec 'Wielogóra', Fig. 7: 1), bluntly rounded (Tyniec 'Wielogóra', Fig. 7: 2) or straight 'cut' (Maszkowice, Fig. 11: 1). They can be referred to as Świbie type rings due to their most numerous occurrence in Poland in this Upper Silesian cemetery (114 items; Michnik, Dzięgielewski 2022, 101). The specimens from the discussed hoards that were preserved in their entirety and not secondarily unbent allow us to conclude that they were usually spirals of 1.2-1.25 coils (Fig. 7: 1), but there are also examples (perhaps secondarily reduced to the size of a bracelet?) reaching over 1.5 coils (Maszkowice, Fig. 11: 2). The specimens from the deposits were made of a massive, usually circular in cross-section, iron bar up to a maximum thickness of 16 mm. The diameters of the ornaments allow us to distinguish among them rings the size of both an ankle ring and a bracelet. However, as shown by research in inhumation cemeteries (*e.g.*, in Gliwice-Łabędy 'Przyszówka', Częstochowa-Raków or Świbie – Dobrzańska-Szydłowska and Gedl 1962; Błaszczyk 1965; Michnik and Dzięgielewski 2022), rings of the same size could have been both arm and leg ornaments. In particular, small specimens (the size of a bracelet) could have been ankle rings in children's graves. The reverse is rare, so here we refer to all rings over 11 cm in diameter as ankle rings. In Świbie, the discussed type of iron rings is indicative of the middle and, mainly, the late phase of the necropolis, dated to Ha C2 and C2-D1, respectively (Michnik and Dzięgielewski 2022, 122-123, table 4.1). A similar chronology (Ha C2) is indicated by the results of a seriation of hoards, including those from Małopolska (Maszków, Kraków District), containing this type of ornament (Dzięgielewski *et al.* 2020, 234, fig. 20). Interestingly, the massive bronze spirals the size of ankle rings, classified as the Stary Sącz, Kujawy and Masovia varieties (Andrzejowska 2016; Maciejewski 2019), are younger (Ha D) than the iron specimens (Dzięgielewski *et al.* 2020, 234). On the other hand, it is hard not to notice the formal similarity of the latter to the bronze ankle rings of the Górny Śląsk type (Michnik 2022, pl. 15: 14, 15, 169: 7, 8), which at the Świbie necropolis are a form typical of the early phase (Ha C1b) (Michnik and Dzięgielewski 2022, 99-100). Both the Stary Sącz-type bronze ankle rings and the Świbie-type iron specimens are therefore most likely to be later, younger morphotypes derived from Górny Śląsk-type bronze ankle rings.

The second type of iron rings – open, made of a massive bar, with straight-cut, touching ends – also occurs in various sizes/functional variants in Early Iron Age assemblages. The hoard from Kraków-Tyniec 'Grodzisko' included two pairs of massive rings, the size of an ankle ornament, and one smaller ring, the size of a bracelet (Fig. 5). This collection resembles the set known from the nearby hoard from Młodziejowice on the Dłubnia River (Dzięgielewski *et al.* 2020). All of the rings were made of a bar of circular cross-section but hammered flat from the 'lower' side. This feature distinguishes the artefacts of the 'Grodzisko' and Młodziejowice hoards from other fairly numerous specimens from Poland, which are usually made of a bar of circular cross-section, though not always regular (some examples are flattened from the inside). It seems that the rings from Grave 549 from Domasław, Wrocław District, may have had similar cross-sections (Gediga and Józefowska 2018, pl. 72: 4, 5). The only probable specimen from Maszkowice can be classified as this type based on diameter (Fig. 12: 7). This simple type of ring ornament, referring to the analogical bronze rings dated to the end of the Bronze Age and the beginning of the Iron Age, appears sporadically in the older phase of the Hallstatt period in hoards (Brzesko, Pyrzyce District;

Fig. 13. Details of ankle ring no. 3 from Kraków-Tyniec 'Grodzisko': a – hammer-forged constriction of the rod, b – faceting of the surface into a polygonal cross-section. Photo: A. Susuł

Blajer 2001, fig. 27) and in greater numbers in cemeteries (*e.g.*, Chojno-Golejewko, Rawicz District; Nadziejewo, Środa Wielkopolska District) (Dzięgielewski *et al.* 2020, 228).

An interesting and hitherto unrecorded feature in iron rings is a kind of faceting of the rod, evident on a well-preserved surface fragment of a specimen from Tyniec 'Grodzisko',

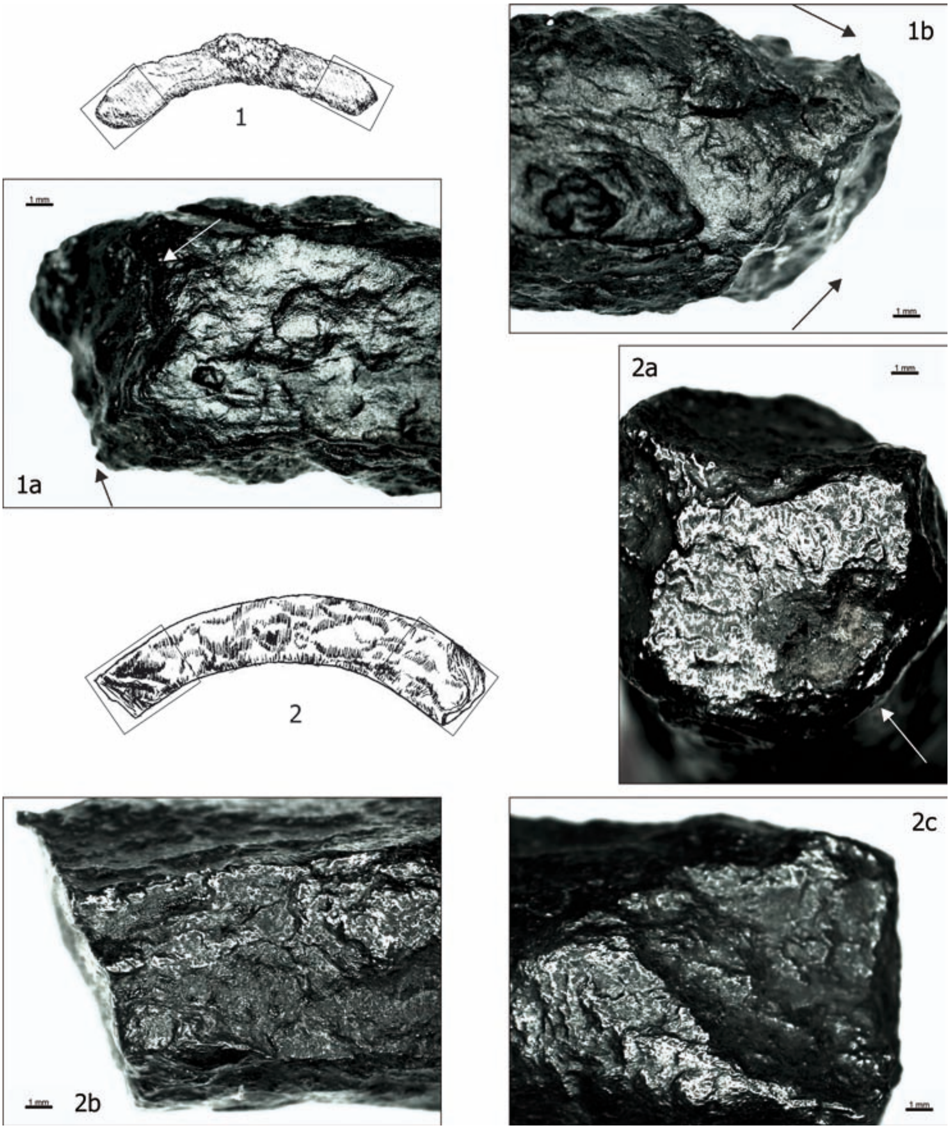


Fig. 14. Traces of intentional fragmentation on iron rings from Maszkowice 'Góra Zyndrama': 1 – ring no. 19, 2 – ring no. 20 (2b – end cut for metallurgical analysis in the second half of the 20th century). Arrows indicate the direction of chisel blows. Photo: K. Dzięgielewski

which makes its cross-section polygonal (Fig. 5: 3; 13: b). The same specimen was also, probably secondarily, hammered differently: on its perimeter, in two opposite places (not at the ends), a distinct narrowing can be seen, most probably made from the centre (Fig. 13: a). This element was not yet known from iron specimens, but still widely described in bronze ankle rings, especially of the Stary Sącz and Masovia types (Maciejewski 2019, 51, fig. 15: c; Michnik 2022, pl. 355: 7, 8). It has recently been shown that narrowings of this type could not have arisen as a result of wear or abrasion, but are the result of intentional hammering and polishing, presumably for a purpose related to some way of use of the ornament (Garbacz-Klempka *et al.* 2022, 300, 301, fig. 15: 6). Observing this phenomenon on an iron specimen, otherwise with an exquisitely preserved (faceted) surface, is further confirmation of this observation. Another interesting feature of some of the analysed ring ornaments from Maszkowice is their intentional fragmentation (Fig. 14), which is discussed later.

The iron rings from the Tyniec deposits, as well as all preserved objects from Maszkowice, were analysed using a portable Spectro xSORT spectrometer (model XHH03) to assess the possibility that they were made from meteoritic iron. This was undertaken because they are roughly contemporary with the specimens from Częstochowa-Raków, which were made entirely or partially from such material (Błaszczyk 1965; Jambon *et al.* 2025). However, none of the examined items exhibited nickel concentrations exceeding 1% in any of the at least three analytical points per object, which rules out the use of meteoritic iron. The detailed measurement results will be incorporated into the project's database on the chemistry and provenance of early iron in Poland (*cf.*, Jambon *et al.* 2025, 4).

Neck-rings

In the analysed set, unlike the previously mentioned hoards from Maszków and Młodziejowice near Kraków, no functional neck-rings were found. Only a fragment of a twisted ornament from Maszkowice (Fig. 12: 1), reused as a bracelet, can be surely classified as a piece of a neck-ring. Observations under an optical microscope of this heavily corroded object may suggest that it was a *Wendelring*, *i.e.*, a twisted ring with a change in the twisting direction (*cf.*, Fig. 15: b, c). This assumption could not be confirmed by X-ray imaging (performed by M. Goryl from Cracow University of Technology) due to the absence of a metal core and the object's support solely by a corrosion layer. However, it does not seem likely that the twisting was unidirectional – in almost all the fully preserved neck-rings, an alternating direction of twisting is visible (Derrix 2001, 119-122; possible exception: Łubnice, Wieruszów District – Kaszewski 1969, 99, fig. 2: 3). Due to the presence of an eyelet (Fig. 15: a), the specimen can be classified as a Maszków type neck-ring (Dzięgielewski *et al.* 2020, 225, fig. 10: 2). This type differs in one detail from the most numerous type of iron *Wendelringe* – the Gorszewice type according to R. Heynowski (2000, 15, 16, pl. 78: 1): the form of the terminals, which are hammered flat and rolled up into loops, similarly to Late Bronze Age bronze neck-rings made of a thin bar, known as the Kaliszanki type in Heynowski's

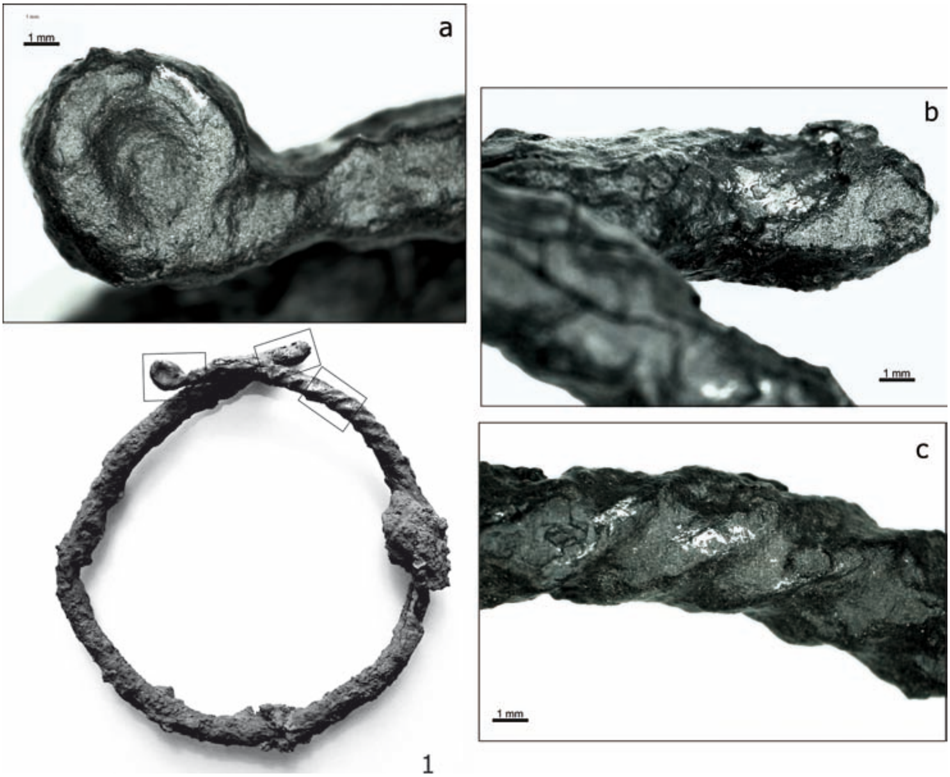


Fig. 15. Details visible on a fragment of a neck-ring from Maszkowice 'Góra Zyndrama', secondarily coiled into a bracelet (no. 12): a – loop made from a flat, hammered rod, b – presumably rectangular cross-section of the rod (a non-twisted segment possibly indicating a change in the twisting direction), c – twisted section. Photo: K. Dzięgielewski

classification. Another specimen of this kind was discovered in recent years in a hoard of bronze and iron objects from the early Hallstatt period from Grabionna, Piła District (Garbacz-Klempka *et al.* 2024b, 174, fig. 1). The dating of the hoards from Maszków and Grabionna should not be later than the Ha C2 phase (Dzięgielewski *et al.* 2020, fig. 232). The remaining two secondarily reduced twisted rings from Maszkowice (one to the size of a bracelet – Fig. 12: 2; the other most probably an ankle ring – Fig. 12: 3), may also be made from *Wendelringe* neck-rings. However, the length of their circumferences and state of preservation do not allow for an ascertainment of this fact.

Tools: knife, sickles and axes

The three deposits presented here (Tyniec 'Grodzisko', Tyniec 'Wielogóra', Maszkowice 'Góra Zyndrama') did not include tools. However, based on the composition of the hoard from Młodziejowice, it can be stated that the deliberate deposition of this category of iron objects was not unknown in Małopolska at the beginning of the Iron Age. For this reason, we treat individual finds of large tools from settlements or distinctive terrain forms as possible intentional depositions. This assumption is supported by loose finds of sickles and axes from Porąbka and Kobiernice, Bielsko-Biała District, discovered at a distance from settlement sites in a high landscape zone (Chorąży and Chorąży 2022, 21, 22). Multi-element iron deposits also come from the exact locations.

The iron sickle from Maszkowice (Fig. 12: 11) represents the group of iron sickles with a perpendicular projection at the base – the most popular sickle type in the Early Iron Age in the Odra and Vistula rivers basins (Gedl 1995, 94-99, pls 33-35, 46B; Derrix 2001, 80-82, fig. 38). Sickles of this type are among the tools in which bronze was most quickly replaced by iron. Alongside the less numerous tanged sickles, they were widespread in Poland from the beginning of the Hallstatt period (Dzięgielewski *et al.* 2020, 229).

In Sobolów, Bochnia District, an iron knife (Wardas-Lasoń *et al.* 2025, fig. 2 – here mistakenly referred to as a sickle) appeared in a deposit for the first time in Lesser Poland – a tool commonly found in grave inventories from the Early Iron Age (Gedl 1973, 53; Gediga *et al.* 2020, 73, figs. 119, 122; Szczurek 2021, 191). Due to its state of preservation, it is probable, but not sure, that it represents the group of large knives with an angled, roof-shaped back, which in the cemetery in Świbie usually occurred in the middle and late phases (Ha C2-D1) (Michnik and Dzięgielewski 2022, 105). Outside Lesser Poland, the presence of a knife in an early Hallstatt hoard was noted only in Kiełpino, in the Gryfice District (Kozłowska-Skoczka 2012, 179-181), and perhaps in Biskupin, Hoard II (Durczewski 1961, 10). This category of tools appears in greater numbers only in deposits from the late Hallstatt period (*e.g.*, Bąków Dolny, Łowicz District; Michalski 2000; Myštěves, Hradec Králové District; Mangel *et al.* 2025, fig. 4).

A recurring element of the discussed hoards and among single finds are axes, representing only a few types: trunnion axes (flat hatchets with lateral projections, *Ärmchenbeile*) and simple, loopless socketed axes. The first type is represented by an axe from the settlement in Biskupice, Wieliczka District (Gedl 2004, 91, pl. 10: 91; Dzięgielewski 2024a, fig. 1.2.41: 13). Its intentional deposition, perhaps together with other large iron objects (a sickle, less likely also a bracelet – Dzięgielewski 2024a, fig. 1.2.41: 11), and not a loose settlement find, is supported by the fact that such tools, sometimes also interpreted as weapons, in Polish lands come in the vast majority from grave inventories (Gedl 2004, 56) or hoards and single item deposits (Blajer *et al.* 2021, 526; Půlpán *et al.* 2022, fig. 25). Slightly more finds from settlement contexts are recorded in Slovakia, but even there they are usually part of multi-element hoards (Půlpán *et al.* 2022, 41, 42). In Świbie, as well as in Domasław, trunnion axes occur throughout the older period of the functioning of these necropolises (Ha C1-C2) (Gediga *et al.* 2020, 75, 76; Michnik and Dzięgielewski 2022, 105, 106).

The second type of iron axes found in Lesser Poland in hoards (Młodziejowice) or as single finds (Maszkowice – Fig. 12: 10, 12; Kobiernice-Wołek, Bielsko-Biała District – Chorąży and Chorąży 2022, 14) are socketed axes. Two simple varieties, without a loop or decoration, can be distinguished by the socket's circular or rectangular cross-section (Gedl 2004). For the early Hallstatt assemblages (Ha C-D1), specimens with a socket of circular cross-section seem to be more typical, as indicated by several well-dated grave inventories and hoards from the Polish Lowlands (Gedl 2004; Gediga *et al.* 2020; Michnik and Dzięgielewski 2022; Garbacz-Klempka *et al.* 2024b) or Slovakia (Čambal and Makarová 2020, fig. 6). In turn, axes with rectangular-sectioned sockets seem to be slightly more common in the late Hallstatt period (Ha D). Their earlier chronology – within the Ha C phase, or at least its younger part – is confirmed by only a few well-dated assemblages, *e.g.*, graves from Żukowice, Głogów District (Gedl 2004, pl. 75), or Domasław (Gediga and Józefowska 2018). The hoard from Młodziejowice also seems to represent the younger Ha C period (Dzięgielewski *et al.* 2020). Most of the remaining axes of this type from Poland, including a large series from the stronghold in Wicina, Żary District (Michalak and Jaszewska 2011), should be linked mostly with the Ha D phase. This date is also confirmed by some closed assemblages from Bohemia (Mangel *et al.* 2025, 138, fig. 4). Both specimens from Maszkowice have a rectangular cross-section (Fig. 12: 10, 12). They are generally linked to the V-VI phase of this settlement, and therefore it is possible to date them to both the end of the Ha C and Ha D1 phases.

Bipyramidal bars

Seventeen whole or fragmented bars of iron in the form of two slender pyramids joined at the base (so-called bipyramidal bars, double-pointed bars, *Doppelspitzbarren*), present in the hoards and finds from the Małopolska region, almost exhaust the list of such forms of iron semi-product identified to date in Poland. In addition to three separately found specimens from Maszkowice (Fig. 12: 13-15; 16), there are three securely documented hoards containing seven (Porąbka I), two (Porąbka II) (Chorąży and Chorąży 2022), and five bars (Witów III) (Dzięgielewski *et al.* 2024b, fig. 2.3.15). Apart from these, only two other bipyramidal iron bars are known from Poland – from Biskupin, Hoard II (Durczewski 1961, 10, figs 1 and 2), and from Wicina (Michalak and Jaszewska 2011, 189). Except for the bars from Biskupin, these objects were long considered to possibly have originated from later periods of the Iron Age (pre-Roman or Roman) (Bukowski 1982, 373, fig. 27), due to their rare occurrence in multi-element assemblages or other well-dated contexts outside of Poland. A later chronology was suggested by non-representative and, as it turned out, uncertain finds from the North Alpine region, where such items are generally much more numerous (Pleiner 2006, fig. 13; Senn *et al.* 2014, 147; Bauvais *et al.* 2018, fig. 1). In recent years, thanks to direct radiocarbon dating of carbon trapped in steely zones of iron (Bauvais *et al.* 2018; Berranger *et al.* 2021), contextual studies (*e.g.*, Dzięgielewski *et al.* 2020, table 1), and new finds accompanied by other artefacts (Berranger and Fluzin 2012; Chorąży and Chorąży 2022, 21-22 – Porąbka II), it is increasingly safe to attribute an (early) Hallstatt date to this form of semi-product (Berranger *et al.* 2021, figs 11 and 12). In the case of Poland, these are relatively small specimens, rarely exceeding 1 kg in weight (min. 599 g in Witów, max. 1650 g in Biskupin), usually with elongated, pointed ends (altogether comprising up to two-thirds of the bar's length), one of which is sometimes flattened at the tip in a shape reminiscent of a fish tail – a feature known from Neo-Assyrian examples (Khorsabad), as well as from the Delphi deposit and isolated finds from Hungary (Dunapentele-Dunaújváros) and southern Germany (*e.g.*, Aubstadt; Pleiner 2006, fig. 6: 9). All of them fit the BLD1-2 (asymmetric, long bipyramidal) types in M. Berranger's classification (Berranger and Fluzin 2012, fig. 4). The objects from Biskupin (and one from Porąbka) had a hole in the main body, which is also a characteristic found in bipyramidal

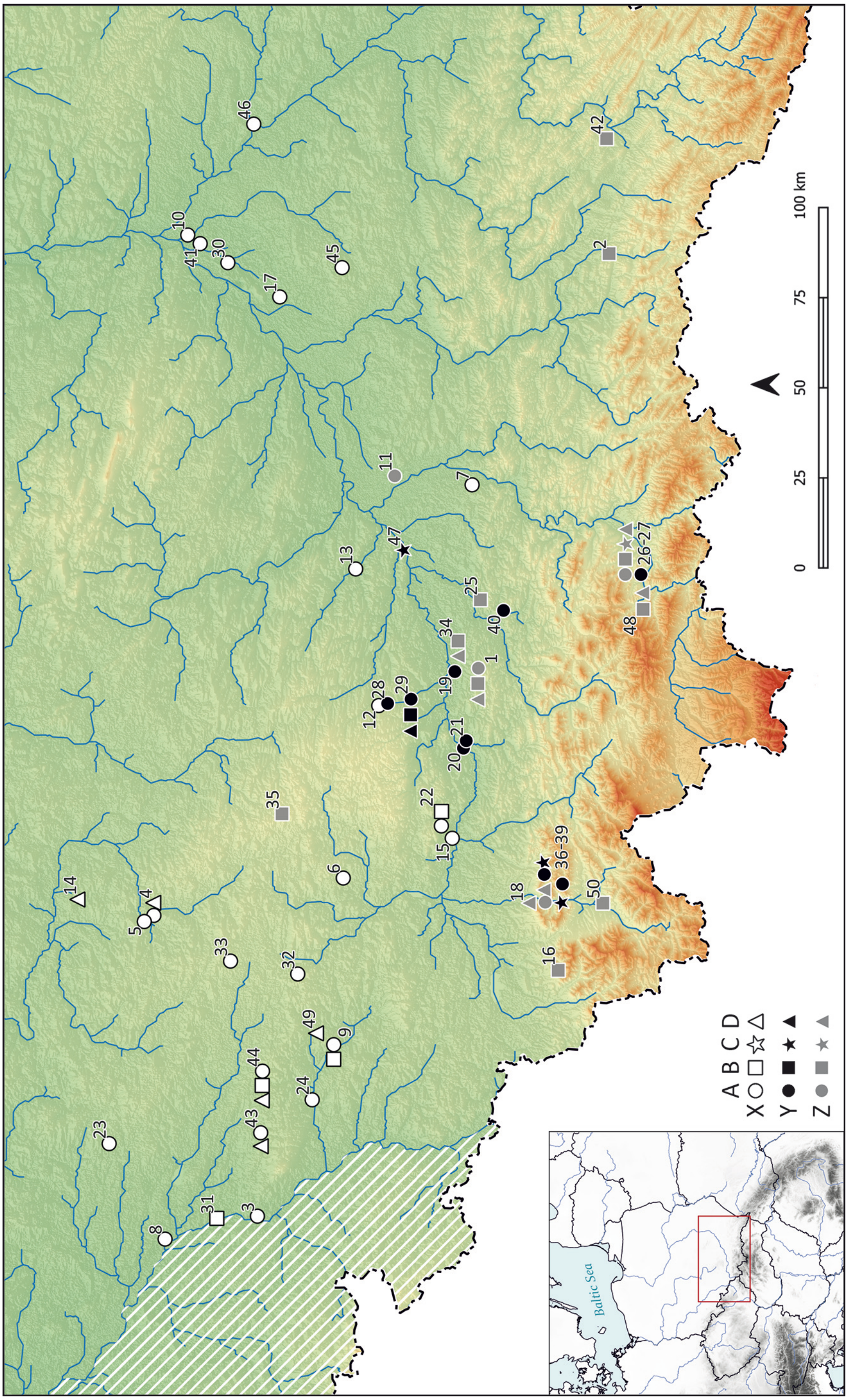
Fig. 16. Traces of intentional fragmentation on a bipyramidal bar from Maszkowice 'Góra Zyndrama' (no. 24): a, d – straight edge indicating a marked or scored line prior to breakage, b-d – irregular marks from one (or two?) chisel or hammer blows (c: note the modern sawing mark, probably from an examination in the second half of the 20th century). Arrows indicate the direction of chisel blows. Photo: K. Dzięgielewski

bars from the aforementioned eastern regions (Pleiner 2006, 23-28, fig. 13). Thus, the Polish assemblage differs slightly from the semi-products most commonly encountered in the late Hallstatt and early La Tène periods in the North Alpine zone, *i.e.*, the symmetrically shaped, short bipyramidal bars (Berranger *et al.* 2021, fig. 12; Ballmer *et al.* 2022, 119-123). This may also point to their earlier dating.

In summary, the analysis of the contexts of the new or verified iron finds from western Lesser Poland presented here does not allow for the formulation of new postulates regarding their chronology. This results from the relatively homogeneous character of most new assemblages, *i.e.*, the co-occurrence of only functionally and typologically similar artefacts. In this situation, referring to the knowledge provided by earlier studies on materials of this type from necropolises and hoards mainly from Silesia, Greater Poland and Lesser Poland (Pieczyński 1954; Gedl 1973; 1991; Heynowski 2000; Derrix 2001; Gediga *et al.* 2020; Dzięgielewski *et al.* 2020; Michnik and Dzięgielewski 2022), it should be stated that the most probable period of deposition of the discussed objects in Lesser Poland are the Ha C1b-C2 phases, and perhaps also Ha D1 (750-550 BC).

CONTEXTUAL ANALYSIS

The phenomenon of 'pure' iron hoards identified in recent years in the broadly understood Western Carpathian zone (including the Vistula River valley near present-day Kraków) is part of a broader trend, manifested in the continuation of the practice of mass deposition of goods, mainly metals, at the beginning of the Early Iron Age on the margins of the Hallstatt cultural circle (Blajer 1992; Westhausen 2018; 2019; Dzięgielewski *et al.* 2020; Mangel *et al.* 2025). It seems that we should now broaden the conceptual scope of this phenomenon. So-called single finds, *i.e.*, single-element deposits, could have similar semantics to hoards, *i.e.*, deposits of at least two objects. This is increasingly suggested by studies on the deposition of metals in the Bronze Age, indicating, among other things, that they are selective, that their spatial distribution may sometimes be similar, and that the functional structure is complementary to multi-element hoards (Becker 2013; Maciejewski 2016; Fontijn 2020; Půlpán *et al.* 2022). A systematic analysis of this issue for the Polish lands was carried out by Wojciech Blajer, who noted the similarity in the distribution patterns of hoards and single finds in some periods of the Bronze Age (Blajer 2001, 259-298). The unequivocal inclusion of single finds in the category of intentional deposits is documented in the literature on the Lusatian culture, usually in relation to large bronze items, especially swords (Kostrzewski 1964; Blajer 2001, 125; Dzięgielewski *et al.* 2024b, 615). Contexts of discoveries of other categories of metal objects from the Bronze and Early Iron Ages, such as axes, sickles, spearheads, or especially small bronzes such as pins or bracelets, do not allow us to rule out that a certain percentage of these finds are elements of destroyed grave inventories, accidental losses or relics of economic activity in settlements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and their surroundings. Nevertheless, most of these objects must also be intentional single-element deposits or remains of multi-element hoards, as evidenced by the small number and narrow typological spectrum of finds from well-studied cemeteries and settlements. In other words, the low average number of large metal objects in graves and on settlement areas, especially in the Late Bronze Age, does not indicate that most of the so-called single finds originally came from destroyed necropolises or settlements. The above-mentioned correlation between the general distribution of hoards and single finds (Blajer 2001, maps 4 vs 119, 5 vs 121) also leads to the conclusion that most of the latter represent intentional deposits. The situation changed to some extent at the beginning of the Early Iron Age (Ha C), when, especially in Silesia and southern Greater Poland (southwestern Poland in the Odra River basin), cemeteries were routinely equipped with much richer sets of metal objects than before, including large bronze and iron items (*e.g.*, Gedl 1973; Gediga *et al.* 2020; Michnik and Dzięgielewski 2022; Purowski 2024), while the custom of depositing hoards almost completely disappeared (Blajer 2001, 290-291, maps 7 and 124). This was apparently mirroring the situation in the 'core' Hallstatt culture areas. As already mentioned, outside this area (in Lesser Poland, Central Poland, northern Greater Poland and Pomerania), the deposition of hoards continued throughout the Ha C phase (Blajer 2001; Dzięgielewski *et al.* 2020), which clearly indicates that both phenomena – grave furnishings and hoards – were a manifestation of the same need to selectively exclude items from metal circulation (*cf.*, Kubach 1985; Becker 2013; Fontijn 2020, 24).

Our observation regarding the differentiation of the deposition pattern of 'large irons' in the Early Iron Age on the Silesian-Lesser Poland border and in the Western Carpathian zone (Fig. 17) fits into the same line of interpretation. The lack of finds of the analysed objects in graves in the mountain zone is, of course, a derivative of the very modest source base, *i.e.*, the number of cemeteries and graves. Among the certain discoveries, only one larger cemetery can be indicated there. This includes a cemetery made of more than 100 graves in Příbor 'Vodojem'/'Pod Šibeňákem', Nový Jičín District in the Moravian-Silesian Foothills (Stabrava 2011) and several graves from Mucharz 'Za Górą', site 24, Wadowice District, with pottery in the style typical of the Upper Silesian-Lesser Poland group (Kraszewska *et al.*, in print). The

Fig. 17. Distribution of the analyzed categories of iron objects in southern Poland. The uncharted area, where Ha C graves were routinely furnished with iron objects, is marked with hatching. A – rings, B – axes, C – bipyramidal bars, D – sickles; X – grave, Y – iron hoard, Z – single find, including a single find in a settlement. 1 – Biskupice, 2 – Bóbrka, 3 – Chorula, 4 – Częstochowa-Raków, 5 – Częstochowa-Stare Miasto, 6 – Dąbrowa Górnicza-Strzemieszyce Wielkie, 7 – Dębina Zakrzowska, 8 – Dobrzeń Mały, 9 – Gliwice-Łabędy Przyszówka, 10 – Gorzyce (Tarnobrzeg dist.), 11 – Gorzyce (Tarnów dist.), 12 – Iwanowice Włościańskie, 13 – Jakuszowice, 14 – Jamno, 15 – Jankowice, 16 – Jaworze-Ostry, 17 – Knapy, 18 – Kobiernice, 19 – Kokotów, 20 – Kraków-Tyniec 'Grodzisko', 21 – Kraków-Tyniec 'Wielogóra', 22 – Kwaczała-Łozek, 23 – Lasowice Małe, 24 – Łany, 25 – Łapczyca Górna, 26-27 – Maszkowice 'Góra Zyndrama' (26 – hoard, 27 – single finds in the settlement), 28 – Maszków, 29 – Młodziejowice, 30 – Mokrzyszów, 31 – Opole-Groszowice, 32 – Orzech, 33 – Piasek, 34 – Podłęże, 35 – Podzamcze-Góra Birów, 36-39 – Porąbka (36 – single finds, 37-39 – hoards), 40 – Sobolów, 41 – Sokolniki, 42 – Srogów Górny, 43 – Strzelce Opolskie-Adamowice, 44 – Świbie, 45 – Trzęsówka, 46 – Ulanów, 47 – Witów, 48 – Zabrzeż 'Babia Góra', 49 – Ziemięcice, 50 – Żywiec 'Grojec' (drawn by K. Dzięgielewski, J. A. Markiewicz and M. S. Przybyła)

Dunajec River valley stands out in this respect (*cf.*, Dzięgielewski *et al.* 2024b, fig. 2.3.4), where, among others, the cemetery in Chełmiec, Nowy Sącz district (Abłamowicz and Abłamowicz 1989), and the cemetery in Janowice, Site 44 (Korczyńska 2014; 2021), are located. Single sepulchral sites from the Early Iron Age have also been identified in the upper San River basin (Sanok-Olchowce – Zielińska 2005; Zasław – Zielińska-Durda 1973; Gedl 1998, 246). These sites did not yield the category of objects of interest to us, apart from the cemetery in Příbor, representing the Silesian variant of the Lusatian culture from the Hallstatt period, *i.e.*, a community that regularly equipped the deceased with iron objects, in this case ring ornaments, knives and a short bladed scythe (Stabrava 2011, fig. 6). However, the key in this case is the situation noted in the zone north of the Carpathian foothills, *i.e.*, on the lowland and upland border of Silesia and northern Lesser Poland, where there are virtually no hoards and single finds in the form of 'large irons' (Fig. 17). The state of archaeological recognition cannot explain this observation, since most deposits are everywhere discovered accidentally and also because several bronze hoards from earlier and later periods (Ha B, Ha D) are known from the interfluve of the upper Odra and the upper Vistula (Blajer 2001, maps 6, 8). As for the discussed period (Ha C-D1), only the areas around Kraków stand out in this regard, with a particular, perhaps apparent at this point, concentration of iron hoards (Fig. 17). This 'wedge' of the Carpathian deposition pattern on the border of the Polish Jura and the Western Lesser Poland loess upland, coincides with the range of infiltration of people of the Częstochowa-Gliwice subgroup of the Upper Silesian-Lesser Poland group of the Lusatian culture in the Early Iron Age, which is visible, among other things, in the appearance of inhumation graves near today's Kraków (Dzięgielewski *et al.* 2024b, 626, fig. 2.3.12: 4, 2.3.21). Such locating of hoards on a cultural borderland (east of the Dłubnia and Raba rivers, there was a zone covered by late Tarnobrzeg group influences – *cf.*, Dzięgielewski, Godlewski 2009; Markiewicz 2024) resembles the regularity of depositing metal objects in liminal zones and on the borders of ecumenes, noticed by M. Maciejewski (2016a; 2016b; *cf.*, Mangel *et al.* 2023, 144).

A distinctive feature of deposits in the uplands and mountains is their association with exposed parts of the landscape, which may or may not be the dominant elevations in the area (Fig. 18). It could even be said that the higher slopes of such hills were preferred, but not the tops. This applies to both hoards deposited within hilltop settlements or in their immediate vicinity (*e.g.*, Maszkowice 'Góra Zyndrama', Tyniec 'Grodzisko', Młodziejowice), as well as those spatially unrelated to settlement sites (*e.g.*, Kobiernice and Porąbka). In the case of the latter, special attention is paid to zones where depositions were repeatedly made over a relatively short period (*e.g.*, Porąbka – Chorąży and Chorąży 2022; Sobolów – Wardas-Lasoń *et al.* 2025) or at different periods of prehistory (*e.g.*, Mount Wroczeń – Maciejewski 2022, 209). In the Polish Carpathians (Blajer 2023, 98), at least 26 of 62 particular and presumed hoards from the Early Bronze Age to the Middle La Tène period were deposited on exposed terrain forms (slopes or peaks of mountains or hills, promontories, high terraces). In turn, on the scale of the entire area of Poland, deposits made on exposed elevations constitute only 3-8% of all hoards from the Bronze Age and Early Iron Age (Blajer 2001, 254, fig. 41). These proportions seem to be a natural consequence of the diversified landscape relief, but it is worth noting that within the analysed group of hoards and single finds of iron objects from southern Poland, sites located on slopes or peaks of hills constitute the vast majority (the exception here are the settlements located on the Carpathian Foothills marginal zone – Kokotów, Podłęże, Łapczyca Górna, Gorzyce in Tarnów district). It cannot, therefore, be ruled out that the observed tendency is at least partly conditioned by cultural factors and stems from the actual preferences of prehistoric

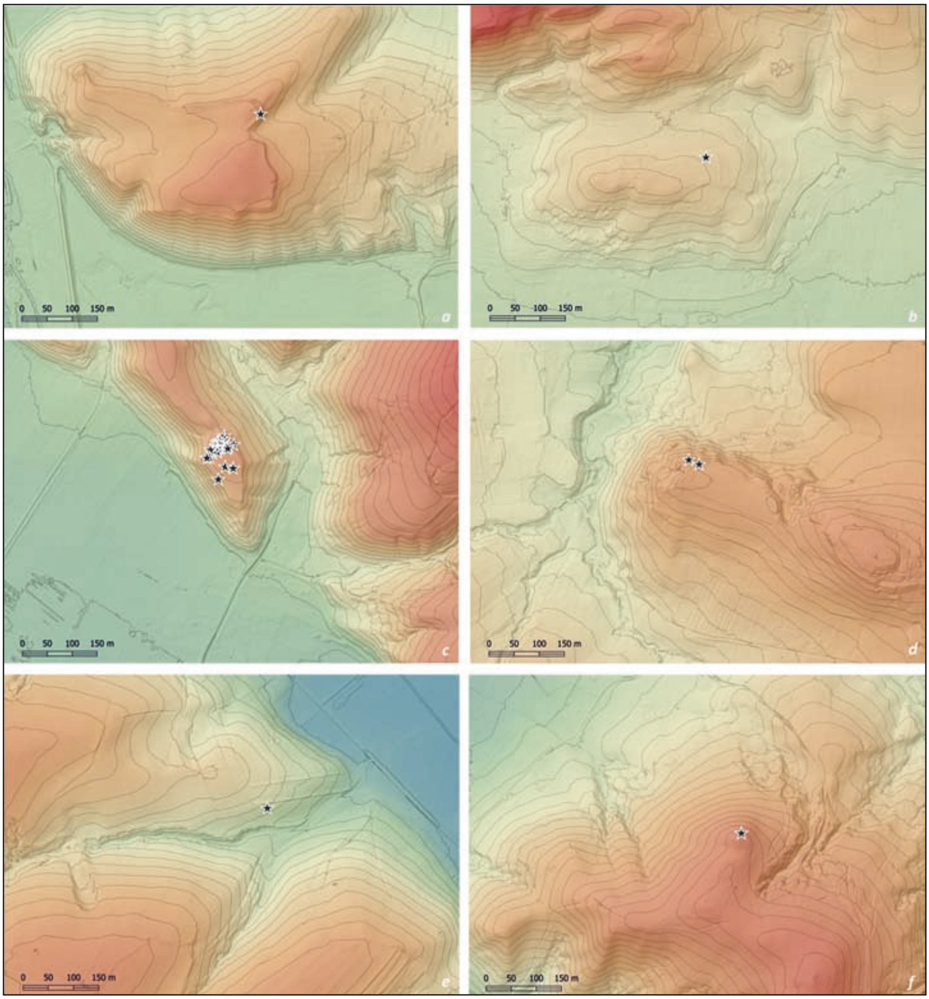

Fig. 18. Examples of locations of hoards and single finds of iron objects on exposed terrain forms. a – Kraków-Tyniec 'Grodzisko', b – Kraków-Tyniec 'Wielogóra', c – Maszkowice 'Góra Zyndrama', d – Biskupice, e – Młodziejowice, f – Sobolów (drawn by M. S. Przybyła)

communities in the sphere of ritual behaviours. A similar analysis recently performed for East Bohemia showed various patterns of Early Iron Age hoard location (including purely iron ones): from deposition in open lowland landscape, through the predominant slopes of hills, to their summits (Mangel *et al.* 2025, 140, figs 8-10).

As already mentioned, some deposits, such as the hoard from Tyniec 'Grodzisko', or from Kokotów, Wieliczka district (Dzięgielewski *et al.* 2020, 206-207, fig. 2), were located within functioning settlements or their immediate hinterland. The hoard of rings (items no. 1 and 2) from Maszkowice 'Góra Zyndrama' (Fig. 11: 8, 11) can be included in this category. The phenomenon of depositing metals, including those from scrap or ingots, is widely known from contemporary defensive settlements, *e.g.*, in Smolenice-Molpír, SW Slovakia (Čambal and Makarová 2020), although their character as intentional deposits, rather than simply household metal storage, sometimes leaves doubts (*cf.*, Dzięgielewski 2024b). The single finds of sickles and axes from the settlements we analyse do not provide certainty that these were intentional deposits. Some of them, especially from well-recognised settlements, such as Maszkowice or Podłęże (Dzięgielewski *et al.* 2024a, fig. 1.5.1.19; Dzięgielewski *et al.* 2024b, fig. 2.3.7), may be considered remnants of everyday economic activity.

FRAGMENTATION OF IRON

However, another observation leads us to conclude that some finds from settlements should be treated semantically differently from those in grave or hoard inventories. Namely, only among finds from settlements do we encounter examples of intentional fragmentation of metal objects. Although the phenomenon of fragments is widely described in the case of bronzes, mainly from the Bronze Age (Brück 2006; Fontijn 2020; Ialongo and Lago 2021), due to the smaller number of iron hoards in Europe, there is no systematic description of the phenomenon of iron fragmentation in the Early Iron Age. Moreover, in Poland, the phenomenon of fragmentation of bronze items never took on a mass character, neither in the Bronze Age nor in the Early Iron Age. At the turn of these ages, only about 10-15% of hoards contained fragments defined as 'scrap', *i.e.*, smaller than half of the original object (Blajer 2001, fig. 37). In the analysed group of artefacts, definitely intentionally fragmented iron objects were only found in Maszkowice. This applies to a series of ring fragments, preserved in half or 1/3 of the circumference (Fig. 12: 4-9), of which at least those preserved to this day can be assessed as broken as a result of intentional action in prehistory, and not as a result of depositional and post-depositional processes. This is evidenced by the sharp edges of the fractures perpendicular to the circumference (in the presence of well-preserved iron cores), and sometimes also traces of oblique or perpendicular flaking, resulting from a blow with a chisel or hammer (Fig. 14). Detailed observations of the ring fragments indicate that the bar was struck from two sides, to create a wedge-shaped narrowing, which was then the point where the piece was broken off.

The bipyramidal bar from Maszkowice (Fig. 12: 13) was split in half in the same way. It shows evident traces of two blows on one side of the wider surface (Fig. 16: b), and on the other side, probably marking the break line with a chisel (or sawing?), as indicated by the straight course of the edge (Fig. 16: a). Probably, the second specimen, now lost, had been broken in this manner too (Fig. 12: 15). A massive bipyramidal bar of the Colmar type (*cf.*, Senn *et al.* 2014, 150) from the defensive settlement in Wicina, Żary District, was broken similarly (Michalak and Jaszewska 2011, fig. 59: 4), leaving a piece still weighing more than 2,7 kg. An analogous pattern of fragmentation, perpendicularly at the thickest point, was also found among numerous *Doppelspitzbarren* from the Late Hallstatt defensive settlement in Mont Lassois in France (Ballmer *et al.* 2022, fig. 113a).

In the hoards of Lesser Poland, intentionally fragmented ring ornaments have not been found so far. Among the bars, also the whole specimens dominated (Chorąży and Chorąży 2022, 24; Dzięgielewski *et al.* 2024b, fig. 2.3.15), similarly to the assemblage of such objects from the settlement in Biskupin (Durczewski 1961, 10-11, figs. 1-2). A halved bipyramidal bar is known only from the hoard II from Porąbka (Chorąży and Chorąży 2022, 21). Outside Małopolska, the inclusion of fragments of a semi-finished iron product in a hoard was noted in Przybysław, Jarocin District (Durczewski 1961, 51-52, fig. 45: 1, 2). However, this relates to another form of semi-products, *i.e.*, quadrangular bars; moreover, the coherence of this assemblage is not certain – *cf.*, Durczewski and Śmigielski 1966, 130-131). Nevertheless, at least based on the find from Porąbka, the 'deposit' character of the fragmented bars from Maszkowice cannot be ruled out.

Two ring fragments from Maszkowice are about 7.5 cm long. However, due to the various thickness of the bar, their weight differs significantly: 28 g in the case of the fragment preserved 'in its entirety' (Fig. 12: 8) and 55 g in the case of the fragment cut off for metallurgical analysis (Fig. 12: 9). The second one probably originally was twice the mass of the first one. Both values should be supplemented by the mass of the loss resulting from corrosion and conservation treatments (2-4 g?). With such an assumption, they would represent approximate multiples (3× and 6×) of a unit recently identified in the weight structure of bronze fragments in European hoards, a derivative of the Middle Eastern shekel that weighs about 10.2 g (Ialongo and Lago 2021; Ialongo *et al.* 2021). The weight of the halved bipyramidal bar (227 g) would correspond to half a *mina* unit, which usually weighs 400-500 g (Ialongo and Lago 2021, 5). For comparison, whole bars from Witów and Porąbka weighed 600-1350 g and therefore exceeded the value of a *mina*. These facts could be consistent with the general observation that it is the fragments, not whole ingots, bars or finished items, that more closely reflect the weight system used in prehistoric transactions (Ialongo and Lago 2021, fig. 6). On the other hand, halved iron ingots of a different type (trapezoidal and rectangular) from the Smolenice-Molpír hoard weighed 426, 178, 174 and 197 g (Čambal and Makarová 2020, 208, fig. 6: 23-26), respectively, thus corresponding to a *mina* and half a *mina*. The significance of our remarks, made for two or three fragmented artefacts, is of course negligible, and we should refrain from drawing further conclusions until the identification and statistical evaluation of the weight of larger series of fragmented iron objects. In this regard, the settlement in Wicina may raise hopes as it provided dozens of pieces (including intentional fragments?) of iron objects (Michalak and Jaszewska 2011), as well as traces of activity of metallurgical workshops and fragmentation of semi-products for their needs, at least ingots made of copper alloys (Garbacz-Klempka *et al.* 2024a). Also, the release of data on the weight of the fragments of the Mont Lassois bars would be valuable (*cf.*, Ballmer *et al.* 2022, 211).

CONCLUSIONS

After c. 750 BC, with the influx of the first significant quantities of the new metal, iron, into areas north of the Carpathians (Derrix 2001; Michnik and Dzięgielewski 2022) and with the stabilisation of new social structures modelled on the Hallstatt culture (Gedl 1991; Gediga 2011; Chochorowski *et al.* 2024, 37-38), the Oder River basin saw the abrupt abandonment of the centuries-old tradition of metal deposition in specific zones of the landscape. Instead, on an unprecedented scale (qualitatively and especially quantitatively, *i.e.*, in terms of the percentage of graves), metal deposition began to be associated with the furnishing of burials (Gedl 1973; Blajer 2001; Gediga *et al.* 2020). This phenomenon, however, did not reach the periphery of Silesia, *i.e.*, the zone subject to the most intensive Hallstatt influence (Dzięgielewski *et al.* 2020). This includes the upper Vistula basin, where single iron objects began to arrive as early as the turn of the 9th and 8th centuries (Blajer and Chochorowski 2015), and as late as the second half of the 8th to the first half of the 7th c. BC, the custom of depositing hoards, in this case virtually always purely of iron items, persisted (Maszków, Młodziejowice, Kokotów, Kraków-Tyniec, Sobolów). In the areas near Kraków, this method of excluding iron from circulation 'competed' in the Ha C period with its deposition in cemeteries, particularly strongly represented in biritual necropolises whose users probably came from areas of Upper Silesia (Gedl 1982; Dzięgielewski 2024a, 109).

Thanks to the observed dichotomy, we obtain regional-scale confirmation of the complementary nature of the deposition phenomenon, a pattern also noted elsewhere in Europe (*e.g.*, in Ireland; Becker 2013), often across various categories of items or across subsequent periods of the Bronze Age and Early Iron Age. In Małopolska, on the other hand, we have a completely different, spatially exclusive (given the current state of research) pattern of deposition of all categories of products made from a single raw material. Similar to grave goods (see *e.g.*, Błaszczyk 1965; Abłamowicz 1994; Michnik and Dzięgielewski 2022), the described hoards and single-item deposits exhibit a specific functional and typological range: these are primarily ornaments and tools, with weapons (trunnion axes) being rare. However, there are also notable differences – for example, the absence of pins in hoards, which, even in the Bronze Age, were among the types of objects rarely deposited in such a manner. Conversely, iron semi-products are never found in graves. Bipyramidal bars were deposited exclusively as hoards or single finds, sometimes on the outskirts of settlements. It seems that, as valuable raw material and relatively large objects – even when halved – they were unlikely to have been lost accidentally. This category also illustrates the complementary character of deposition on yet another level: thanks to the enduring custom of depositing goods in the landscape in Małopolska, we gain insight into the nature of iron semi-products circulation – its forms, dimensions, quantities, and qualities – in neighbouring Silesia, which was almost certainly even better supplied. The absence of recorded semi-products in this region does not suggest their nonexistence; rather, it reflects the lack of a local tradition of metal hoarding and deposition.

The cultural norm, understood as 'the right way to act' (Fontijn 2020, 26), according to which the deposition of iron could not take place outside of funerary contexts, remained unchanged in the areas of Małopolska north of the Vistula until the very end of the hoarding tradition – that is, until the mid-6th century BC (Ha D1, possibly still D2; Westhausen 2019, figs 2-6 – note: maps 5 and 6 in this publication require correction, as the continuation of this phenomenon in Polish territories does not persist on a large scale beyond Ha D2). The observed resurgence in the popularity of bronze in hoards during Ha D (Blajer 2001) may reflect a shift in attitudes toward iron, which, although still imported, was now valued differently. The increase in the size and weight of semi-products during this period (Wicina, Przybysław), which now resemble those from the North-Alpine region in terms of weight, may indicate a growing scale of importation.

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A THEORETICAL, INEQUALITY-BASED MODEL OF CULTURAL CHANGE CULMINATING IN THE EMERGENCE OF BISKUPIN-TYPE FORTIFIED SETTLEMENTS

ABSTRACT

Staniuk R. 2025. A theoretical, inequality-based model of cultural change culminating in the emergence of Biskupin-type fortified settlements. *Sprawozdania Archeologiczne* 77/1, 141-172.

Early Iron Age (EIA) Biskupin-type fortified settlements are viewed as unique examples of high-density urbanism (HDU) with limited (if any) evidence of social inequality. This argument is supported by two lines of evidence: uniform house sizes and small-scale differences in burial rites of the associated Early Iron Age Lusatian Urnfield culture. These two observations are rooted in rudimentary archaeological empiricism, highlighting the pitfalls of induction-based inference for identifying social phenomena and essentialist notions in studies of social inequality, thereby overlooking the dynamics of social processes. This paper will review the state of research on Biskupin-type fortified settlements to discuss how an inequality framework can help conceptualise their emergence, florescence, and decline. Finally, I apply this framework to develop a qualitative, theoretical model of the trajectory of social changes that results in the emergence of these sites.

Keywords: inequality; archaeological theory; culture-history; Early Iron Age; Biskupin-type fortified settlements

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INTRODUCTION

As global academic attention shifts towards understanding the impact of present-day inequalities on our future, archaeology is at the forefront of research into the historical relationship between inequality and human development (Mattison *et al.* 2016; Quinn and Beck 2016; Kohler and Smith 2018; Lalueza-Fox 2022; Bogaard *et al.* 2024; Feinman *et al.* 2025). Especially in recent years, inequality has become one of the leading 'buzzwords', spawning numerous investigations into virtually all contexts and materials to determine the presence of inequality and how it affected social organisation in the past (Przybyła 2013; Smith *et al.* 2014; Großmann 2021). In this context, the Early Iron Age is increasingly recognized as one of the defining periods in human history, coinciding with the rise of monotheistic religions as well as the establishment of states and monetary systems (Kristiansen 1998; Graeber 2011; Turchin 2015; Schumann and van der Vaart-Verschoof 2017; Scott 2017; Dunbar 2023; Gretzinger *et al.* 2024; Rönnlund 2024). These three aspects are interlinked by the notion of inequality, establishing a system where material (coinage), ideological (religion), and organisational (state) aspects have effectively formed the blueprint for the evolution of the present-day world (Wengrow 2010; Graeber 2011).

However, the evolutionary pathway we document retrospectively is hardly the one that developed through the ages (Turchin 2015; Graeber and Wengrow 2021). As the Early Iron Age was a moment where numerous societies practised different forms of social organisation, shaped by specific, broadly defined environments as well as historical trajectories (Haselgrove *et al.* 2023), it is worth considering how particular outcomes developed as a consequence of processes common to all human societies.

The Hallstatt C (820-580 cal. BCE, after Goslar 2019) Biskupin-type fortified settlements are part of this puzzle, although their emergence, florescence, and decline are consistently examined within the particular context of Lusatian culture (Niesiołowska-Wędzka 1974; 1991; Dzięgielewski 2017b; Nowakowski 2023). Considered as a unique discovery in the 1930s, the growing number of sites discovered since indicates a particular habitation form specific to present-day North-Central and Western Poland throughout the Early Iron Age (Szamałek 2009; Kaczmarek and Szczurek 2015). Their preserved wooden architecture, comprising ramparts, breakwater, foundation platforms, multiple house rows separated into individual house units, and pathway systems, drew immediate attention due to their excellent preservation, as well as the high degree of collective effort involved in their construction (Kostrzewski 1950; Durczewski 1970; Kaczmarek and Szczurek 2015). This High-Density Urbanism (HDU) appears to be a novel way of organising communal living in an environment previously characterised by a dense but dispersed network of small settlements (Ignaczak 2002; Kaczmarek 2002; Szamałek 2009). However, by adapting the culture-historical framework and relying on internal processes specific to the Lusatian culture, archaeologists have put themselves in a difficult position, as causes, drivers, and effects need to be examined from the perspective of a particular archaeological culture rather than a historical or evolutionary process. As such, the goal of this paper is to outline how shifting the focus to an inequality framework can help us re-conceptualise the processes involved in the emergence, florescence, and decline of Biskupin-type fortified settlements. My argument will be based on a brief characterisation of the recent findings in inequality research, followed by a critical overview of existing concepts surrounding Biskupin-type fortified settlements. My analysis will be followed by an outline of the candidate processes taking place in the European Late Bronze Age. I will examine these candidate processes in the context of Biskupin-type fortified settlements by relating them to specific social processes occurring on these sites, thereby providing a tangible proposal for research on Early Iron Age inequality.

EVOLUTION OF INEQUALITY

In its most fundamental sense, inequality refers to the restricted access to resources, enabling some members of a society (groups or individuals) to accumulate more than others (Price and Feinman 2010a; Mattison *et al.* 2016; Smith *et al.* 2018; Kerig *et al.* 2022). This definition is followed by the conceptualisation of wealth itself as an accumulation of social relations, skills, and/or materials (Borgerhoff Mulder *et al.* 2009; Beck and Quinn 2022). Currently, archaeological research suggests that some degree of inequality is to be expected in every society, regardless of its specific socio-economic conditions (Shennan 1996; Smith *et al.* 2010; Kohler and Smith 2018; Graeber and Wengrow 2021). The fundamental difference is upon what the wealth is based, what mechanism drives its increase, the scale of inequality achievable under given circumstances, and the dynamics of this process (Paynter 1989; Mattison *et al.* 2016; Kohler and Smith 2018; Mittnik *et al.* 2019).

As inequality research expanded in scope, definitions of wealth had to encompass the complexity of human experience. Material wealth corresponds to physical objects considered valuable in any cultural setting, specifically ones that can be accumulated over time (Bourdieu 1984; Borgerhoff Mulder *et al.* 2009; Beck and Quinn 2022). Relational wealth corresponds to the possibility of mobilising support from the social networks one is engaged in, as these connections can help individuals or groups sustain themselves through difficult periods, as well as organise people towards a common objective (Borgerhoff Mulder *et al.* 2009; Sztompka 2016; Beck and Quinn 2022). Finally, embodied wealth corresponds to the individual skills people acquire throughout their lives, enabling them to accomplish tasks exceptionally (Borgerhoff Mulder *et al.* 2009; Bender Jørgensen *et al.*, eds. 2017; Beck and Quinn 2022). These theoretical threads of inequality research are not mutually exclusive, as culture provides numerous opportunities for each of these types of wealth to coexist. The distinction serves to estimate potential differences between societies and their priorities in each period.

Unlike forms of wealth, mechanisms driving inequality are less formalised as they often reflect case studies and cultural settings. In terms of evolutionary research, the key driving mechanisms are economic defensibility and intergenerational transmission, as well as population and resource pressure (Feinman 1995; Borgerhoff Mulder *et al.* 2009; Gurven *et al.* 2010; Mattison *et al.* 2016). These fundamental processes should influence the cooperation-competition spectrum of human behaviour, resulting in an increase or decrease in inequality and its institutional manifestation (Price and Feinman 2010b; Mattison *et al.* 2016). This is precisely the avenue where inequality research encounters questions of political organisation, and whether resource accumulation can be decoupled from the means enabling some members of society to achieve it (Price and Feinman 1995; 2010b; Scott 2009; 2017). The core component is the aspect of property, *i.e.,* the exclusive right to things and how it is utilised in a particular society (Earle 2000; Shennan 2011). Currently, we as a Western society tend to employ a specific perspective on property as an attribute of an individual human being, although this is only one of the many forms property has taken throughout human history (Graeber 2011). Whether an extension of an individual or an attribute of a collective, the concept of property — *i.e.*, who has access and how — is the key component of all mechanisms of wealth accumulation, as it affects both intra- and inter-group behaviour.

The question of scale emerges at the intersection of wealth, mechanisms, and property itself, as determining what can be accumulated, how it becomes accumulated, and who has access to it effectively constitutes what form inequality can take. For example, in Early Neolithic Europe, the spread of Linearbandkeramik across Central and Western Europe suggests that, at least in its initial stage, land was considered 'available' until it was settled, effectively enabling a large-scale expansion of early farmers without visible inequality (Shennan 2018). Whether this represents actual 'availability' from the standpoint of hunter-gatherers already present in these areas is precisely the point where the interplay between wealth (land), mechanism (resource pressure), and property (us and them, *i.e.*, early farmers and hunter-gatherers) requires attention (Shennan 2018; Cortell-Nicolau *et al.* 2025).

The resulting model of inequality is far from static, as the accumulation of resources through a particular set of means will inevitably lead to their depletion, necessitating either redistribution or the discovery of new avenues. Whether this process will be voluntary and directed towards the improvement of the overall living conditions or coerced for the benefit of the group or individuals, is specific to a particular setting. However, there is a consensus that while some form of inequality can be common to all societies, its uncontrolled growth, which comes at the expense of others, can be halted by high mortality events, *i.e.,* outbreaks of violence (Scheidel 2017; Turchin 2023). These tragic outcomes tend to bring down inequality to more 'reasonable' levels at the expense of lost lives and destruction of wealth. Determining whether this pattern is universal is one of the driving forces of present-day research into inequality, as understanding long-term dynamics of inequality and its effects on other social responses can only be provided by archaeological research.

Although the outlined epistemological ladder is in some way familiar to the majority of ongoing research, two prevalent schools of archaeological thought have emerged. On the one hand, the quantitative school is based on the principle that past inequality can be investigated through rigorous data collection of common finds, which can then be analysed to determine overall trends in the evolution of inequality (Borgerhoff Mulder *et al.* 2009; Kohler and Smith 2018; Bogaard *et al.* 2024). These trends are then assessed against other types of data to evaluate potential links between inequality and other social phenomena, *e.g.*, violence, innovation, or resilience. On the other hand, the qualitative school is interested in determining the actual effect of inequality in human societies and how specific societies respond to its emergence (Graeber 2011; Arponen 2017). The two approaches are complementary but differ in terms of methodology and scale. The former accentuates the importance of large-scale inference using a well-defined dataset to determine the overall trajectory of change through time. At the same time, the latter emphasises the importance of localised scenarios to provide a detailed perspective on particular societies. These epistemological differences are mutually beneficial, as large-scale investigations benefit from datasets generated in small-scale research. In contrast, small-scale research draws on large-scale inference to inform its research questions. As Early Iron Age research remains in the domain of qualitative research, the following will adhere to this methodology.

EARLY IRON AGE BISKUPIN-TYPE FORTIFIED SETTLEMENTS – (PRE-)HISTORIC PARTICULARITY OR AN EVOLUTIONARY NEXT STEP?

Although we celebrated the 90th anniversary of the discovery of Biskupin in 2024, it is worth noting that we remain no closer to providing a coherent answer to this question (Grossman and Piotrowski 2016). It is an understatement to say that the role Biskupin-type fortified settlements played in the overall trajectory of Early Iron Age social changes is underdetermined. The majority of the subject literature focuses either on the historical and present-day significance of the discovery (Piotrowska 2004; Nowacki 2008; Kaczmarek 2014; Niedziółka 2023), detailed characterisation of the recovered material culture (Kostrzewski 1950; Jaskanis 1991; Grossman 2006b; Purowski 2010) or narrative-based description of how their emergence represents the final development stage of the Lusatian culture (Gedl 1975; 1988; Gardawski 1979; Szamałek 2009; Dzięgielewski 2017b; Nowakowski 2023). The accepted consensus is that the emergence of Biskupin-type fortified settlements is linked to the rapid social development in the previously provincial Eastern Greater Poland and Kuyavia region, which was caused by the decline of the Early Iron Age Lusatian culture in Silesia (Gedl 1975; 1988; Gardawski 1979).

When it comes to the origins of the particular form, the works of A. Niesiołowska-Wędzka were the last comprehensive attempt at answering this question through exploration of potential links to the Mediterranean area (1974; 1991). However, years later, her diffusionist argument has been abandoned as evidence of earlier, Bronze Age fortified settlements has increased (Czebreszuk *et al.* 2008; Jaeger 2016; Przybyła 2016; Jędrysik and Przybyła 2018). Moreover, the dataset she used to build her argument has since undergone substantial revisions as independent dating and review of previous excavation findings have decreased the number of Late Bronze Age and Early Iron Age fortified sites, including Biskupin-type (Harding and Rączkowski 2010; Kaczmarek and Szczurek 2015; Góralczyk 2024).

The florescence phase is even more enigmatic, as there is substantial variability between individual studies (Kostrzewski 1950; Durczewski 1970; 1985; Ostoja-Zagórski 1978; 1993; Harding *et al.* 2004; Szczurek and Różański 2013). The fundamental problem is the unit of analysis, which remains the archaeological dataset recovered throughout the excavations rather than social units like houses. Numerous studies have addressed the intricate details of crafts and, unusually for Central Europe, the significance of the assemblage of wooden artefacts (Kostrzewski 1950; Durczewski 1970; Grossman 2006a; Babiński 2009). These studies indicate the scale and variability of production taking place at the site level, but remain problematic in terms of comparative research. The last point is crucial, as Biskupin-type fortified settlements tend to be investigated in isolation from the overall settlement network. As a result, they often stand out as remarkable. However, it is unclear whether this represents the differentiation of habitation strategies in the Early Iron Age or simply the level of data presentation (Mierzwiński 2000).

Unlike the onset or florescence, the decline has received extensive attention, leading to the consolidation of three prevalent theories. The oldest one, which is explicitly related to the eponymous site, is related to environmental changes causing water level rise and subsequent flooding (Gadomska-Czekalska 1950; Piasecki 1950). More recent research has linked this process to the 2.8ka event, a climatic shift that had further consequences, including a decrease in the annual average temperature and an increase in rainfall (Geel *et al.* 1997; van Geel *et al.* 2004; Dzięgielewski 2017b). The straightforward link between climatic change and settlement collapse is currently under investigation, as evidence from other similar and roughly contemporary sites reveals that while some communities might have been affected by environmental change, the scale of human anthropopressure was also a significant factor (Gałka *et al.* 2022; Kołaczek *et al.* 2025).

J. Ostoja-Zagórski explored the alternative socio-economic factors. Based on demographic and ecological factors, he proposed that the inhabitants of Biskupin-type fortified settlements operated below their carrying capacity but were unable to cope with rapidly changing environmental conditions, potentially caused by climate change (Henneberg and Ostoja-Zagórski 1984; Ostoja-Zagórski 1976; 1983; 1988). From a methodological standpoint, these early works represent the first attempts at raising the issue based on preserved domestic units or recognising the significance of the demographic aspects of human development, but have limited, if any, significance for present-day research, as the exact models used for the estimations are implicit and contradictory (Mierzwiński 1996). However, the theoretical principles and observations made at the sites in Sobiejuchy and Jankowo are becoming increasingly plausible as new evidence from Bruszczewo, an Early Bronze Age and Early Iron Age fortified site, has recently proposed the significant impact of changes in the natural environment on human occupation (Niebieszczański *et al.* 2024; Kołaczek *et al.* 2025).

Finally, the conventional culture-historical theory proposes that the decline of Biskupin-type fortified settlements was caused by the rapid expansion of the Scythian Empire (Chochorowski 2014; Chochorowski and Krąpiec 2020; Nowakowski 2023). The increasing number of independent dating methods (dendrochronology and radiocarbon dating), as well as new findings from SE Poland, show that the relations between the area of present-day Poland and the Scythian Empire are more complex (Czopek and Krąpiec 2020; Czopek *et al.* 2023). Absolute dating of selected sites previously associated with the nomadic raids responsible for widespread destruction occurred before the Scythian presence was established in southeastern Poland. Evidence of violence from Smuszewo or Biskupin remains enigmatic in terms of drivers or causes, suggesting a different scenario for their downfall (Gadomska-Czekalska 1950; Durczewski 1970; Malinowski 1979).

A NECESSARY DETOUR ON THE HOPELESSNESS(?) OF PERIODISATION

Before discussing how new findings from the European Late Bronze Age and Early Iron Age can help identify the macroscale processes responsible for the emergence of this unique settlement form, a short detour is necessary to address the elephant in the room, *i.e.*, the present-day chronological resolution.

Historically, the Bronze and Early Iron Age chronology of Poland has been positioned as an amalgam between the two European periodization schemes by J. Kostrzewski and his students: Northern, *i.e.*, O. Montelius's until the end of the Late Bronze Age (Period V), when it is overtaken by the Southern, *i.e.*, P. Reinecke's (Hallstatt C and D) (Kaczmarek 2012; Czopek 2014). How and whether the two can be combined is irrelevant, as the classification system has withstood the development of radiocarbon and tree-ring dating. The crucial issues are the absolute chronological spans associated with the two periods of the Early Iron Age and how their evaluation has affected the definitions of Hallstatt C and Hallstatt D.

J. Kostrzewski's pre-calibration estimates positioned the Hallstatt C period in Poland c. 650-550 bc, and the Hallstatt D c. 550-440 bc (Goslar 2019; Chochorowski and Krąpiec 2020). Initially, based on the evaluation of finds and contexts, Biskupin, as well as other comparable sites, were dated to Hallstatt D (Niesiołowska-Wędzka 1974; Śmigielski 1991). When the first radiocarbon and dendrochronological findings were reported, indicating a chronological offset of approximately. 300 years, the site's dating as well as other contemporary sites were moved from Hallstatt D to Hallstatt C (Pazdur *et al.* 1991; Ważny 1994). This effectively meant that the entire material culture assemblage contributing to the definition of Hallstatt D was repositioned into Hallstatt C following insights of independent dating rather than stylistic or typological traits. The two previously well-defined periods were effectively mixed. As a result, the groundbreaking discoveries in Biskupin have introduced a new degree of uncertainty, at least when it comes to findings of older investigations. Currently, the distinction between Hallstatt C and Hallstatt D is well documented, at least in terms of burial rite, economy, and material culture, as the former tends to be associated with the 'sedentary' Lusatian Culture, while the latter with the 'mobile' Pomeranian culture (Dzięgielewski 2017a; Kaczmarek 2017). However, uncertainties arise when examining reports from sites published between the 1930s and 1995, and it becomes necessary to determine whether historical Hallstatt D represents present-day Hallstatt C or just Hallstatt D.

Recently, T. Goslar proposed new absolute dating by modelling radiocarbon dates from Domasław, one of the largest Bronze Age and Early Iron Age cemeteries in Silesia (Goslar 2019; Gediga *et al.* 2020). His results indicate that the distinction between Hallstatt C and D is most plausible under the assumption of transitional consecutiveness, rather than a 'hard' boundary (Goslar 2019). As a result, under the Domasław model, Hallstatt C falls between 820 and 580 cal. BCE and Hallstatt D between 549-428 cal. BCE. His assumption of transitional consecutiveness can be maintained further when comparing new

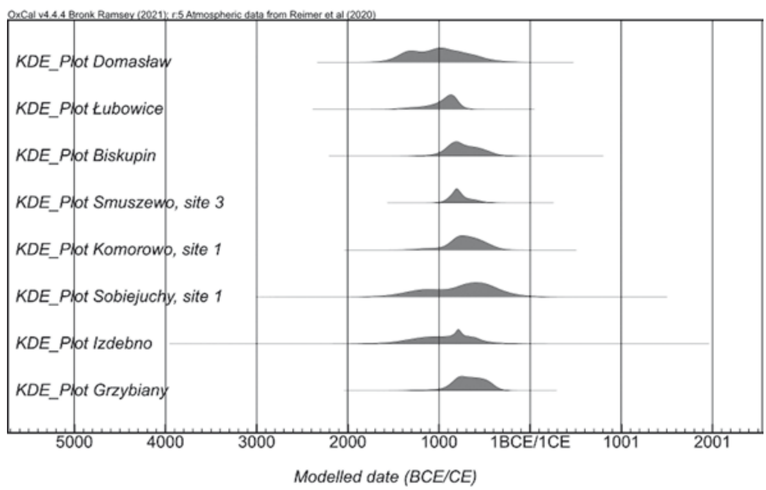

Fig. 1. Kernel Density Estimate plots showing the probability distribution of radiocarbon dating of major Late Bronze Age and Early Iron Age sites in Poland (OxCal v. 4.4.4: Bronk Ramsey 2009; calibration curve: Reimer *et al.* 2020; KDE Plot: Bronk Ramsey 2017; data after: Chochorowski and Krąpiec 2020; Filipović *et al.* 2020; Goslar 2019; Harding *et al.* 2004; Pazdur *et al.* 1991, 1994; Stolarczyk and Baron 2014; Skripkin and Kovaliukh 2004)

and legacy data on Late Bronze Age and Early Iron Age fortified sites in present-day Poland (Fig. 1). For the majority of sites linked to Hallstatt C and D, their chronological range overlaps with the proposed dating of Domasław. Only for Łubowice, Sobiejuchy and Izdebno is it probable that occupation took place prior to the 820 cal. BCE threshold. Given that Łubowice is in Silesia and the early dating of Izdebno represents an outlier, as noted already at the publication stage (Pazdur *et al.* 1994), Sobiejuchy can be considered the hallmark of centralisation in the Greater Poland-Kuyavia region. By the same merit, accounting for sampling bias, and treating the findings as a first-order approximation, this data can support the expansion of fortified sites c. 800 cal. BCE.

ORIGINS OF THE EARLY IRON AGE: DEMOGRAPHY, IDEOLOGY, MIGRATION AND/OR MOBILITY?

Unique archaeologically as they are, Biskupin-type fortified settlements developed in a common European environment initialized by the rapid adoption of cremation *ca.* 1300 BCE. This process was likely accompanied by changes in social relations, where one of the crucial determinants was differential access to resources, triggering the emergence of local elites that became increasingly interregional by Hallstatt C (Schumann and van der Vaart-Verschoof 2017; Großmann 2021; Gretzinger *et al.* 2024). How this change took place is generally explained through (1) demographic growth, (2) ideological change, and (3) mobility/migration (Ostoja-Zagórski 1988; Fokkens 1997; Harding 2000; Nikulka 2016; Kaczmarek 2020; Sørensen and Rebay-Salisbury 2023).

Population growth

The demographic turn in archaeology has revived the interest in investigating the impact of population change on human activity, social organisation, and cultural development (Shennan 2000; Chamberlain 2009; Müller 2015; French *et al.* 2020). As the majority of research has focused on the 'radiocarbon' periods, *i.e.,* periods where radiocarbon dating is the primary method of absolute dating, the Late Bronze Age-Early Iron Age is increasingly recognised as the next significant threshold for determining the trajectory of the demographic of Europe (Capuzzo *et al.* 2018; Feeser *et al.* 2019; Friman and Lagerås 2023). The limitations imposed by the overlap with the Hallstatt plateau, as well as confidence in the reliability of the typological dating for the late 2nd and early 1st millennium BCE materials, are already (in)visible in the summed probability distribution of calibrated radiocarbon dates (SPD; Shennan *et al.* 2013; Timpson *et al.* 2020; Crema 2022). However, despite the long-accepted view that this period represents a surge in the number of archaeological sites, especially cemeteries, the conceptualisation of the phenomenon, as well as its causal mechanisms, is largely unresolved (Bukowski 1992; Kaczanowski *et al.* 1992; Mierzwiński 2012b; Nikulka 2016).

Ideas revolving around the demographic growth of Late Bronze Age-Early Iron Age societies emphasise the importance of economic transformations associated with the introduction of new crops and land-use strategies, which proved successful in previously unsettled or sparsely populated areas (Ostoja-Zagórski 1988; Piontek 1992; Szamałek 2009; Rebay-Salisbury *et al.* 2021; Reed *et al.* 2024). No specific 'trigger' has been suggested, as historically, the widespread occurrence of Late Bronze Age-Early Iron Age archaeological finds was considered evidence of a highly diversified socio-economic model that performed well across the entirety of the settled area (Kurnatowski 1992). Notably, the Urnfield culture, in general, and the Lusatian culture, specifically, are considered relatively homogeneous society (Kaczmarek 2017). As such, the significance of regional differentiation, especially factors contributing to the successful exploitation of previously underused ecological niches, is recognised but treated as secondary to the overall successful performance of the Late Bronze Age-Early Iron Age socio-economic system (Kurnatowski 1992; Kaczmarek 2002; 2017; Szamałek 2009).

Currently, the strongest candidate for driving an economic shift and resulting population growth in the late 2nd and early 1st millennium BCE is the consolidation of *Panicum miliaceum L.* (broomcorn millet) as the new staple crop (Urban 2019). Due to its short vegetational cycle, environmental resilience, and a vast array of uses, it is a potential driver of demographic growth in this period (Filipović *et al.* 2020; Pospieszny *et al.* 2021). While East Asia is generally accepted as the origin of domesticated millet between 7000 and 3300 BCE (Filipović *et al.* 2020; Pospieszny *et al.* 2021; Stevens *et al.* 2021), by approximately 1500 cal. By BCE, it had already reached Central Europe through an East-West 'corridor', which could potentially signal its quantitatively larger spread alongside the cremation rite (Moskal del Hoyo *et al.* 2015; Filipović *et al.* 2020; Pospieszny *et al.* 2021).

Unlike crops, there is little evidence of similar innovations in animal husbandry or, more broadly, the animal economy. Both the Late Bronze and Early Iron Ages are characterised by stability in their reliance on cattle as the primary source of animal produce, with microregional differences related to the importance of pigs and sheep/goats (Ostoja-Zagórski 1983; 1993; Piątkowska-Małecka 2003; 2007; Kaczmarek 2017; Ślusarska 2021). The main novelty lies in the widespread exploitation of previously unoccupied areas, which must have accompanied some adjustments in the husbandry system. However, the causal relationship – whether settling into new niches causes population growth or vice versa – remains open. Furthermore, despite this ecological expansion, which targets areas with large freshwater reservoirs, the existing data does not suggest increased reliance on wild terrestrial or aquatic animals (Makowiecki 2003; Ślusarska 2021).

One potential avenue for innovation in animal management, or rather subsistence, is the impact of increased salt availability due to organised extraction and trade (Harding

2013; Bednarczyk *et al.* 2015; Mazur and Dzięgielewski 2021; Saile 2024). Substantial amounts of salt enable the intensification of long-term preservation of produce, such as meat and cheese, thereby improving the availability of protein and fat during winter and reducing mortality caused by food shortages (Harding 2013). Reducing mortality would then have a positive effect on population growth, potentially explaining the increasing population size but not necessarily its scale, at least not by itself. For the region under consideration, the strongest evidence of such an impact could be associated with Southern Poland, where material remains of salt production dated to the Late Bronze Age-Early Iron Age have increased in the last decade (Bednarczyk *et al.* 2015; Mazur and Dzięgielewski 2021; Saile 2024). However, the areas with the most significant human concentrations (Silesia, Greater Poland, Kuyavia) have no available salt sources for exploitation or have provided evidence of local production only in later periods (Harding and Kavruk 2013; Mazur and Dzięgielewski 2021). While this does not dismiss the possibility of the positive impact of salt availability on population growth, it is necessary to discern whether such a process resulted from the direct transport of salt itself or already processed products.

Ideological change

The alternative to the population growth theory is the revolutionary ideological change associated with the spread of cremation and the accompanying increase in the frequency of burials in society (Fokkens 1997; Mierzwiński 2012b). This change in the burial rites, making it necessary to bury everyone or at least the majority of community members, is often used to explain the quantitative differences between the number of individuals found in cemeteries, especially when comparing the Late Bronze Age-Early Iron Age funerary record with the preceding periods (Sørensen and Rebay-Salisbury 2023). According to this logic, the disproportionally large numbers of burials found in urnfield cemeteries can only be explained by a radical ideological shift which more accurately reflects the actual demographics rather than a pattern of population growth (Fokkens 1997; Mierzwiński 2012b; Sørensen and Rebay-Salisbury 2023).

Accompanying the democratisation of burial rites is the standardisation of material culture deposited together with the deceased (Kaczmarek 2002; 2017). Unlike the preceding heterogeneous Middle Bronze, where not only inhumation and cremation burial were practised alongside each other but the material culture itself was characterised by pronounced morphological and decorative differences, the Late Bronze Age-Early Iron Age displays limited variability despite the large number of regional groups (Gedl 1975; Kaczmarek 2017; Staniuk 2023). The resulting common sense impression of egalitarianism is increasingly challenged as continental and local discoveries suggest that this period represents a consolidation of already present inequality, as shown by the differentiation of grave goods, funerary architecture or the spread of weaponry (Kristiansen 1998; Przybyła 2009; 2013; Harding 2015; van der Vaart-Verschoof and Schumann 2017; Gediga *et al.* 2020;

Desplanques 2022; Marzian *et al.* 2024). On a local scale, even settlement data suggest the existence of large-scale differences in living conditions, as large and small communities coexisted in parallel (Baron 2006; 2007; Bugaj and Kopiasz 2006; Dzięgielewski 2017b).

If we assume that the ideological basis was relatively similar across Urnfield Europe, the development of such pronounced differences in habitation strategies and community size is, in my opinion, the fundamental challenge in determining whether demographic or ideological theory is more valid. Or, even more plausibly, if the two should be considered complementary.

Migration and/or mobility

Aspects of mobility/migration are embedded in the discussion on the Late Bronze Age-Early Iron Age societies, predominantly in terms of the initial source of the Urnfield package (Schmid 2020; Cavazzuti *et al.* 2022; Rose *et al.* 2023), subsequent spread into other regions (Dzięgielewski *et al.* 2010), the increasingly complex network of exchange and trade (Kristiansen 1998; Purowski 2010), and finally, traces as well as effects of migrations from historical records (Chochorowski 2014). One crucial point in these discussions is the distinction between migration and mobility, where the former implies some form of permanent effect, while the latter represents an ongoing but less finite act (Metzner-Nebelsick 2010; Reiter and Frei 2019).

Mobility theories tend to pinpoint the Carpathian Basin as the most probable origin of the Urnfield phenomenon, due to its early chronology and the widespread presence of cremation already in the second millennium BCE (Cavazzuti *et al.* 2022; Sørensen and Rebay-Salisbury 2023). Considering the material culture similarities between present-day Western Poland and the Carpathian Basin, the logic that the emergence of the Lusatian culture represents an effect of migration is not an unreasonable assumption. However, cremation has a long chronology outside of the region, and more importantly, shows a gradual increase in frequency prior to the arbitrary start threshold of the Late Bronze Age 1300 BCE (Schmid 2020). Moreover, despite the problematic end of Middle Bronze Age tell communities, the spread of the cremation rite outside the Carpathian Basin is unlikely to be explained by a rapid depopulation of the region and migration (Staniuk 2021; Molloy *et al.* 2023; Bruyère *et al.* 2024). Presently, the cumulative effect of small-scale mobility between communities causing a similar pattern cannot be ruled out (Przybyła 2009, 2016).

However, the problematic onset is only part of the puzzle, as the spread of the Urnfield package remains one of the crucial questions for explaining the rapid emergence of a similar cultural model in other environments after the emergence of Lusatian culture (Cavazzuti *et al.* 2022). By the end of the Late Bronze Age, most communities of present-day Poland followed a similar cultural model, and this likeness extended further east and northeast, indicating a rapid effect of increasing mobility (Dąbrowski 1997; Lang 2007; Makarowicz 2010). The adoption of a relatively uniform cultural model in the previously highly heterogeneous Trzciniec Cultural Circle, without evidence of aggregations parallel to those from Western Poland, suggests a complex interplay of small-scale processes that accelerated by 1200/1100 BCE. These could have been linked to inequality, as previously limited networks of cooperation were widely extended, potentially due to limited possibilities of becoming incorporated in local structures or through means to increase resource accessibility. Some effects are visible in terms of the changing frequency of metal deposition and the emergence of hoarding behaviour in areas with previously limited depositional records (Blajer 2001). Long-term, they even indicate the emergence of aggregations, different from the ones known from Western Poland but suggestive of profound changes taking place after the spread and consolidation of the Lusatian culture (Żurek *et al.* 2023).

The arbitrary distinction between 'permanent' migration and 'temporary' mobility will not allow us to differentiate between the mechanisms of this process. It is more fruitful to approach this issue from the perspective of the scale required for the effect we see archaeologically to be justified.

BISKUPIN-TYPE FORTIFIED SETTLEMENTS: A RESPONSE TO A CHANGING ENVIRONMENT?

The emergence, florescence, and decline of Biskupin-type fortified settlements happened in a dynamic environment shaped by the effects of population growth, ideological change, and mobility, each providing sufficient avenues for inequality-based relations to affect human behaviour. In this context, the hypothesis regarding egalitarianism refers strictly to the internal processes of social organisation when the settlement was constructed (Dzięgielewski 2017b). While conclusive evidence, *i.e.,* a comparison of domestic house units and inventories, remains unaddressed, it is worth considering how this dynamic environment may have stimulated the emergence of this settlement form. Although this process was inherently social, *i.e.,* representing the ability of social groups to plan, execute, and succeed, it is worth considering first from the standpoint of material prerequisites necessary to organise it and how inequality-based relations have influenced the trajectory of change. What follows is an outline of how this process could have unfolded and what mechanisms might have driven the emergence of Biskupin-type fortified settlements.

Late Bronze Age (1218-820 cal. BCE)

First, the construction of Biskupin-type fortified settlements required areas with limited human activity for at least 100 years to enable the acquisition of wood for construction purposes (Durczewski 1970; Niewiarowski 2009). This 'natural' prerequisite is, of course, based on the assumption that wood was not a commodity. Given comparative data from other Late Bronze Age-Early Iron Age fortified sites, such large-scale settlements were accompanied by land clearance indicators (Gałka *et al.* 2022; Szambelan 2022; Niebieszczański *et al.* 2024; Kołaczek *et al.* 2025; Szambelan *et al. in press*). This suggests that resource availability in previously provincial areas was one of the key factors for deciding where to settle.

Second, the process of population aggregation had to precede the planning itself, as area selection, preparatory works, and construction had to account for resource availability to ensure the successful execution of the project. Assuming that this process was initialized at the Sobiejuchy, as proposed by J. Ostoja-Zagórski and A. Harding as it represents the largest of all contemporary sites in the region with first occupation phase dating to the Late Bronze Age (Ostoja-Zagórski 1993; Harding *et al.* 2004), the mechanisms motivating people to abandon previously dispersed occupation and devote substantial amount of time and labour in favour of aggregations, conceptualizing how and why such a large community came together in this region requires consideration.

A. Mierzwiński has proposed that Late Bronze Age and Early Iron Age Urnfield societies practised feasting as an essential part of burial ceremonies (Mierzwiński 2012a). His exploration of the surge in drinking and serving vessels as part of the burial inventory, as well as their metric properties, indicates an increasingly collective behaviour towards the Early Iron Age. In an environment of growing population size and its expansion into other environmental niches, a persistent communal and integrative activity would provide a basis not only for maintaining cultural ties but also for establishing numerous new relationships (Dunbar 2021). Assuming that this was a time of both population growth and an ideological change, the missing link for bringing people together may be precisely the frequency of burial practices. These occasions could have provided chances for other forms of beneficial interactions to occur through maintaining familial and community ties, creating new ones through mating arrangements, and stimulating information or gift exchange. If we are looking for a social process responsible for the cultural similarity between the Late Bronze Age and Early Iron Age, a maintained form of interaction between multiple members of different communities sharing a similar background would be a good candidate.

Third, assuming that these meetings fall under the umbrella term of 'feasting', the prerequisite for their organisation is the acquisition of sufficient produce for sustenance (Hastorf 2017). The increasing reliance on millet could have been stimulated by this process as upholding the social convention would encourage individuals or groups to increase their crop yields. Repeated, successful fulfilment of this obligation could have attracted members to thriving groups, encouraging them to perform just as well or better over time. This would stimulate an increase in group-level sizes at the cost of a continuous need to maintain the growth trajectory. In instances where random events would hinder the ability to procure produce locally, the personal network could have been utilised to generate surplus, either through persuasion or coercion (Scott 2009). Alternatively, failed attempts at organising feasts or their unsuccessfulness would have an adverse and detrimental effect on their communities, temporarily hindering their growth through stagnation or even causing dispersion. Low yields, diseases, poor organisational skills, or all of the above would convey the message that the community or individuals are not capable of fulfilling social obligations. The resulting pattern would be of a gradual decrease of settlement dispersion at the cost of centralisation, with inter-group relations gradually shaped by unequal access to resources.

Fourth, the emerging dependency for increasing food procurement would become a challenge for field and herd management, as dispersed and extensive agriculture would give way to intensive land use, as well as reducing areas for herding. For some members of society, the decreasing availability of accessible, 'free' land surrounding existing settlements would require expansion into previously unsettled areas, encouraging mobility and expansion. For others, it would require adjusting their skill set to compensate for the lack of personal fields by focusing on crafts, such as pottery, metallurgy, or both. Craft specialisation was well-established by the Late Bronze Age (Gedl 1975; Mogielnicka-Urban 1984; Hansen 1991; Dąbrowski 1997; Kaczmarek 2002; Mierzwiński 2012a; Vachta 2016), but the key question is the degree of seasonality specific to each craft, as well as intra-group dependencies between people involved in agriculture and other economic activities. It is plausible that in an environment of cooperative behaviour, landowning individuals would exchange produce for specific objects, assistance in field management, or share resources based on familial or community ties. However, it is plausible that this differential access will eventually lead to internal tensions based on material wealth inequality.

Fifth, tensions between growth, food procurement, and social obligations would culminate in the rise of external and internal inequality, encouraging competition. This could trigger raiding behaviour as well as other hostile actions aimed at reducing the success of certain groups. Acts of violence like stealing cattle by skirmishers, setting fields on fire, or even disrupting safe passage in movement corridors are all examples of strategies utilised to counteract centralising tendencies in agricultural societies (Scott 2009; 2017). Whether these actions were undertaken by members of the same groups or not is of secondary importance, since the detrimental effect on growth would be the same. It is only that in the first instance, internal tensions would accelerate the process of social disintegration.

Sixth, counter-acting such behaviours would be directed first towards protection and deterrence, through labour investment in manufacturing weaponry or fortifications (Fogel 1979; 1988; Hansen and Krause 2018). Generally, Late Bronze Age and Early Iron Age societies were well-equipped with weapons and used to resolve their disputes or interact through violence (Kristiansen 1998; Horn and Kristiansen 2018). It is plausible that violence was the ever-present reality of this system, and the highly cooperative model of inter-group interaction is a too optimistic assumption (Kadrow 2001; Turchin 2015). However, the destructive nature of the cremation rite on osteological evidence of violence is likely the reason why research on Late Bronze Age violence in Central Europe relies so heavily on material culture studies and settlement data. If violence became more common due to centralisation, the growing number of fortified settlements would indicate the importance of defensive strategies rather than manifestations of individual status. This is not to say that inequality was not present on an individual level. Given the shifts in metal deposition between the Bronze Age Period V and Hallstatt C (Blajer 2001), hoarding became an important practice for mitigating the cumulative effects of wealth accumulation and transmission (Borgerhoff Mulder *et al.* 2009). However, once hostile actions towards specific communities became a means not only to hinder their expansion but also to offset negative conditions in less successful communities, deterrence had to become the norm, and ensuring safety became one of the prerequisites for new groups to emerge (Roscoe 2009).

Seventh, deterrence and ensuring safety to maintain the status of the settlement could have overtaken the importance of maintaining soft power ties between communities in favour of a highly competitive, coercion-based system. As the previous system of communal, integrative activities was beset by challenges for ensuring sufficient food and material supply with restricted, defensible fields, decisions had to be made on how to designate tasks in an increasingly complex organisational system, while maintaining a sufficient workforce to execute them. It is possible that by the end of the Late Bronze Age, social members were forced to join communities as a way of ensuring manpower. Given the shared cultural background, this might not have been accompanied by further social differentiation into free and unfree, as evidence of internal hierarchies remains dubious. However, this is where the depth of ideological change in this period requires consideration, as it is possible that from a thanatological perspective, earthly status had limited effects on the perception of the afterlife (Mierzwiński 2012b). Unfree in life would not necessarily mean unfree in death.

Early Iron Age (820-580 cal. BCE)

Bearing in mind that the proposed pathway is just a possible inequality-based model (Fig. 2) of how, by the Early Iron Age, community size, organisational skills, resource economy, and defensive behaviour were already intertwined, it is possible to outline how the emergence of Biskupin-type fortified settlements became possible.

As mentioned earlier, by 820 cal. BCE, areas with defensive capabilities and easily accessible woodlands were the first choice for establishing new, defensive settlements as a community effort. Exploitation of woodlands had the simultaneous effect of creating lands suitable for agriculture, while the existing networks were sufficient to mobilise large populations capable of executing such endeavours. Distance from existing centres was beneficial as it reduced the risk of raids and coercion into existing communities. Finally, the limited effect of existing overexploitation of soils in densely inhabited or exploited areas offered an additional advantage to survive winters.

The groups building Biskupin-type fortified sites were probably operating in an environment of shared cultural identity amplified by familial and community ties, which

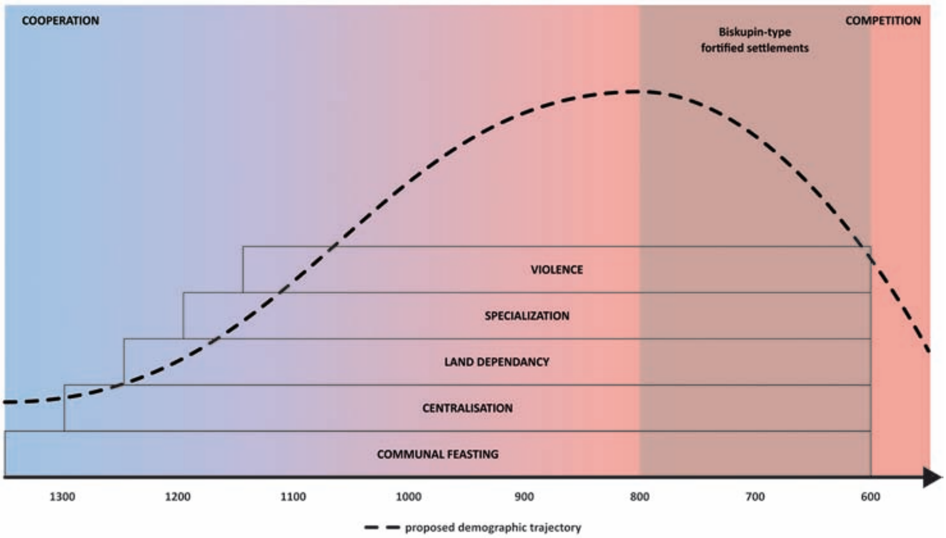

Fig. 2. A theoretical model of how the Biskupin-type fortified settlements emerge in an increasingly competitive environment at the onset of the Early Iron Age

formed a 'stable' basis to start 'fresh', avoiding the pitfalls of growth accompanied by increasing competition. The shared, relatively egalitarian burial rite, together with a strong sense of community and diverse skillset (woodworking, pottery production, metal production, and other crafts) would have enabled the inhabitants to quickly resume regular economic activities, maintaining their usual practices, while expanding their contact networks towards new areas which were explored in a limited fashion.

Whether the process was initiated at Sobiejuchy or other roughly contemporary sites, indicating the fissioning of the founding group, is currently of secondary importance. The crucial aspect to account for is that now, the same cultural setting that initially enabled a relatively peaceful population growth through a system of fulfilling social obligations based on accountability was no longer the only organising principle. Maintained, high food supply dependency was already in place, and some relations between individuals and communities were strained, limiting the possibilities of offsetting below-average yields through soft power. Acquiring the necessary resources through raiding, either neighbouring communities or travelling groups, was an ever-present possibility.

The ultimate decline of this settlement model, characterised by high population density, was likely a unique story specific to each site. Some could have maintained their growth for a prolonged period (*e.g.*, Wicina – Bugaj 2022), while others were less successful (*e.g.*, Smuszewo – Durczewski, 1970), and some managed to adapt to even more complex circumstances caused by random events (*e.g.*, Biskupin – Kostrzewski, 1950). It is even plausible that the different archaeological sites reflect a long history of a large, single community moving across the landscape, as each consecutively occupied area became unsuitable for continued settlement due to the prevailing socio-economic model and its environment. However, while such a model cannot be ruled out, it currently cannot be assessed based on the existing data.

CONCLUSIONS

It has been more than 90 years since the first excavation campaign in Biskupin, and the question of how and why this particular settlement model emerged requires urgent addressing if archaeology is to incorporate it in research on the evolution of human societies. By reviewing research on inequality in archaeology and discussing existing theories on the emergence, florescence, and decline of Biskupin-type fortified settlements, I propose a theoretical, qualitative model as a potential pathway for conceptualising their emergence. In it, the emergence of these sites is explained through a long trajectory of Late Bronze Age social change, from highly cooperative to highly competitive communities developing in the Polish lowlands. The relatively homogeneous and egalitarian society established and maintained a strong network of connections, not only through feasting practices. I suggest that through coupling with the overall population increase enabled by the spread of millet, this process stimulated community growth. At the same time, the emergent reliance on fulfilling social obligations created a dependency for maintaining the growth trajectory. As centralisation processes began to emerge, their negative effects became more pronounced, particularly in maintaining food supplies, necessitating expansion into new areas, creating a further reliance on supply networks, and increasing specialisation to offset the decreasing availability of land. Initially, inter-group inequality became pronounced to provide the necessary resources for growing populations. Later, intra-group inequality became more pronounced as group membership was no longer based on benevolent interaction but coercion. I propose in the model that the emergence of Biskupin-type fortified settlements is a consequence of a competitive, violent environment, encouraging communities to settle outside of previously established centres as an attempt to propose structural solutions to problems that drove communities away from the previous areas. However, these solutions were no longer suitable in a highly competitive environment, where new, high-density communities proved unsuccessful due to anthroporessure, scalar stress, or random events.

(In)validating the model I outline above will require archaeological empirical work through dating, modelling, and comparing sites. However, it will also require theoretical and analytical testing of the proposed sequence of events. Site-based investigations, providing high-resolution data on domestic economies, will be crucial, as will macro-scale investigations into patterns of cultural change between the Late Bronze Age and the Early Iron Age. Perhaps by the 100th anniversary of the first excavation campaign in Biskupin, we will be able to say at least which of the above processes I have outlined above were the least likely to have taken place.

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COMPARISON OF PALAEOECOLOGICAL AND ARCHAEOLOGICAL EVIDENCE OF HUMAN ACTIVITY FROM THE LATE BRONZE AGE TO THE EARLY IRON AGE IN CENTRAL POMERANIA (NORTHERN POLAND)

ABSTRACT

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This article presents a synthesis of palaeoenvironmental and archaeological data from the Bronze/Iron Age transition (1200-500 BC) in Central Pomerania. Based on pollen, non-pollen palynomorphs (NPPs), charcoal, and geochemical analysis of the sediments from Wierzchowo Lake, five stages of local environmental transformation have been distinguished. Anthropogenic influence on vegetation was relatively limited from the Middle Bronze Age to the Period V of the Bronze Age, according to Montelius (hereinafter referred to as PBA V). A substantial increase in settlement populations and significant environmental changes (deforestation, spread of ruderal habitats, and increased lake eutrophication) correspond to the transition between the PBA V and Hallstatt C phases. During the Hallstatt C/Władysławowo II A2 phase, a brief period of diminished settlement activity preceded the subsequent increase in human impact observed during the spread of societies linked to the Pomeranian culture. The final phase spans approximately 200 years of weakened settlements preceding the expansion of groups associated with the younger pre-Roman Period.

Keywords: Lusatian culture, Pomeranian culture, settlement development, pollen and NPPs data, environmental changes

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INTRODUCTION

Palaeoecological data from numerous Pomeranian sites (*i.e.*, the Pomerania region of Poland) indicate an abrupt vegetation change associated with the final decline of diverse deciduous woodlands dominated by broad-leaved trees during the Bronze/Iron Age transition (approximately 1200-500 BC; see Latałowa 2003; Ralska-Jasiewiczowa 2004). The causes of changes in vegetation composition and landscape transformation are attributed to both climate shifts and human activity. The process of transition from a relatively dry, warm, and continental climate to cooler and wetter conditions has been recorded over a similar period in both hemispheres (van Geel *et al.* 2000; Chen *et al.* 2025) and has been linked to a decline in solar activity (Bond *et al.* 2001; Beer and van Geel 2008, 152-154). This climate shift led to a new phase in forest history in Pomerania, characterised by the expansion of *Carpinus betulus* and *Fagus sylvatica* within forest communities. At the same time, the dynamics of the vegetation changes were also shaped by human influence. This was related to the activities of societies, which, in the classical view, were associated with the Lusatian and Pomeranian cultures (both strongly linked to the Urnfield tradition), as well as the Jastorf culture (Bukowski 1998; Dzięgielewski 2016; 2017; 2018; 2023; Ślu-sarska 2022; 2023).

Palynological data indicate that, depending on the site's location, natural conditions, particularly the soil cover and land use in its immediate vicinity, the settlement phases exhibit different dynamics and characteristics (*e.g.*, the predominance of crop cultivation or animal husbandry indicators). The exceptions here are sites (*e.g.*, Święta-Musznicka 2005) where, due to the low sedimentation rate, it was not possible to separate the levels corresponding to the Lusatian and Pomeranian cultures, and they are therefore considered together as one cultural horizon (Lusatian/Pomeranian phase). In the eastern Baltic coastal zone (Latałowa 1982a), in the Gdańsk Upland (Pędziszewska and Latałowa 2016), at some sites in the Kashubian Lakeland (Pędziszewska *et al.* 2015), in the eastern part of the Tuchola Forest (Miotk 1986; Filbrandt-Czaja 2009), and in Central Pomerania (Madeja 2012), a short but distinct settlement hiatus between the Lusatian and Pomeranian culture phases is marked. However, for other sites in the Kashubian Lakeland, palynological data suggest continuity of settlement between the two cultures (Pędziszewska 2008). This variation is also visible, to some extent, from the perspective of archaeological data, in relation to both the western (Ślusarska 2022; 2023) and eastern parts of Pomerania (Dzięgielewski 2017). Due to the current state of research, the situation in the central part of Pomerania, which is the focus of this study, remains unclear in this respect.

In recent years, new data have been published on the history of the development of plant communities in Central Pomerania (Fig. 1). In this article, we have utilised published palynological data from Wierzchowo Lake (Niedziółka and Święta-Musznicka 2023), which indicate that the first significant development of settlement in Central Pomerania did not occur

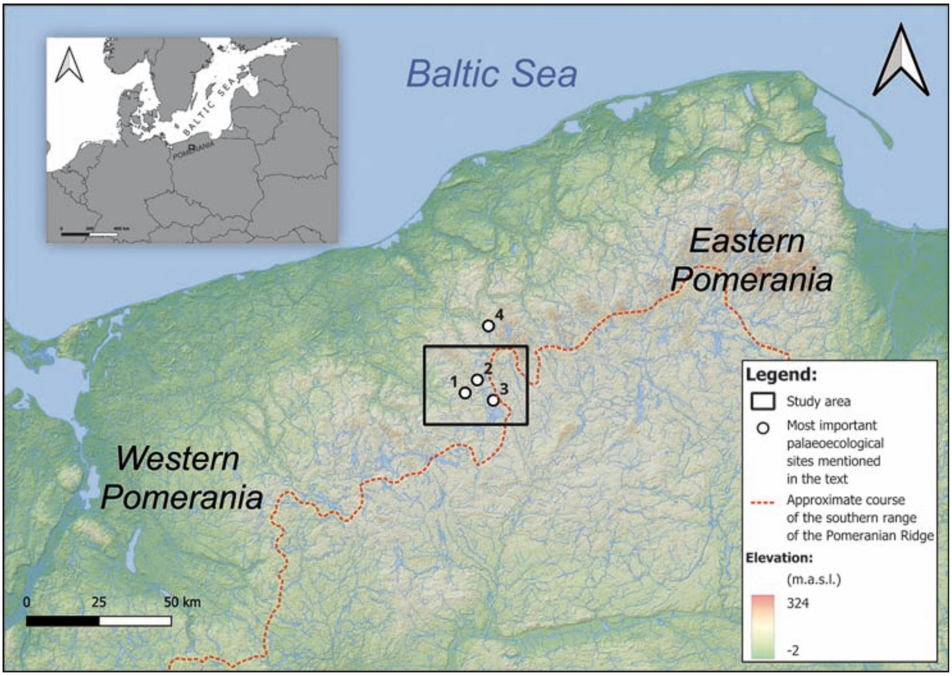

Fig. 1. Location of the study area and the four most important palaeoecological sites mentioned in the text: 1 – Kusowskie Bagno (after Lamentowicz *et al.* 2015); 2 – Wierzchowo Lake (after Niedziółka and Święta-Musznicka 2023); 3 – Spore Lake (after Pleskot *et al.* 2022a, 2022b); 4 – Kwiecko Lake (after Madeja 2012)

until the end of the Late Bronze Age. However, our aim was not only to demonstrate significant changes in the vegetation during this period (*e.g.*, deforestation, spread of ruderal habitats), but also to track the response of the local aquatic ecosystem to the dynamics of human settlement. To evaluate changes in the trophic status and water level of the lake, we utilised new, unpublished data on the representation of wetland and aquatic plants, as well as selected NPP (non-pollen palynomorph) taxa. The bioindicator properties of plants and green and blue-green algae were used to illustrate the response of the local ecosystem to climate change and to support conclusions regarding the scale of grazing. The reconstruction of the settlement in the studied area at the transition from the Bronze to the Iron Age is based on all available archaeological data within the study area. From a geographical point of view, it concerns not only the vicinity of Wierzchowo Lake, but also the areas around the nearest palaeoecological sites: Kusowskie Bagno (Lamentowicz *et al.* 2015) and Spore Lake (Pleskot *et al.* 2020; Pleskot *et al.* 2022a; 2022b). In this article, we also refer to the available archaeobotanical data to fully evaluate the role of plant cultivation in the economy of the societies inhabiting Pomerania at the turn of the Bronze and Iron Ages (*e.g.*, Klichowska 1967; 1979; Urban 2019).

Bearing in mind the above facts, as well as recently published archaeological data, we aim to synthesise the palaeoenvironmental and archaeological data from the turn of the Bronze and Iron Ages in Central Pomerania, and to answer the following questions:

1. What was the composition of vegetation before settlement development that appeared during the late phases of the Bronze Age (appearance of societies of the so-called Lusatian culture)?

2. Can we observe significant changes in the local environment during the late phases of the Bronze Age as a result of human settlement?

3. Can we observe significant changes in the local environment during the Early Iron Age as a result of human settlement?

4. Was there continuity of settlement between the Lusatian and Pomeranian cultures, or was there a hiatus in human occupation?

5. Are the changes in settlement intensity revealed by the pollen records consistent with the archaeological evidence related to this chronological frame?

The answers to these questions will significantly broaden our understanding of the relationship between humans and the environment in this area, which has been neglected in terms of research, from both palaeoenvironmental and archaeological perspectives.

STUDY AREA AND HISTORY OF RESEARCH

Geographical delimitation and environmental description of the study area

The research area covers locations where materials for palaeoenvironmental analysis have been obtained in recent years. These are Wierzchowo Lake, Spore Lake, and Kusowskie Bagno (Fig. 1, no. 1-3). Furthermore, data obtained from Kwiecko Lake, located slightly north of the study area (Fig. 1, no. 4), will also be taken into account. From the point of view of physical and geographical divisions, this area covers the eastern part of the Drawsko Lakeland and a small fragment of the northern part of the Gwda River Valley (Solon *et al.* 2018; Niecikowski *et al.* 2021; Wiśniewski *et al.* 2021). The geomorphology, geological structure, and hydrographic network of the study area were formed by the last glaciation (Weichselian), resulting in a fairly diverse landscape with a relative elevation difference of 114 metres (64-233 m a.s.l.). The eastern part of this area is dominated by glacial sand and gravel, while the western part is mainly covered with glacial clay. There are also areas of sand, gravel and clay deposits associated with terminal moraines, kames consisting of silt and clay covering higher areas, as well as peat bogs located in depressions (Marszałek and Szymański 2005; Popielski 2006; Winnicki 2011; Zlonkiewicz 2012). Given this geological structure, the soil cover consists of poor soils, dominated by podzols and pseudo-podzols, with small pockets of more fertile brown soils (Kabała *et al.* 2019; WOD-GiG-Szczecin 2023). This type of soil composition, however, is characteristic of almost the entire Pomerania region.

There are numerous lakes in the study area, although most of them are small in size (Jańczak *et al.* 1996). The exceptions here are Wierzchowo Lake, with an area of 732 ha and a maximum depth of 26.5 metres, and Wielimie Lake, the largest water reservoir in this region (1,754.6 ha). The network of watercourses is relatively well-developed, with the Gwda River, which flows out of Wierzchowo Lake and flows directly south to the Warta River, likely serving as a convenient communication route in the past. It is worth noting that the research area is situated on the watershed running along the Pomeranian Ridge, which, during the Bronze Age, may have also served as a favourable communication route between the eastern and western parts of Pomerania (Horst 1990; Fogel 1993; Niedziółka 2017).

Based on the potential natural vegetation map and geobotanical regionalisation (Matuszkiewicz 1993; 2008; Matuszkiewicz *et al.* 2023), the study area would have predominantly been covered by pine forests (*Leucobryo-Pinetum*) and mesotrophic oak-pine forests (*Querco-Pinetum*), with smaller areas of subatlantic beech-oak-hornbeam (*Stellario-Carpinetum*), acidophilous beech-oak (*Fago-Quercetum*), and beech (*Luzulo pilosae-Fagetum*) woodlands. Wet environments would support azonal vegetation such as alder carrs (*Carici elongatae-Alnetum*) and bog pine forests (*Vaccinio uliginosi-Pinetum*). Due to the region's limited commercial development, forests continue to dominate the local landscape, particularly in the eastern part of the study area, where pine and mixed stands, including oak, beech, and birch, prevail. Acidophilous beech forests with oak are limited to only small, specific areas. Fertile woodland patches with oak and beech exist farther from the Wierzchowo site, and alder carrs survive near water bodies. The contemporary settlement network is sparse, with most of the area comprising wastelands, limited arable fields, meadows, and peatland ecosystems. The latter ones are most affected by human intervention. Certain bogs, like Kusowskie Bagno in the southwestern part of the study area, were drained for peat extraction in the 20th century CE but are now regenerating and supporting typical bog forest vegetation. Although drainage ditches were constructed, the northern part of this bog remains waterlogged and appears to have preserved some of its natural features (Lamentowicz *et al.* 2015, 262).

The above information suggests that during prehistoric and early historical periods, this area may have been relatively attractive for settlement from the perspective of societies that relied on extensive agriculture or animal husbandry. Some areas may also have been particularly attractive from a defensive point of view, such as the hillfort located in Grąbczyn (archaeological site no. 1; see: Olczak 1971; Olczak and Siuchniński 1970, 38-46; Niedziółka 2017).

Table 1. Catalogue of recognized archaeological sites located within the study area (AZP – the Polish Archaeological Record; nn – no number)

No.	Locality & site no.; AZP no.	Description	Chronology	Location accuracy	Source
1	Bobolice 57, 58, 59, 60; AZP 20-25/30-33	Loose finds from several PC cemeteries	HaD	unknown, marked with accuracy to the locality	La Baume 1963, 43, 51; Malinowski 1969, 178; AZP cards no. 20-25/30, 20-25/31, 20-25/32, 20-25/33
2	Chociwle 6; AZP 20-25/70	PC cemetery, numerous urns, four cist graves	Lt A-B	accurate, according to AZP	AZP card 20-25/70
3	Dalęcino, nn; AZP 23-25/nn	LC burial mound cemetery, approx. 20 burial mounds with pottery burnt bones, charcoal, and bronze items (knob, sickle, ring, pin)	PBA IV-V (?)	unknown, marked with accuracy to the locality	Kostrzewski 1958, 260; AZP card 23-25/nn
4	Dalęcino nn; AZP 24-25/nn	PC cemetery, cist graves with 1 and 2 urns; urn covered with a lid	HaC	unknown, marked with accuracy to the locality	Kostrzewski 1958, 361; Malinowski 1981a, 46 (assigned to Skotniki locality); AZP card 24-25/nn
5	Dalęcino, nn; AZP 24-25/nn	PC cemetery, cist graves with one or several urns, including a face urn	HaD (?)	unknown, marked with accuracy to the locality	Malinowski 1981b, 161 (assigned to Opoczyska locality); AZP card 24-25/nn
6	Gałowo, nn, AZP 24-26/nn	PC cemetery, cist graves	EIA (HaC-HaD?)	unknown, marked with accuracy to the locality	Malinowski 1979, 137; AZP card 24-26/nn
7	Grąbczyn (Grąbczyński Młyn) nn, AZP 21-25/64	Deposit of bronze items (9 items), found in a bog, in a 'stone hiding place' in the first half of the 19th century	PBA V	unknown, marked with accuracy to the locality	AZP card 24-25/64
8	Grąbczyn. 1 (+ 3, 4); AZP 21-25/1, 3, 4	A settlement with a large amount of archaeological material (mainly pottery) from the transition between the LBA and EIA, alleged hill-fort from the LBA	PBA V- HaC	accurate, according to AZP	Olczak 1971; Niedziółka 2017; Niedziółka, Święta-Musznicka 2023; AZP card 24-25/1, 3, 4
9	Grąbczyn, nn; AZP 21-25/nn	LC burial mound cemetery, five burial mounds	PBA IV-V (?)	accurate, verified in the field	Publication in preparation
10	Grzmiąca 5; AZP 22-23/16	PC cemetery, seven cist graves, some containing pottery vessels and bronze ornaments	HaC/D	accurate, according to AZP	Malinowski 1979, 182; AZP card 22-23/16

11	Kaliska 37; AZP 20-27/46	Two very large deposits of bronze items placed in the same location	PBA V HaC	accurate, according to the publication map	Kaczmarek et al.. 2021; Szczurek, Kaczmarek 2022
12	Kowalki 31; AZP 20-23/22	Alleged cemetery of the PC, probably a destroyed cremation grave	EIA	accurate, according to AZP	AZP card 20-23/22
13	Mieszałki 2; AZP 21-23/3	PC cemetery, one cup - burial accompanying vessel? loose find	HaD	accurate, according to AZP	Hamling 1963, 602-603
14	Mieszałki 1; AZP 21-23/22	Deposit of metal items, four necklaces made of gold	PBA V	unknown, marked with accuracy to the locality	AZP card 21-23/22
15	Parsęcki Młyn nn	Multi-phase urnfield cemetery, LC urn graves containing i.a. bronze pin from the 3rd period of the BA, a pin with a swan neck from the late BA; 34 cist graves associated with PC, richly decorated cinerary urns	PBA III - V BA, HaC - HaD - Lt A-B	approximate, marked with accuracy to the remains of an old mill in the village of Parsęcko	Skrzypek 2010, 30-39
16	Parsęcko 28; AZP 24-24/106, cemetery I	PC cemetery, cist graves, graves reinforced with stones, urns covered with bowls, lids and stones, charcoal found in graves. Traces of funeral feasts were spotted, *e.g.*, charred barley grains.	HaD	unknown, marked with accuracy to the locality	Malinowski 1981b, 179; AZP card 24-24/106
17	Parsęcko 29; AZP 24-24/107, cemetery II	PC cemetery, cist graves containing urns, including face urns. The spatial relationship to the cemetery I is unknown.	HaD (?)	unknown, marked with accuracy to the locality	Malinowski 1981b, 179-180; AZP card 24-24/107
18	Porost, stan. 10	PC cemetery, seven cist graves with stone reinforcement, inside which were cinerary urns, some of which had lids	late HaD - Lt A-B	accurate, based on a map from a published source	Skrzypek 1983, 3-22
19	Porost, 11; AZP 20-25/101	PC cemetery, two urn graves, two vessels, one knife	EIA	unknown, marked with accuracy to the locality	AZP card 20-25/101
20	Porost, 13; AZP 20-25/103	PC cemetery, four pottery vessels	Lt A-B	unknown, marked with accuracy to the locality	AZP card 20-25/103
21	Porost, 14; AZP 20-25/104	PC cemetery, three urns, two lids	Lt A-B	unknown, marked with accuracy to the locality	AZP card 20-25/104
22	Sępólno Wielkie 1, AZP 20-26/25	LC burial mound cemetery, approx. 20 burial mounds, containing fragments of pottery, a bronze fibula, a pin with a cylindrical head and one bronze ring	PBA III/IV (III BA according to T. Malinowski)	unknown, marked with accuracy to the locality	Kostrzewski 1958, 313

Table 1.

No.	Locality & site no.; AZP no.	Description	Chronology	Location accuracy	Source
23	Smilicz 1; AZP 24-23/49	PC cemetery, 23 cist graves, amateurishly excavated	HaC	accurate, according to AZP	AZP card 24-23/49
24	Stare Wierzchowo nn AZP 22-25/nn	PC cemetery, cist graves, Malinowski 1981, katalog cment. KP, t. 3, s. 68	EIA	unknown, marked with accuracy to the locality	Malinowski 1981a, 68; AZP card 22-25/nn
25	Stepień 8; AZP 22-26/6	LC urnfield cemetery, urn graves, partially reinforced with stones, some graves contained the remains of a pyre. A bronze sickle was found in one of the graves.	PBA IV - V (?)	unknown, marked with accuracy to the locality	Kostrzewski 1958, 320; AZP card 22-26/6
26	Sucha 2; AZP 22-23/4	PC cemetery, 1 cist grave containing, among other things, an iron arrowhead	EIA	unknown, marked with accuracy to the locality	Wołagiewicz, Wołągiewicz 1963, 13; AZP card 22-23/4
27	Sucha 3; AZP 22-23/5	LC urnfield burial mound cemetery – 1 burial mound with a chamber grave, bronze objects: knife, bronze fibula with a bow and spiral discs, tweezer, ring	PBA IV - V (?)	accurate, according to AZP	Kostrzewski 1958, 324; AZP card 22-23/5
28	Wierzchowo nn; AZP 22-25/nn	PC cemetery, cist graves	EIA	unknown, marked with accuracy to the locality	Malinowski 1981a, 149; AZP card 22-25/nn
29	Wierzchowo nn; AZP 21-25/62	Large deposit of bronze items (22 items)	V PBA V	unknown, marked with accuracy to the locality	Wilkens 1997 AZP card 21-25/62

Current state of research: palaeoenvironmental studies

In Central Pomerania, in the vicinity of Wierzchowo Lake (within a 20 km radius), palaeoecological studies have so far been carried out at three other sites. Wierzchowo Lake is the largest of them (723 ha). Each of the other reservoirs exceeds 80 ha in area, so the pollen source area of all sites is significant (Jacobson and Bradshaw 1981; Sugita 2007). We assume that for this reason, the available pollen data have a lower proportion of local components, and fluctuations in tree pollen composition largely reflect regional-scale changes in forest communities. Despite the overrepresentation of trees, it is reasonable to assume that a decline in their proportion, accompanied by an increase in the total sum of herbaceous pollen and anthropogenic taxa, indicates the development of local settlement (Behre 2007; Kreuz 2008). Given the low pollen productivity of most cereals (Broström *et al.* 2008; Abraham and Kozáková 2012) and many herbaceous plant taxa, such as those typical of pastures (Hjelle 1999), even their relatively low values may reflect local environmental changes caused by human activity in the catchment areas of larger lakes.

A profile from Kwiecko Lake (Madeja 2012), located to the north of the defined study area (Fig. 1, no. 4), provides valuable information on local vegetation changes from the beginning of the Preboreal to the late Middle Ages. In addition, the high-resolution pollen data from the site have been correlated with archaeological data, illustrating six settlement phases, including the human impact on the environment during the Lusatian and Pomeranian cultures. Unfortunately, the palaeoenvironmental reconstruction is based on palynological chronology rather than an age-depth model because the obtained radiocarbon dates were too old. Some dates were incorrect because the study used material from carbonate sediments, including moss tissues, which can absorb carbon from dissolved old carbon in the basin (Madeja and Latowski 2008). Nevertheless, we used data from the Kwiecko site to discuss the changes that occurred in the forest communities of Central Pomerania and the type of economy prevalent during the period of interest to us.

For the other two sites located within the study area (Kusowskie Bagno, Spore Lake, Fig. 1, nos 1 and 3), palaeoecological research has primarily focused on studying past hydroclimatic changes and their impact on local vegetation transformation. The reconstruction of the regional hydroclimatic signal from the Kusowskie Bagno was based on testate amoebae, stable carbon isotopes, and plant macrofossils from the local mire (Lamentowicz *et al.* 2015). In the case of Spore Lake, a chironomid-derived reconstruction of mean July air temperature is available (Pleskot *et al.* 2020; Pleskot *et al.* 2022a); unfortunately, the palynological data from both sites are published only in a simplified form. The summarised curves of anthropogenic indicators and cereals, combined with the lack of data on taxa associated with grazing or ruderal habitats, make it difficult to conclude the development of settlement in the vicinity of these sites. This is likely a result of the focus of these papers, as palynological data were used only as a proxy to describe the main changes in vegetation composition and human-induced deforestation in the catchment (Lamentowicz *et al.* 2015; Pleskot *et al.* 2022b), but unfortunately, without reference to archaeological sources. Therefore, the well-dated pollen profile from Wierzchowo Lake, which records environmental changes from the Neolithic to Medieval Times (Niedziółka and Święta-Musznicka 2023), can serve as a reference site in Central Pomerania for reconstructing settlement dynamics.

The results of analyses of plant macroremains from archaeological sites can serve as an additional source of information, providing important insights into the agricultural economies of prehistoric communities (Lityńska-Zając and Wasylikowa 2005). Unfortunately, for the period we are interested in, archaeobotanical data from Central Pomerania are available from only one Lusatian culture site, located to the southwest of our study area (Klichowska 1967). So far, archaeobotanical analyses at the investigated site of the Pomeranian culture in this area have not revealed any traces of cultivated plants (Abramów 2013). For this reason, we decided to use macroremains data on cultivated plants from a few sites located in neighbouring areas, *i.e.*, Eastern and Western Pomerania, the northern part of Greater Poland, Kuyavia and Chełmno Land, dating to the period of the Lusatian (Klichowska 1971; Urban 2019) and Pomeranian cultures' activity (Klichowska 1962; 1979; Podgórski 1979).

Current state of research: archaeology

Pomerania is very unevenly explored in terms of archaeological research on the Late Bronze Age and Early Iron Age. Its western (Ślusarska 2022; 2023) and especially its eastern parts (Dzięgielewski 2017; 2018; 2023; see also further references therein) are relatively well-explored, both in terms of synthetic and more detailed approaches. When it comes to scholarship covering the entire region, Józef Kostrzewski's classic work and Zbigniew Bukowski's later work remain important research resources (Kostrzewski 1958; Bukowski 1998). The work of Janusz Ostoja Zagórski (1982) should also be mentioned. It addresses issues related to the natural environment within the context of settlement network development during the Hallstatt period.

Broadly, research on the transition from the Bronze Age to the Iron Age in Central Pomerania is much more sparse. The few, more general studies of the region are incomparable with more recent data sets, due to the data collection methodologies of the time (Sikora 1975). The situation is similar regarding the research area presented here (Janocha and Lachowicz 1971; Skrzypek 2010). When it comes to specific archaeological sites (Table 1), the most notable finds in the area under study are deposits of bronze objects dating back to the Late Bronze Age. These include the famous hoard from Wierzchowo (Wilkens 1997, 223–225), as well as finds from Grąbczyn/Grąbczyński Młyn (Blajer 2001, 344); however, the exact findspots of these items remain unclear to this day. In recent years, a double hoard consisting of costume ornaments and horse harness elements was discovered in the immediate vicinity of the study area (Szczurek and Kaczmarek 2022;

Kaczmarek *et al.* 2021). Burial areas, frequently unrecognised, are also present in the region, although, much like research in the region more broadly, there is a dearth of publications. There is one known, possibly flat, burial ground associated with the Late Bronze Age located in Stepień (Kostrzewski 1958, 320), as well as two burial mound cemeteries from this period located in Dalęcino (unnumbered archaeological site, Table 1, no. 4) and Sępólno Wielkie 1 (Table 1, no. 22). It is also worth mentioning the multiphase cemetery (Middle/Late Bronze and Early Iron Age) at Parsęcki Młyn. Cemeteries associated with the Early Iron Age are also known from several locations both within the study area and in its vicinity (Skrzypek 2010, 38, 39).

Recently, a study of the palynological profile taken from the Wierzchowo Lake was published. It is presented against the background of available archaeological data for the entire microregion (Niedziółka and Święta-Musznicka 2023), providing important insights into the relationship between humans and the environment in this area.

MATERIAL AND METHODS

Palaeoenvironmental study

The core for palaeoenvironmental study was taken from the southwestern part of the Wierzchowo Lake (53°51'26" N, 16°38'47" E) using a Więckowski piston corer. The profile was dominated by calcareous gyttja with variable proportions of fine-grained sand, silt, and traces of shell detritus (Table 2) and was analysed as a continuous sequence. In this paper, we focus on a 62 cm-long section of the core, spanning a depth range of 740 to 802 cm, where pollen analysis was conducted at a higher resolution.

Samples for pollen analysis were acetolyzed (Fægri and Iversen 1989). Pollen and spore identification followed Beug (2004) and Punt *et al.* (1976-2003). The analysis was subsequently expanded to encompass the identification of microcharcoal particles >20 µm and

Table 2. Lake sediments description

Unit no.	Depth (cm)	Description/ Troels-Smith formula (1955)
1	740-742	detritus-calcareous gyttia with admixture of fine-grained sand, silt and traces of shell detritus/ Ld⁴Lc2 Gmin1 AsAg1 test. (moll.) ++ nig. 3, strf. 0, elas. 2, sicc. 2, humo. 4, 5Y 2,5/1
2	742-784	calcareous gyttia with admixture of fine-grained sand and silt, traces of shell detritus at the depth of 775-776/ Lc3 Gmin1 AsAg+++ test. (moll.) +, nig. 2, strf. 0, elas. 3, sicc. 3, lim. sup. 0, 5Y 4/1
3	784-802	calcareous gyttia with admixture of silt and fine-grained sand, Lc4 AsAg+++ Gmin +++, nig. 1-2, strf. 0, elas. 3, sicc. 3, lim. sup. 0, 5Y 6/1- 5Y4/1

NPPs (van Geel 2001), including coprophilous fungi (van Geel *et al.* 2003; Henry 2020) and green and blue-green algae (Komárek and Jankovská 2001; Kuhry 1997). The identification of phases illustrating environmental changes in the vicinity of the site was based on the ratio of arboreal pollen to non-arboreal pollen, the proportion and diversity of anthropogenic indicators (Behre 1981; Brun 2011), and the changes in microcharcoal. To determine the human impact on the lake ecosystem, the bioindication properties of NPPs and selected geochemical indicators were also used. Loss on ignition (LOI) was applied to calculate the percentage contribution of organic matter in lake sediments (Heiri *et al.* 2001). Nitrogen and phosphorus contents were employed as markers of higher nutrient loading and eutrophication of the lake due to increased human impact on the environment (Smol 2008), and titanium served as an indicator of mineral matter delivery from the catchment affected by deforestation-induced erosion (Davies *et al.* 2015). The proportions of calcium and iron were examined to estimate lake level changes (Pleskot *et al.* 2018, 454; Tylmann *et al.* 2024, 9).

Table 3. AMS provenance and results (dates calibrated using the calibration curve with OxCal v4.4.4)

Sample no.	Lab. code (Poz-)	^{14}C yr BP	yr cal. AD/BC 95.4% ranges	Material dated
706-708	133500	850±30	1054 (0.9%) 1060 AD 1157 (94.6%) 1267 AD	*Betula* sect. *albae* (fruits, bud scales), *Alnus glutinosa* (fruits, fragments of cone), *Pinus sylvestris* (periderm), bud scales, leaf fragments
724-726	140135	1885±30	78 (7.1%) 101 AD 107 (88.3%) 234 AD	*Betula* sect. *albae* (fruits), *Pinus sylvestris* (periderm), bud scales, leaf fragments
776-778	117449	2615±30	825 (95.4%) 771 BC	*Betula* sect. *albae* (fruits), *Alnus glutinosa* (fruits), *Pinus sylvestris* (periderm), bud scales, leaf fragments
874-876	140835	5210±35	4221 (2.6%) 4201 BC 4164 (8.0%) 4132 BC 4061 (84.9%) 3955 BC	*Betula* sect. *albae* (fruit and bud scale), *Alnus glutinosa* (fruit, fragment of cone), *Pinus sylvestris* (periderm), bud scales, leaf fragments
958-960	157093	6930±40	5963 (1.0%) 5956 5896 (94.5%) 5725	*Betula* sect. *albae* (fruit and bud scale), *Alnus glutinosa* (fruit), *Pinus sylvestris* (periderm), *Schoenoplectus lacustris* (fruit), bud scales
984-986	160780	9080±50	8455 (0.7%) 8444 8435 (94.7%) 8225	*Betula* sect. *albae* (fruit and bud scale), *Pinus sylvestris* (periderm, seed, dwarf shoot), *Carex* sp. (fruits), bud scales
1006-1009	140209	9560±50	9191 (1.0%) 9177 BC 9163 (94.4%) 8753 BC	*Carex rostrata, C. pseudocyperus, Schoenoplectus lacustris* (fruits), *Betula* sect. *albae* (fruits), *Pinus sylvestris* (periderm, dwarf shoot), bud scales

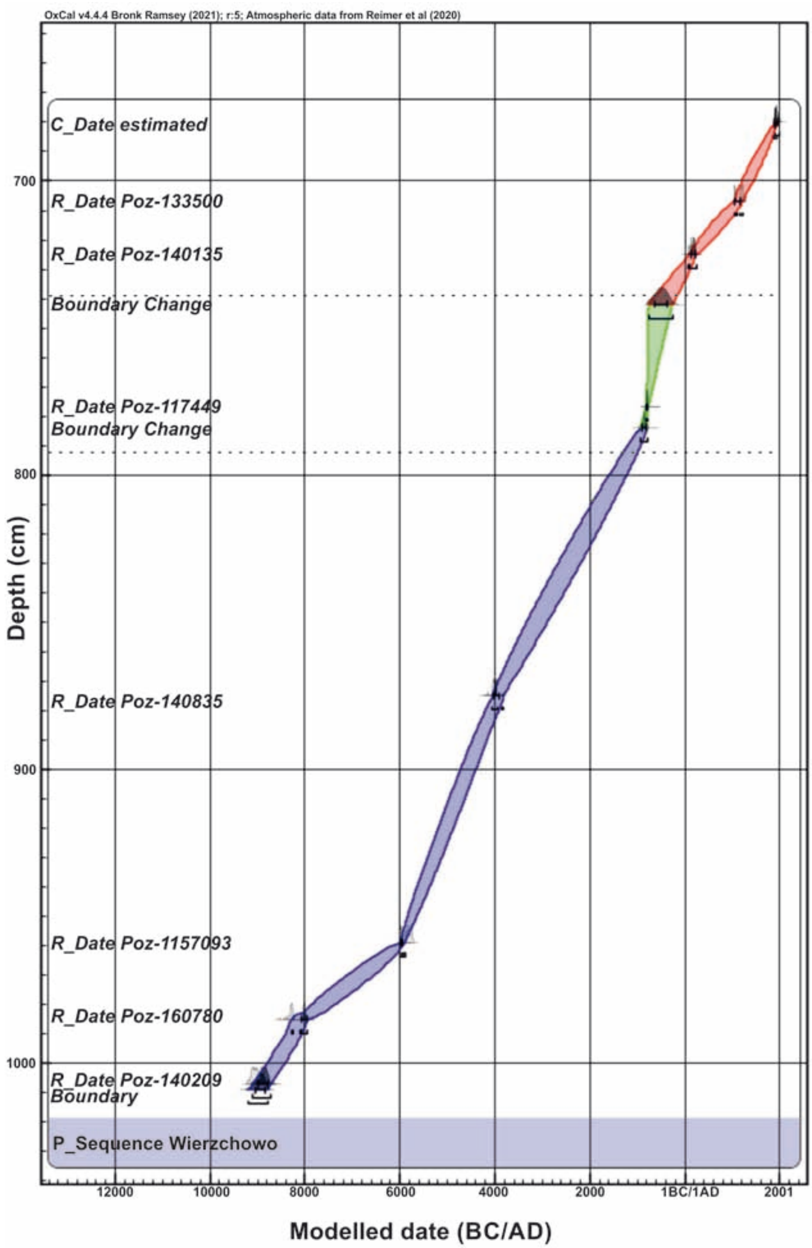

Fig. 2. The age-depth model (95.4% probability) for the analyzed profile and graphs showing the probability ranges (2σ) for individually calibrated ^{14}C dates (Poz- acc. to Table 3). The section of profile selected for further analysis is limited by horizontal dashed lines

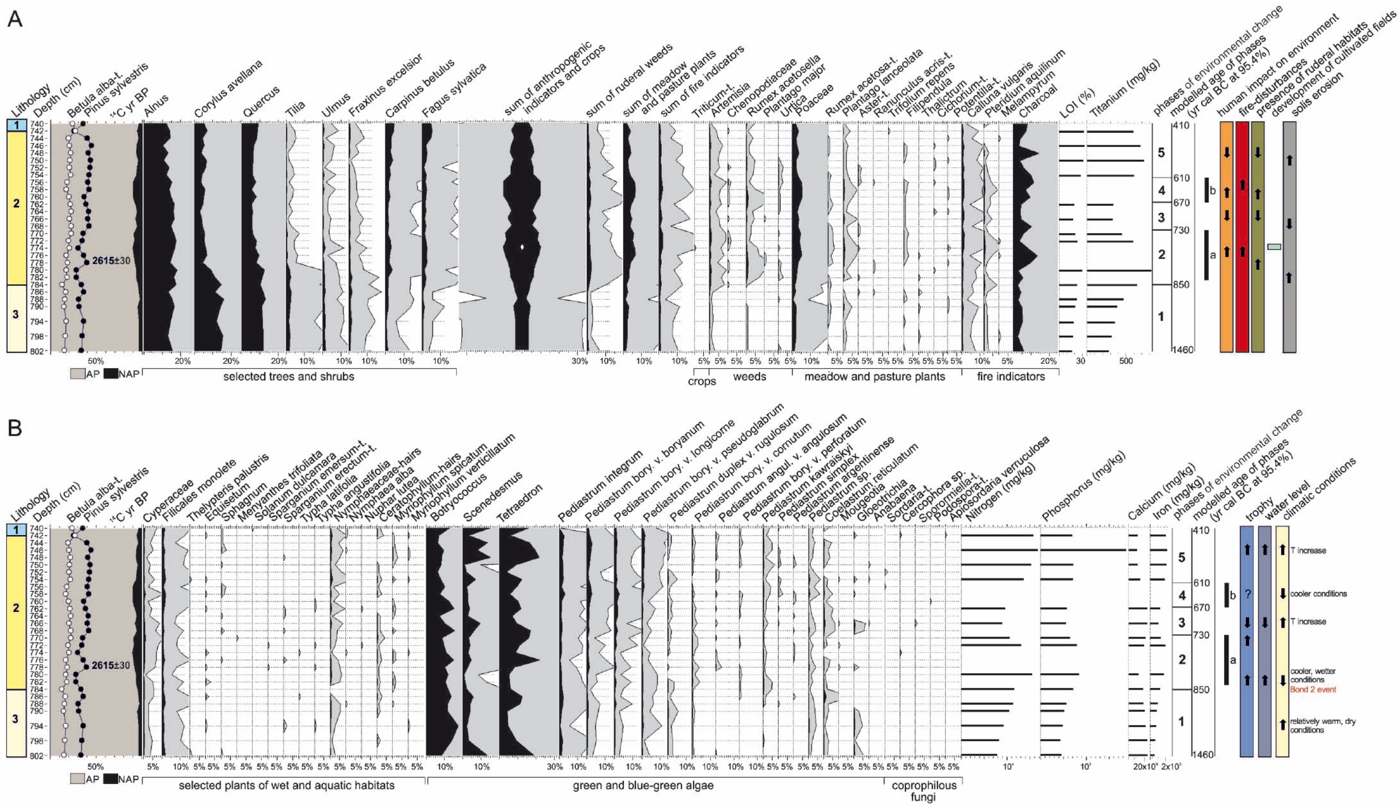

Fig. 3. The simplified diagram from Wierzchowo Lake (W/7 profile), A – illustrating environmental changes in the vicinity of the lake according to selected curves of trees, herbs, charcoal, and geochemical data; B – illustrating changes in the lake ecosystem according to selected curves of local plants, algae, coprophilous fungi, and geochemical data; lithological units acc. to Table 2; AP – arboreal pollen, NAP – non-arboreal pollen; black rectangle – the palaeoecological signal of human activity associated with Lusatian (a) and Pomeranian (b) cultures

The chronology of environmental change was established by AMS radiocarbon dating of 7 samples in the complete sequence of the profile (Table 3). Terrestrial plant remains from lake sediments were used for dating at the Poznań Radiocarbon Laboratory. Among the dated material, remains of trees (*Betula* sect. *albae*, *Pinus sylvestris*, bud scales) and plants of local origin, forming the wet communities around the lakes (*e.g.*, *Carex rostrata*, *C. pseudocyperus*, *Schoenoplectus lacustris*), predominated. To obtain calendar years, the BP dates were calibrated using OxCal version 4.4.4 (Bronk Ramsey 2021) based on the IntCal20 atmospheric curve (Reimer *et al.* 2020). The age-depth relationship of the sediments (Fig. 2) was determined using the set of consecutive ^{14}C dates supplemented by the estimated age of level 680, calculated based on the sedimentation rate in the upper part of the profile, which consisted of the same type of gyttja. An age/depth model was obtained using the OxCal P_Sequence algorithm with a 95.4% probability range and used to establish the chronology of individual stages of environmental change, expressed as a modelled median. Radiocarbon dating of the entire profile spans the time interval between approximately 8700 BC and 1880 CE, encompassing the entire Holocene sequence. The part of the profile presented in this article accumulated over a period of almost 1000 years, from 1460 to 410 BC (Fig. 3), and therefore covers a time span from the period preceding the expansion of the Lusatian culture in Central Pomerania during the Late Bronze Age to the Early Iron Age.

Archaeological study

The archaeological data discussed in this study were sourced through archival research conducted at the Provincial Conservation Service Office in Koszalin within the Polish Archaeological Record (AZP) archive. By integrating 1:10,000-scale topographic maps with AZP site cards in QGIS software, it was possible to prepare updated maps (Fig. 4) and analyse the entire study area. Data from a total of 9 AZP sheets were used: 21-24, 21-25, 21-26, 22-24, 22-25, 22-26, 23-24, 23-25, 23-26.

It is important to note, however, that the AZP was initially designed as a conservation and scientific programme, rather than a purely scientific one. Therefore, its data should be approached with caution and critical awareness. The chronological assessment of sites is especially uncertain when it relies predominantly on fragmented pottery collected from surface surveys, materials often disturbed by contemporary agricultural activities (Czerniak 1996; Matoga 1996; Niedziółka 2016). Uncritical dependence on AZP data for reconstructing prehistoric settlement patterns risks producing a distorted interpretation (Furmanek and Wroniecki 2020), potentially leading to the identification of non-existent sites or the omission of authentic ones.

A review of the available literature was conducted. A list of archaeological sites dating from the Late Bronze Age and Early Iron Age that have been investigated so far was compiled (accidental finds were also considered, see: Table 1). This made it possible to create

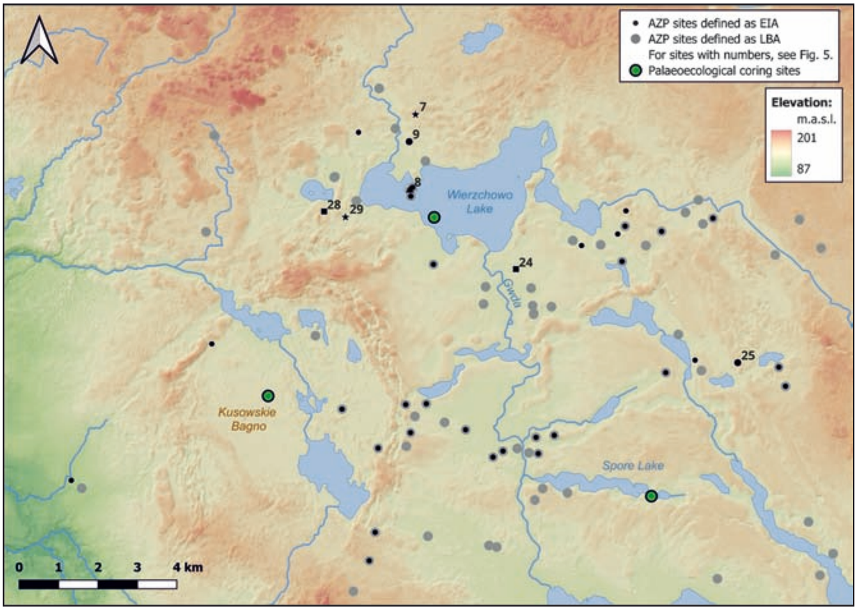

Fig. 4. Locations of palaeoecological sites presented on the background of the AZP data; better-known archaeological sites are marked with numbers (see: Table 1, Fig. 5)

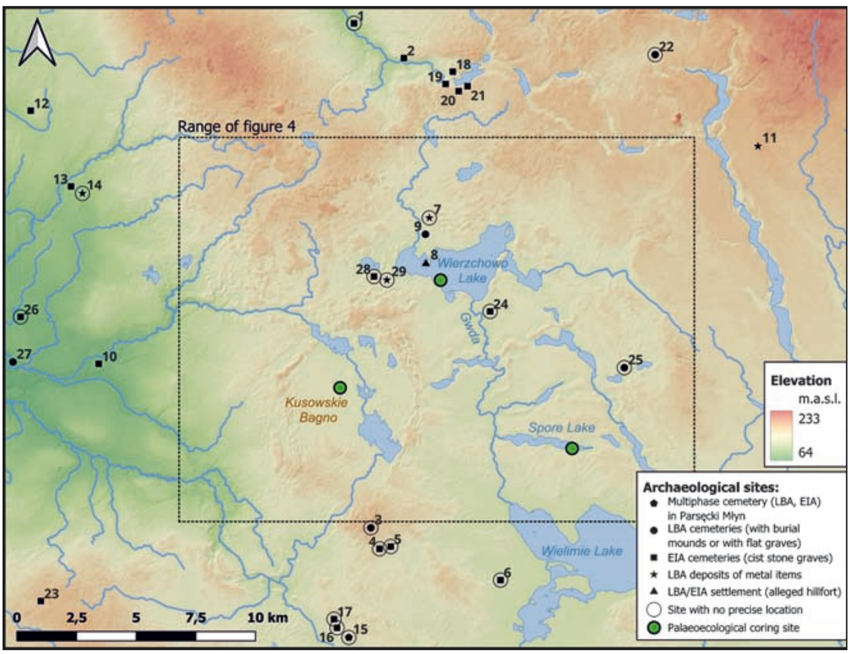

Fig. 5. Study area with marked locations of better-recognized archaeological sites from the LBA and EIA (see: Table 1)

a catalogue of known sites, the chronology of which, in most cases, was determined with greater precision than was the case with AZP sites discovered during surface surveys. This search had a wider range covering approximately the area of the neighbouring AZP sheets in relation to those mentioned above (*i.e.*, additionally sheets no. 20-23, 20-24, 20-25, 20-26, 20-27; 21-23, 21-27, 22-23, 22-27, 23-23, 23-27, 24-23, 24-24, 24-25, 24-26, 24-27; see: Fig. 5).

Comparison of palaeoenvironmental and archaeological data

In the final stage, the palaeoenvironmental data summarizing the history of the development of plant communities were divided into five phases according to the age-depth model (Fig. 2). These phases were then juxtaposed with the current periodisation of the Late Bronze Age and Early Iron Age for the area of Eastern and Central Pomerania by K. Dzięgielewski (2017, fig. 2; 2018, fig. 1), based on the earlier system developed by J. Podgórski (1992). The results, presented in Figures 3 and 6, enabled a comparison of the palaeoenvironmental analyses with the available archaeological data.

HUMAN IMPACT ON ENVIRONMENT IN CENTRAL POMERANIA AT THE TURN OF THE BRONZE AND IRON AGES

As mentioned above, within the time span of interest, we were able to distinguish five stages of environmental change that occurred near Wierzchowo Lake and in the local aquatic ecosystem under the influence of diverse human activity dynamics (Figs 3 and 6).

The first phase represents the period from 1460 to 850 BC. The palynological data indicate the existence of a dense forest cover around the lake, with its edges overgrown by well-developed rush vegetation, including Cyperaceae, *Typha latifoli*a, *T. angustifolia*, and *Sparganium erectum*. It was composed of alder forest stands on wetland habitats and mixed deciduous woodlands, the most important components of which were *Corylus avellana* and *Quercus*, with admixtures of *Ulmus*, *Fraxinus excelsior*, *Tilia*, *Fagus sylvatica*, *Carpinus betulus,* and *Pinus sylvestris* communities on the less fertile mineral soils. During this period, the human impact on the local environment was somewhat limited, as indicated by a low proportion of anthropogenic indicators. However, given the high proportion of hazel and oak in the woodlands surrounding the lake, it cannot be ruled out that the activities of local societies led to the formation of coppice forests. This vegetation type was widespread in the microregion and throughout Pomerania (*e.g.*, Latałowa 1992; Milecka *et al.* 2004; Pędziszewska *et al.* 2015), and techniques to stimulate the development of hazel-oak thickets, including burning and trimming, were practised not only in the Neolithic but also in the Bronze Age (Madeja 2012; Kłusek and Kneisel 2021). The catchment of the Wierzchowo Lake may have been used for grazing, as indicated by the regular occurrence of *Plantago lanceolata* and *Rumex acetosa*-t., species typical of pastures (Latałowa 1992) or other anthropogenic habitats (Brun 2011). The grazing animals near the lake may have contributed to an influx of nutrients, leading to regular algal blooms in the local ecosystem. This is evidenced by the presence of *Gloeotrichia*, a blue-green algae indicative of eutrophic to mesotrophic waters (van Geel *et al.* 1994, 102; Kuhry 1997), and relatively warm

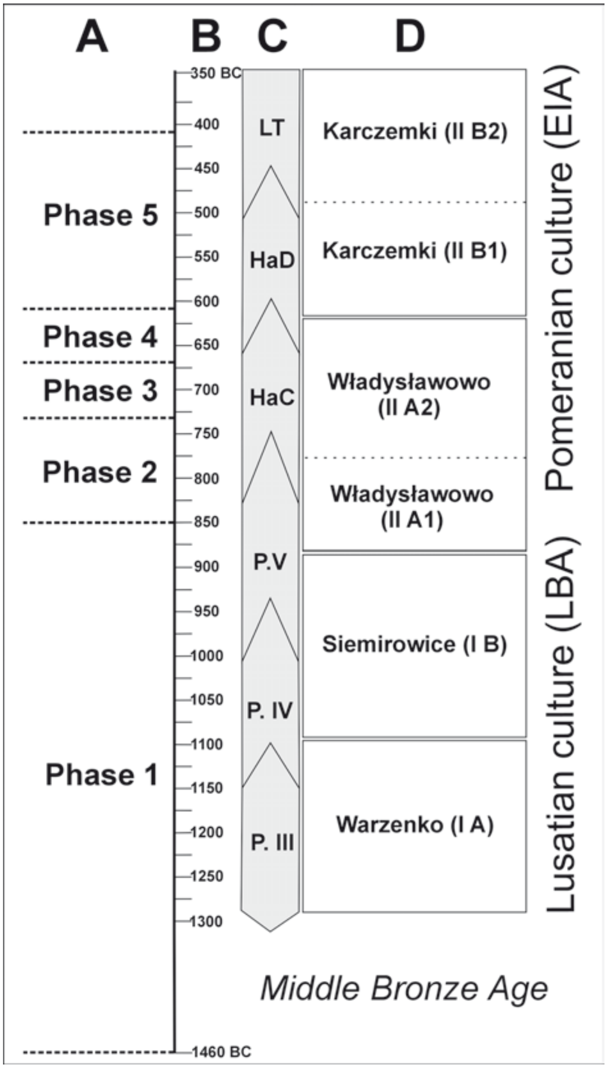

Fig. 6. Five stages of environmental change that occurred near Wierzchowo Lake juxtaposed with absolute and relative archaeological chronology and periodisation (A – phases of environmental change; B – calendar years, C – relative chronology, D – J. Podgórski periodisation [1992] updated by K. Dzięgielewski [2018]; figure based on: Dzięgielewski 2018, fig. 1)

climatic conditions (van Geel *et al.* 1989, 92-94). Important components of the green algae flora were *Pediastrum integrum*, *Pediastrum boryanum,* and *Coelastrum reticulatum*, which may have been favoured by a well-developed macrophyte zone (Apolinarska *et al.* 2018, 43) with *Nymphaea alba*, *Ceratophyllum*, *Myriophyllum spicatum* and *M. verticillatum*. The taxonomic composition of aquatic plants typical of eutrophic waters (Kłosowski and Kłosowski 2001) confirms the higher trophic status of the reservoir at this time. However, it should be emphasised that another factor supporting *Tetraedron* and *Coelastrum reticulatum* blooms may also have been higher temperatures in the local ecosystem (Jankovská and Komárek 2000, 69-71; Mirosław-Grabowska *et al.* 2015, 181) and drier conditions (Stivrins *et al.* 2015, 110).

From an archaeological point of view, the beginning of this phase is linked to the end of the PBA II and with the beginning of the PBA III ('Warzenko' phase according to the periodisation of J. Podgórski/K. Dzięgielewski: Fig. 6; see also: Podgórski 1992; Dzięgielewski 2017, fig. 2; 2018, fig. 1). The archaeological information for this period is consistent, to some extent, with the palynological data, as human activity during this time, particularly in Central Pomerania, was very limited (Gedl 1990, 27-36; Bukowski 1998, 117-26; Kaczmarek 2018, 11-16). Most of the sites consist mainly of burials, deposits of bronze items, and isolated finds. As such, archaeology does not provide much data on the economy of the inhabitants of Central Pomerania. The situation becomes clearer during the 'Siemirowice' phase, which can be compared with PBA IV and early PBA V (Fig. 6; see also: Dzięgielewski 2017, fig. 2). During these periods an increasing number of sites began to appear in both the eastern and central parts of Pomerania, with burial mounds still clearly dominating within the list of sites (Bukowski 1998). In the eastern and central parts of Pomerania, a local group associated with urnfields (in older literature referred to as the Kashubian [local] group of Lusatian culture; see: Dąbrowski 1979, 74) was already clearly distinguishable at that time. However, there are still no satisfactorily recognised settlements from this period, and it also seems that the economy was based more on animal husbandry than on cereal cultivation (Dzięgielewski 2017, 313).

A discussion of the role of cereal cultivation between PBA II and PBA V is difficult due to the lack of macroscopic remains from the archaeological sites in the studied area. Nevertheless, archaeobotanical data from Western Pomerania and Chełmno Land confirm that *Panicum miliaceum*, *Hordeum vulgare*, *Triticum dicoccum,* and *Triticum aestivum* were cultivated during this period (Urban 2019). However, the predominance of cereal remains in the form of imprints on pottery fragments and daub, as opposed to the accumulation of grains in storage pits, makes it difficult to determine the role of individual species in sowing practices and yields. An exception is the material found in storage pits and settlement layer in Bruszczewo (Greater Poland), dated to around 1370 BC. The dominance of *Triticum dicoccum* grains, with a small admixture of *Hordeum vulgare* and *Triticum monococcum* in the samples, suggests that it played a significant role in local agriculture (Klichowska 1971).

Regarding the presence of archaeological sites from the Early Iron Age in the study area, these are isolated discoveries (*e.g.*, early finds in a multiphase cemetery in Parsęcki Młyn, Tab. 1, no. 15, see also: Skrzypek 2010, 29, 30; or potentially from the cemetery in Sępólno Wielkie 1, tab. 1, no. 22), which is consistent with the palaeoenvironmental data indicating low human activity in the analysed area.

The second phase can be dated to the period between 850 and 730 BC (Fig. 3), which corresponds to the transition between the PBA V and Hallstatt C phases (*i.e.*, Władysławowo II A1 and partly Władysławowo II A2 (Fig. 6). It covers a time of significant environmental changes during the settlement and occupation of the microregion by groups of the Lusatian culture. The beginning of this phase is characterised by significant deforestation around the lake. The sharp decline in the proportion of *Corylus*, synchronised with the decline in *Quercus*, *Tilia*, *Ulmus,* and *Fraxinus,* suggests the destruction of forest stands growing on the more fertile soils. The more open landscape of Central Pomerania at that time – a result of human-induced deforestation – is also reflected in the pollen spectra from Spore Lake (Pleskot *et al.* 2022b) and Kusowskie Bagno (Lamentowicz *et al.* 2015). The simultaneous rise in microcharcoal content in the Wierzchowo Lake sediments and the increased representation of pollen from plants that colonise lands with sandy soil and after fires (*Pteridium aquilinum*, *Melampyrum*, *Calluna vulgaris*, *Rumex acetosella*) indicate the disturbance of woodland through fire. The considerable intensification of settlement processes during the Late Bronze Age is documented by the appearance of farming and settlement indicators, as well as an increase in LOI and titanium, which confirms the increase in erosion within the catchment.

The economy of the Lusatian culture societies in Pomerania was based mainly on animal husbandry and, to a lesser extent, on plant cultivation, as suggested by archaeological (Dzięgielewski 2017; Urban 2024) and palaeobotanical (Latałowa 1997; Rembisz *et al.* 2009; Urban 2019) data. In the case of the Wierzchowo microregion, livestock farming was also more important than cereal cultivation. This is indicated by the low proportion of pollen from wheat (*Triticum*-t.; Wierzchowo Lake) or cereals (Kusowskie Bagno, Lamentowicz *et al.* 2015), its absence in the sediments of Spore Lake (Pleskot *et al.* 2022b) and the high proportion of pollen from plants typical of meadows and pastures (*e.g.*, Poaceae, *Plantago lanceolata*, *Ranunculus acris*-t., *Rumex acetosa*-t.) at all sites. However, this may have been specific to the area, where poor soils without much economic value predominate, as pollen data from the neighbouring Kwiecko site (Madeja 2012) and other parts of Pomerania, Wolin Island (Latałowa 1992), and the Kashubian Lakeland (Pędziszewska *et al.* 2015) indicate a larger scale of cereal cultivation. In addition, finds of macroremains confirm that during this period, cereals (*Panicum miliaceum*, *Hordeum vulgare*, *Triticum aestivum*, *T. dicoccum*) and legumes (*Pisum sativum*, *Vicia faba* var. *minor*) were cultivated in the areas neighbouring Pomerania, that is, Greater Poland, Kuyavia and Chełmno Land (Lityńska-Zając and Wasylikowa 2005; Urban 2019). Unfortunately, the only archaeobotanical material (indeterminate, charred grains) from the

Lusatian settlement at Central Pomerania (Klichowska 1967) is insufficient to determine whether the same species were cultivated in the region.

The previously mentioned data also correspond with the latest view of the economy of the groups inhabiting Eastern Pomerania after 900 BC. It appears that this was then when local groups began to place greater emphasis on agricultural development (Dzięgielewski 2023, 222). This was also associated with the expansion of local settlement to areas located directly on the seacoast (including the Gdańsk Bay). Human occupation near Wierzchowo Lake is also demonstrated by the regular presence of pollen from *Artemisia*, Chenopodiaceae, *Urtica,* and *Plantago major*, which are indicators of trodden places and ruderal habitats (Behre 1981). Significant local pressure from anthropogenic activity caused a rise in eutrophication of the lake, as illustrated by an increase in the proportion of nitrogen and phosphorus in the sediment. This provided favourable conditions for the development of green algae in the basin, including *Pediastrum boryanum* var. *cornutum*, *Pediastrum boryanum* var. *boryanum,* and *Tetraedron*, taxa typical of eutrophic bodies of water, although not very polluted lakes (Komárek and Jankovská 2001, 84-86; John *et al.* 2002).

The changes observed in the local environment coincided not only with an increase in human activity but also with a shift in climate from relatively dry and warm to cooler, wetter conditions (discussed in detail in Niedziółka and Święta-Musznicka, 2023). Such conditions may have limited the cultivation of cereals in poorer quality soils and favoured the spread of *Carpinus betulus* and *Fagus sylvatica* in local stands. The population expansion of both of these species in Pomerania has been linked to an increased opening of the landscape due to more intense human activity (Latałowa 1982b; Pędziszewska and Latałowa 2016). Additionally, in the case of the study area, the impact of climate change, as well as the removal of *Corylus* and *Quercus* from local forests, woodland disturbance due to fires, and increased livestock grazing, could have been potential drivers of beech and hornbeam population increases. Climate change also affected the transformation of the green algae assemblages in the basin. The decrease in the proportion of *Coelastrum reticulatum* in relation to the previous phase and the appearance of *Pediastrum kawraiskyi,* which prefers lower temperatures (Komárek and Jankovská 2001, 81), are indicative of a cooling of the lake water. Cooler climatic conditions and higher water levels in the basin are also indicated by geochemical data, indicating drops in calcium concurrent with peaks in iron. The changes visible in the Wierzchowo Lake ecosystem correlate with the climate conditions observed in the region (Pleskot *et al.* 2022a; Tylmann *et al.* 2024) and reflect global shifts that are linked to the Bond 2 event (Bond *et al.* 2001).

If we look at the turn of the PBA V and Hallstatt C around Wierzchowo Lake and the surrounding area, there is a certain number of archaeological sites that can be related to that period (Table 1). Unfortunately, their dating is not precise enough to assign them to this specific palaeoecological phase, rather than, for example, the later phase 3.

However, the two deposits from Kaliska 37 (Table 1: no. 11) are worth mentioning. They were deposited in precisely the same place, as two separate deposits, which proves their uniqueness, also emphasised by the size of this double discovery. The Kaliska I hoard consisted mainly of ornaments and jewellery (breastplates made from sickle–shaped rings, necklaces, plate fibulas, bracelets, and clothing buckles), as well as fewer items related to horses (including phaleras) and weapons (spearheads). These items were deposited in a large bronze vessel, which is a variant of the Gevelinghausen–Veio–Seddin type. In addition to the aforementioned items, the vessel also contained three other smaller bronze vessels (Kaczmarek *et al.* 2021). In the case of the deposit known as Kaliska II, these were mainly decorative elements of a horse harness (several dozen phaleras, bells), weapons (an antenna-type sword, a tanged sword, and spearheads), ornaments (fragments of clothing buckles) and two bronze vessels (Szczurek and Kaczmarek 2022). The chronology of these two hoards, based on detailed archaeological analysis supported by radiocarbon dating, indicates a time span of 800-730 BC for the Kaliska I deposit and 790-720 BC for the Kaliska II deposit. This corresponds very well with the chronological scope of the second phase. Moreover, two other interesting deposits from the transition between the Bronze and Iron Ages were discovered in the area around Wierzchowo Lake. These are the discoveries from Grąbczyn (Grąbczyński Młyn) containing ornaments (Tab. 1: no. 7; Blajer 2001, 344) and, in particular, the deposit from Wierzchowo (Tab. 1: no. 29; Wilkens 1997, 223–225) containing an impressive set of jewellery (*i.e.*, breastplates made from sickle–shaped rings), ornaments (*i.e.*, plate fibulas) and weapons (*i.e.*, Mörigen-type sword hilt) with distinctly Nordic connotations, as well as its local adaptations. These abundant deposits could therefore be potentially associated with the period of the first economic intensification within this area, which is also visible in the pollen diagrams.

During the third phase, dated between 730 and 670 BC (which can be correlated with the Hallstatt C/'Władysławowo' II A2 phase (Fig. 6), there was a brief period of diminishing settlement activity. This is indicated by the absence of cereals, the decrease in the proportion of ruderal weeds (*Artemisia*, Chenopodiaceae, *Urtica*), the lower proportion of meadow and pasture plants and the expansion of stands dominated by *Pinus* or, in places, also by *Fagus* and *Carpinus*. The inhibition of erosion processes in the catchment, as a result of vegetation cover regeneration, is also evident in the geochemical data, which shows a lower proportion of titanium and LOI. However, a variable representation of fire indicators (microcharcoal, *Pteridium aquilinum*, *Calluna vulgaris*), *Plantago lanceolata*, and the constant representation of *Quercus* and *Corylus* suggest further transformation of forest communities, possibly for grazing animals. It can be assumed that the scale of grazing was negligible, as indicated by a decrease in the trophic status of the lake (lower nitrogen and phosphorus content), due to less nutrient run-off from the catchment area. The periodic change in water quality is also confirmed by the lower representation of green algae, typically found in eutrophic waters (*Tetraedron*, *Pediastrum boryanum* var. *cornutum*), in the lake sediments. This phenomenon is consistent with a rise in *Pediastrum boryanum* var. *longicorne* and *Pediastrum integrum*, taxa responding positively to the supply of dystrophic waters from peat bogs (Komárek and Jankovská 2001, 87). Hence, it cannot be ruled out that Wierzchowo Lake was more loaded at this stage with water inflow from the neighbouring Wielkie Błoto peat-bog, located on its southern shore, in the vicinity of the coring site. A higher proportion of *Coelastrum reticulatum* than in Phase 2, and the occurrence of *Pediastrum simplex* may indicate improved climatic conditions, for example, increased summer temperature (Jankovská and Komárek 2000, 71). Moreover, data from the neighbouring Spore Lake (Pleskot *et al.* 2022a, 6) illustrate that there was an increase in temperature in the period *c.* 750-650 BC. This thermal change may have caused a periodic drop in water level at Wierzchowo Lake, as indicated by a rise in calcium with a decrease in iron. The question is, why was the area around the reservoir used less during this stage, despite the favourable climatic conditions? It can only be assumed that, as a result of previous agricultural activity, the soils became depleted and local groups had to move further away from the lake. From an archaeological perspective, this phase may seem particularly interesting, as it most likely encompasses the transitional period between the Lusatian culture and the post-Urnfield Pomeranian culture. While the distinction between the burial sites of these two cultural units is obvious (burial mounds with cremation burials vs. flat stone cist graves containing, among other things, face urns), the distinction between settlement sites is not so clear.

It is quite difficult to assign specific archaeological sites in the vicinity of Wierzchowo Lake to this phase. It cannot be ruled out that the cist graves in flat cemeteries from Dalęcino and Smilicz 1 (Tab. 1, nos 4 and 23; Kostrzewski 1958, 361; Malinowski 1981a, 46, in this case, Dalęcino was assigned to Skotniki locality), may be connected with this transitional phase. Unfortunately, dating these historically discovered contexts is impossible.

Following a decline in human activity, another increase in human settlement is observed during the fourth phase, which spans from 670 to 610 BC. In archaeological studies concerning Pomerania, this period is associated with Pomeranian cultural activity (Dzięgielewski 2017; 2018; 2023). In the pollen profile, the beginning of this phase is marked by a decline in the proportion of *Pinus sylvestris* and *Alnus*, pointing to woodland clearance around the lake and on its margins. The destruction of the plant communities growing on the lake shores is also evidenced by the lower representation of rush vegetation (decrease of Cyperaceae, lack of *Typha latifolia* and *Sparganium erectum*-t.). The simultaneous increase in the proportion of microcharcoal in lake sediments and higher representation of light-demanding taxa typical of vegetation spreading in disturbed forest habitats, especially on sandy soil (*Calluna vulgaris*, *Pteridium aquilinum*, *Rumex acetosella*), indicates woodland disturbance by fire. The important rise of *Plantago lanceolata* and Poaceae correlating with the presence of other meadow and pasture plant pollen (*Rumex acetosa*-t., *Aster*-t., *Cichorium*-t., *Ranunculus acris*-t.) and coprophilous fungi (*Sordaria*-t., *Podospora*-t.) could be indicative of grazing near the lake.

Based on the palynological data from our study site, it is difficult to determine the significance of crop cultivation in the agricultural economy of that time. The absence of cereal pollen may suggest that human influence was somewhat weaker than in the case of Lusatian cultural activity, and animal husbandry probably dominated the local economy. However, the possibility of under-representation of cereals in the Wierzchowo Lake sediments during this settlement phase must be taken into account, not only due to their low pollen productivity (Broström *et al.* 2008; Abraham and Kozáková 2012) but also their poor dispersal ability (Theuerkauf *et al.* 2016) within such a large reservoir. This conclusion is supported by data from sites near Wierzchowo, confirming that cereals (Lamentowicz *et al.* 2015), including wheat (Madeja 2012), were cultivated in Central Pomerania, although the importance of this activity was marginal compared to grazing.

Although the results from Wierzchowo Lake do not indicate cereal cultivation, data from other sites in Pomerania suggest otherwise. Evidence from smaller palynological sites in Eastern Pomerania, which reflect primarily local changes (Sugita 1993), indicates that *Triticum* and *Hordeum* cultivation may have played a key role in the economy of the Early Iron Age societies (Pędziszewska *et al.* 2015; Pędziszewska and Latałowa 2016; Lamentowicz *et al.* 2019). This is also supported by finds of macroremains on archaeological sites, including *Hordeum vulgare* and *Triticum dicoccum* grains, as well as imprints of *Triticum aestivum*, *Triticum spelta*, *Panicum miliaceum* and *Pisum sativum* (Klichowska 1962; 1979; Podgórski 1979). The primitive type of agriculture in small fields, cultivated in a garden system, covered only part of the food requirements, so the diet was still supplemented by gathering nuts, mushrooms, or forest fruit (Fudziński 2011).

Despite the lack of pollen from cultivated plants, the constant human presence in the vicinity of Wierzchowo Lake is evidenced by the high representation of ruderal weeds (*Artemisia*, Chenopodiaceae, and *Urtica*). Their proportions are comparable to those of the Lusatian phase. Hence, it can be assumed that human activity has caused a slight increase in dissolved nutrients in the water in the basin, resulting in algal blooms of *Tetraedron* and *Pediastrum boryanum* var. *boryanum*. An increase of *Pediastrum kawraiskyi* coinciding with a significant decline of *Coelastrum reticulatum* representation at the end of the phase may illustrate the algae's response to the impact of cooling on the aquatic ecosystem (Fiłoc *et al.* 2018, 111). Such climatic fluctuations could also have caused a drastic decrease in crop yields with the farming model of the Pomeranian culture population (small plots, cultivated in a garden system), where much depended on weather conditions (Fudziński 2011).

Harsh climatic conditions are also confirmed by the results of bioanthropological research. The high mortality rate of the population, certainly caused by difficult living conditions, is verified by bioanthropological studies of human remains from the cemeteries in the eastern part of Pomerania, in the Kashubian Lakeland (Fudziński 2011). As a result, this situation could have led to population shifts during the later, fifth phase, as the limited capacity of the local natural environment forced some local groups to seek more promising ecological niches. In this way, as if through a lens, one can observe a process that, on a larger scale, encompassed the entire eastern and central portions of Pomerania, leading to the gradual disappearance of post-urnfield cultures within this region and, at the same time, their appearance outside the borders of this region (Dzięgielewski 2016; 2017).

Unfortunately, this phase is too narrow to reliably assign it to specific archaeological sites from the study area. Most of these sites were recognised several decades ago, and in many cases, their documentation does not meet modern standards. Moreover, some of these materials have been lost.

The fifth phase covers about 200 years (610-410 BC) of diminished settlement activity in the Wierzchowo area. This is the period preceding the expansion of groups associated with the younger pre-Roman Period that has occurred over the last two centuries BC (Strobin 2016). Weakened human activity is indicated by an absence of cereals, a decline in the proportion of ruderal taxa (*Artemisia*, *Urtica*, Chenopodiaceae) and fewer meadow and pasture plants (Poaceae, *Plantago lanceolata*). A significant rise in the representation of *Fagus sylvatica* and *Carpinus betulus* and a higher proportion of *Quercus* and *Pinus sylvestris* illustrate the regeneration of forest cover around the lake. However, the higher titanium and LOI values suggest that there were areas with disturbed vegetation in the lake catchment, which promoted erosion. There may still have been small-scale grazing, as indicated by the continuous curve of the *Plantago lanceolata*, the first appearance of *Trifolium repens*, a plant typical of the more open grasslands, regarded as an important component of cattle's diet. Even the sporadic occurrence of *T. repens* is considered an indicator of the local presence of cattle dung (Dietre *et al.* 2012), which, in the case of the Wierzchowo site, is confirmed by the finds of coprophilous fungi spores (*Sordaria*-t., *Apiosordaria verruculosa*, *Cercophora* sp.). Washout of nutrients from animal dung into the reservoir may explain the high nitrogen and phosphorus content of the sediments during the period of low settlement. This resulted in an increase in water fertility, which favoured the expansion of macrophytes, including *Nymphaea alba*, *Myriophyllum spicatum*, *Myriophyllum verticillatum,* and green algae blooms, especially during the middle part of this phase. The significant increase in the proportion of *Tetraedron* and *Scenedesmus* demonstrates that, like other sites (Stivrins *et al.* 2015, 113, 114; Tylmann *et al.* 2024, 6), climate warming and a decrease in landscape openness were important environmental variables affecting phytoplankton community dynamics. The highest values for both taxa were recorded at a level dated to around 550 BC, that is, at a time which a marked increase in temperature was registered in the study area (Pleskot *et al.* 2022a, 6). The subsequent rise in the lake's water level, as indicated by the calcium-to-iron ratio, perfectly illustrates the variability in climatic conditions that prevailed during the early Iron Age.

Within the studied area, a relatively large number of cist grave cemeteries have been recorded so far (some of them contained face urns, see: Table 1 no. 5, 17), which can be associated with the classical phase of the Pomeranian culture linked with the Hallstatt D period or even with the subsequent early La Tène period (La Tène A-B, see: Table 1 no.: 2, 18, 20, 21). It seems that this area, despite its relative distance from Eastern Pomerania, was subject to the same influences and/or transformations as those that took place in the aforementioned part of Pomerania.

CONCLUSIONS

The palaeoecological data from Wierzchowo Lake precisely document the settlement dynamics in Central Pomerania during the turn of the Bronze and Iron Ages. By answering the questions outlined in the introduction, we demonstrate the potential of multiproxy studies and the use of high-resolution pollen analysis to capture even short-lived periods of local environmental transformation triggered by different types of human activity. This study also shows that palaeoenvironmental data correlate well with available archaeological data from the area of interest, despite the relative incompleteness of this historical dataset.

The comprehensive reconstruction of environmental changes illustrates that during the period from the Middle Bronze Age to the PBA V, the vicinity of Wierzchowo Lake was overgrown by mixed deciduous forests, and human influence on the vegetation was somewhat limited. A significant transformation of vegetation occurred around 850 BC, thus during the transition between the PBA V and Hallstatt C phases. The significant deforestation around the lake, the larger scale of livestock rearing, the intensification of erosion in the catchment, and a rise in the eutrophy of the lake illustrate the economic intensification during the period of the spread of Lusatian culture groups. Such a significant signal of environmental change is also confirmed by archaeological data indicating an increase in the number of Late Bronze Age archaeological sites, as well as their location near the lake, mainly in the western and northern parts of the catchment. Similar to other sites from Pomerania, a short but distinct settlement break between the Lusatian and Pomeranian culture phases is marked in the Wierzchowo area. However, our data indicate that during this period, further transformation of forest communities for grazing animals was possible, although the scale of this type of farming was negligible, as indicated by the decline in lake eutrophication. The absence of cereals during the Pomeranian culture phase may suggest that animal husbandry was the dominant economic activity in the local economy. At this time, settlement activity in the vicinity of Wierzchowo Lake is evidenced by woodland clearance, a similar proportion of ruderal weeds as in the Lusatian phase and a slight increase in the nutrients in the lake waters, resulting in algal blooms. This stage was terminated at ca. 610 BC, when diminished settlement activity caused a regeneration of forest cover around the lake. Nevertheless, pollen and geochemical data suggest small-scale grazing in more open grasslands and the presence of areas covered by disturbed vegetation, which promoted erosion. These weak, but ever-present, traces of economic activity since the Pomeranian culture phase are confirmed by numerous archaeological sites within the studied area, especially a relatively large number of cist grave cemeteries.

Our research demonstrates that the possibility of reconstructing settlement dynamics depends strongly on the size of the basin, as some anthropogenic indicators (mainly cereals) may be underrepresented in the sediments if the economy of local societies was mainly based on animal husbandry. The location and density of settlements in relation to the shoreline of the lake are also of great importance in this respect. Furthermore, the palaeoenvironmental study from the Wierzchowo area also provides new data on the transformation of the local terrestrial and aquatic environment as a result of climate change and shows correlations with cooler and wetter periods recognised both locally and at the supra-regional level, including the Bond 2 event.

In conclusion, it can be said that the multifaceted relationships between the natural environment and the people who inhabited it in the past are, in a sense, pushing archaeologists and palaeoecologists to collaborate more frequently in this area, while also offering great potential in this regard.

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REMARKS ON THE DIVERSITY AND RELATIVE CHRONOLOGY OF THE POMERANIAN CULTURE IN ITS ALLOCHTHONOUS ZONES

ABSTRACT

Kaczyński B. 2025. Remarks on the diversity and relative chronology of the Pomeranian culture in its allochthonous zones. *Sprawozdania Archeologiczne* 77/1, 209-233.

The article presents a new perspective on the differentiation and chronology of Pomeranian culture in allochthonous zones, *i.e.* outside Pomerania. The first part focuses on the variation in the spread of the Pomeranian cultural model, resulting from different rhythms of acculturation in territories formerly belonging to various Lusatian Urnfield zones and exposed to influences from diverse European directions. The second part proposes a new, and at the same time first for allochthonous areas, system of relative chronology of the Pomeranian culture, consistent with the latest schemes for the Hallstatt–La Tène zone. For regions outside Pomerania, two phases are distinguished: the Karczemki phase and the Pierzwin/Ulesie phase, further divided into six sub-phases, corresponding to Hallstatt and La Tène sub-periods. In the discussion of artefact sets assigned to specific intervals, attention is given to migration-related population movements, as well as to external relations that shaped the development and character of the Pomeranian culture in the Polish Lowland.

Keywords: Pomeranian culture; Early Iron Age; chronology; pins; migration; brooches
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INTRODUCTION

The development of the Pomeranian culture from the very beginning of defining its basic aspects in the first half of 20th century aroused research interest (Kostrzewski 1914; Petersen 1929). A special place in the issues concerning this unit was given to analysis of the presence of unique and characteristic features of the funeral rite of the Pomeranian culture, *i.e.*, box burials or cinerary face urns, the presence of which outside the home zone, *i.e.*, Eastern Pomerania, was undoubtedly considered to be effect of expansion or population migration (*e.g.*, Malinowski 1969; Kruk 1969; van den Boom 1980). However, doubts arose among research ers when assessing the nature and course of this process, especially setting it in time along with the distinguishing of individual stages. The first of the issues, especially in the mainstream of the traditional conceptualisation of archaeological cultures, was initially interpreted as an armed invasion of the Pomeranian culture population into the areas previously occupied by the Lusatian culture communities, then as peaceful acculturation or solely as a flow of ideas – especially in the sphere of beliefs (Dzięgielewski 2010, 174-176; 2015, 98-99). Many more doubts, mainly due to the insufficient state of research, were raised by the second of the above-mentioned issues, *i.e.*, the setting in time the spread of the Pomeranian culture population. These issues on the so-called allochthonous areas, *i.e.*, those where their population and material culture are intrusive elements, were and remain quite complex. Analytical difficulties did not result from the number of available and published sources, as these should be assessed as representative, but from the lack of problem-based works based on the analysis of the interactions of the Lusatian Urnfields communities with the immigrant population of the Pomeranian culture, and especially an attempt to stratify them chronologically, allowing for understanding and tracing the mechanism of the Lusatian-Pomeranian transformation in individual regions. In this respect, studies carried out for the areas of southern and south-eastern Poland – Lesser Poland and Outer Subcarpathia, developed on the basis of newly discovered materials interdisciplinary analysis, based on regional chronologies, compatible with newer approaches for the Hallstatt and Scythian zones look the best (*e.g.*, Dzięgielewski 2015; Dzięgielewski, Gawlik 2021, 149-151). For the remaining areas of Polish lands, crucial for the issues of Pomeranian culture, *i.e.*, Pomerania, Greater Poland, Lower Silesia, central Poland and Masovia, there are outdated chronological systems based on the post-War findings of Józef Kostrzewski (Chomentowska 1970; Krzyżaniak 1971; Pazda 1970; Jadczykowa 1975). There is still lacking a tool that would represent an attempt to explain the issues addressed that would be an internal, coherent, comprehensive chronological system of the archaeological remains of the Pomeranian culture, synchronised with the latest approaches developed for the neighbouring areas – mainly the Hallstatt and Elbe zones.

The first of the main goals of this article is to indicate differences of Pomeranian culture in its allochthonous zones, especially through the prism of transformation of the

Lusatian Urnfields local substrate. The second is to present a description of a new chronology of the Pomeranian culture, based on studies of garment-fastening items.

ALLOCHTHONOUS POMERANIAN CULTURE

Already since the times of pre-War studies conducted by Polish and German researchers, Eastern Pomerania has been referred to as the indigenous zone in which, under the influence of external cultural-and-exchange contacts, the basic attributes of the Pomeranian culture were developed (Petersen 1929, 116-118; Kostrzewski 1933; La Baume 1939). The intensification of post-War desk-based research on its genesis, and especially the gradual arrangement of material sources, undertaken successively by Leon Jan Łuka, Tadeusz Malinowski and Janusz Podgórski allowed the separation of a group of sites of the so-called Wielka Wieś phase (germ. Großendorf, actually Władysławowo) – separated before the War by E. Petersen (1929; Podgórski 1990) – along with the characteristics of the material immediately preceding the emergence of the classical Pomeranian culture (Łuka 1966; 1968; 1971; 1979; Malinowski 1969; 1979; 1981a; 1981b). The stage of research on explaining the genesis of the phenomenon of Pomeranian culture ends with the latest processual research approach of Karol Dzięgielewski, describing the transformation between the Late Bronze communities of Pomerania and the separation of the 'Pomeranian' cultural model (Dzięgielewski 2015, 98; 2017b, 24-26). The occurrence of structural conditions for increasing population mobility and its migration southward, which took place around the mid-7th century BC, resulted in crossing the Noteć River border and the gradual spread of the Pomeranian population and their material culture in the areas previously inhabited by the communities of the Lusatian Urnfield culture.

The process of spreading elements of Pomeranian culture outside Pomerania has been considered in two ways. The first direction of interpretation was to see the spread of ideas (elements of 'northern' origin, *i.e.*, cist burials, economic model, settlement pattern), which were intended to be a better form of adaptation to new political circumstances (threat from steppe peoples) and climatic conditions – a cooling connected with the Subatlantic fluctuations (Hensel 1971; Ostoja-Zagórski 1980; Malinowski 1989). The second, and at the same time the oldest, interpretative model was the adoption of diffusionism, initially closely associated with the ethnic identification of Pomeranian culture (identifying them with the Germanic peoples of the Skirae, Bastarnae, or Proto-Slavs, and even the Balts or Celts). Among the most important mechanisms invoked was climate change and its consequences, and the use of evidence from cemeteries as an almost exclusive source for research were mentioned (van den Boom 1980). In recent years, the dispersion of elements of Pomeranian culture in the Polish Lowland, with the simultaneous disappearance of sites in Eastern Pomerania, has been clearly interpreted as a migration movement triggering acculturation processes (Czopek 2022, 162). It was emphasised that it is unlikely that an entire, coherent package of characteristic cultural behaviours would be transferred to large territories by diffusion without physical presence of their carriers (Dzięgielewski 2010, 178, 179). Among the set of features of the Pomeranian cultural model, defined as the 'northern component', indicated were major attributes of Pomeranian culture, always present in the set, *i.e.*, multi-urn cist graves, cinerary face urns, pear-shaped vessels, vessels with recessed and overlapped cover as well as multi-piece bronze breastplates (Dzięgielewski 2015, tab. 1; 2017b, 24). Allochthonous areas of the Pomeranian culture, due to their 'saturation' with elements of the so-called 'northern component' and varying degrees of their adaptation by Lusatian structures, different cultural contacts as well as a different inventory of material sources can be divided into two zones: the south-western and the south-eastern one.

The south-western zone (also as Silesian-Greater Poland zone) appeared in post-War literature, mainly due to the studies of Leon Jan Łuka, who included in this area elements not found in Pomerania (Łuka 1979, 161-164). It covers Greater Poland (south of the Noteć River, excluding the Krajna Lake District), the lowland and plain part of Lower Silesia (the basin of the upper and middle Oder) and the Silesian Lowland. The eastern border of the zone is the areas of central Poland to the right-bank areas of the Bzura and Pilica rivers. The south-western zone as a Silesian-Greater Poland zone was often used in literature by researchers of the Roman period, usually in studies devoted to influences coming from the La Tène world (*e.g.*, Grygiel and Orzechowski 2015, 174)

The second zone, the so-called south-eastern one was distinguished by Sylwester Czopek and included Pomeranian culture materials found in the areas south of the Narew River, as well as east of the Vistula and Wisłoka rivers (Czopek 1992). In the light of current knowledge, its eastern border is the central part of the Podolia Upland, and is confirmed by sites in the localities of Uvisla and Cherneliv-Ruskyi in Ternopil Oblast (Bukowski 1977, 351-353; Gereta 2013, 23-25, 112, 113, fig. 5, 6). Due to certain characteristic cultural elements occurring only in this zone, it was proposed to expand it also west of the Vistula, to the areas of western Masovia and western Lesser Poland (Kopyt-Cieślak and Miraś 2013, 53).

The division of the Pomeranian culture into three zones, the indigenous zone and two allochthonous ones, has two main goals (Fig. 1). The first is an attempt to pigeonhole and organise evidence that will prove helpful when analysing newly discovered materials. The second is an attempt to indicate the regularity and rhythm of the occurring Lusatian-Pomeranian transformation and its chronology.

The south-western allochthonous zone of the Pomeranian culture mostly coincides with the areas previously occupied by the communities of the Oder River Lusatian Urnfields – a region covered by intense Hallstatt influence since the end of the Bronze Age, both in constructing of chambered burials and equipping them with imported objects (ornaments, tools, weapons), as well as using painted ceramics with a different style. The picture of the allochthonous Pomeranian culture is revealed to be different in the south-

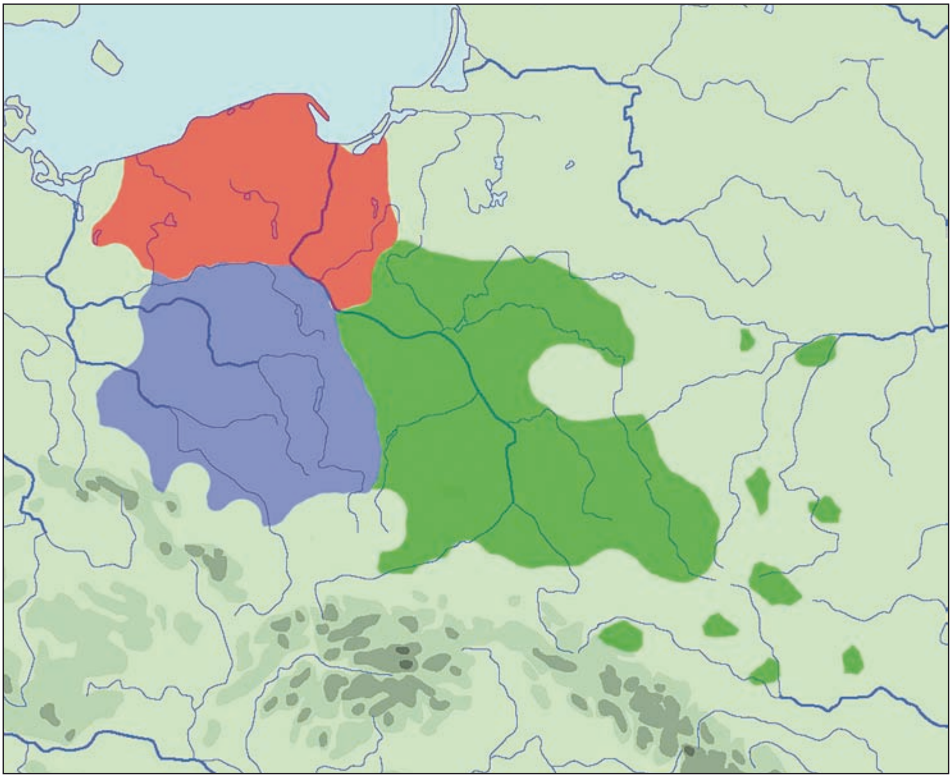

Fig. 1. Pomeranian culture – division into zones:
red colour – the indigenous zone; blue colour – the Silesian-Greater Poland allochthonous zone; green colour – the south-eastern allochthonous zone. Graphic design by B. Kaczyński

eastern zone, which was previously occupied by communities of the Masovian, Lusatian Urnfields, a unit much poorer in equipment, based on Trzciniec traditions, and throughout its entire operation period remaining under influences of eastern and 'south-eastern' origin. Cultural differences observed in these areas were reflected in the degree of adaptation of the immigrant 'Pomeranian' cultural model (see also Chochorowski *et al.* 2024, 47-48).

In the Oder River areas of the Urnfield culture subjected to intensive 'Hallstattisation', in the era of the appearance of Pomeranian groups, we see a dominance of multi-urn graves (cist or stone-lined burials), unlike the situation in Pomerania, equipped with numerous accompanying small vessels, especially the so-called libation sets (a mug or jug standing in a bowl). Much more commonly than in the indigenous zone, the deceased were provided with everyday items (in Pomerania, these items often had only a substitute in the form of a pictogram on a cinerary urn). In the south-western allochtonic zone, in the same way as in Pomerania, there are both sepulchral and settlement ceramics, the activity of craftsmen producing original ornaments and the occurrence of late Hallstatt, La Tène and Jastorf imports are observed (Fig. 2). The Pomeranian culture in the areas previously occupied by the Masovian Urnfields communities exhibits a completely different character, distinguished primarily by the homogeneity of phenomena, among others a clear impoverishment of inventories and an uniformisation of ceramics. In the zone that had been settled in later phases of development, where the 'Lusatian-Pomeranian' cultural transformation took on a slightly different dimension, unlike the situation in the south-western zone, we see the dominance of single burials (cloche and cinerary urn burials) which were equipped with accompanying vessels in the earliest stages only. Elements with 'eastern' features (such as the presence of animal and children's and animal pit graves or secondarilary-burnt pottery fragments, numerous bone objects and products of the 'Scythian' world) are also recorded. What is also noteworthy is the lack of typical forms of artefacts that could be clearly defined as products from these areas. The analysis of ceramic material from settlements and cemeteries (with the exception of the 'northern component' sites in this area) shows that 95% of them did not use any specially prepared forms for funeral purposes, and everyday vessels were used for eating, storing or carrying meals. Of course, more differences could be identified between the two zones discussed, but this general comparison clearly proves how internally inconsistent the Pomeranian culture was in its allochthonous dimension, which resulted largely from a different cultural background (Fig. 2).

Silesian-Greater Poland allochthonous zone	South-eastern allochthonous zone
• dominance of multi-urn graves • graves equipped with numerous accompanying small vessels, especially the libation sets (a mug or jug standing in a bowl) • deceased provided with everyday items • sepulchral and settlement pottery • the activity of craftsmen producing original "Pomeranian" ornaments • Hallstatt, La Tène and Jastorf imports	• dominance of single burials (cloche and cinerary urn burials) • animal and children's-animal pit graves • seconary-burnt pottery fragments in graves • the same forms of pottery in graves and settlements • numerous bone artifacts in graves • products of the "Scythian" world • lack of typical forms of artefacts that could be clearly defined as products from these areas

Fig. 2. An attempt to define features typical of the Silesian-Greater Poland allochthonous zone and south-eastern allochthonous zone

CHRONOLOGY OF THE ALLOCHTHONOUS POMERANIAN CULTURE

For the Pomeranian culture outside Pomerania, chronological systems were operated that were created just before or after World War II, as well as those developed in the 1970s, based mainly on the classic chronology of Paul Reinecke and corrections made for Polish lands by Józef Kostrzewski. Dating of the phase of presence usually fell within the range HaD – middle La Tène period. First half of the 1990s, proposals for relative internal systems of Pomeranian culture appeared. The first one was presented by Sylwester Czopek for the purposes of research on the south-eastern zone of the Pomeranian culture, dividing its functioning into four phases (I-IV) between the HAC and LTC1 periods (Czopek 1985; 1992, 86-88). The second one was presented by Janusz Podgórski for Eastern Pomerania and included four phases of cemeteries: Warzenko, Siemirowice, Władysławowo and Karczemki, starting from Montelius Period III until the older pre-Roman period (Podgórski 1992).

The system proposed by Janusz Podgórski was used by Karol Dzięgielewski in studies on cultural changes in Pomerania during the Bronze Age and the Early Iron Age based on new chronological approaches for the Hallstatt zone (Dzięgielewski 2017a, 300, fig. 2). It should be assessed as a basic tool that chronologically organises cultural phenomena in Pomerania. Unfortunately, a major difficulty in undertaking studies of Pomeranian culture, especially in allochthonous zones, is the constant lack of an internal relative chronological system, which, however, given the diversity of the culture in question and the amount of new materials, is an extremely difficult task. The system developed by Sylwester Czopek has not been widely used due to the high level of generality in the description of individual phases. It was used only in the study of materials from the south-eastern zone.

A helpful tool in undertaking the study of Pomeranian culture, both in Pomerania and beyond (thus, in all provinces of Pomeranian culture), may be a relative chronological system made for clothing-fastening items. The purpose of this scheme, created for the purpose of the analysis of such items, was not so much to 'rigidly' adhere to the Hallstatt-La Tène scheme, but first of all to try to distinguish relative horizons, which could turn out to be compatible with external approaches. To make such an internal chronological system consistent with the one currently in force for Pomerania, the same source was used as Janusz Podgórski, namely Wolfgang La Baume's chronological division, prepared for the purposes of developing face urns (La Baume 1963, 7-9). La Baume had divided the Pomeranian culture into three phases for phenomena that took place in the south-western zone in the older pre-Roman period. These took their names from the cemeteries with a characteristic inventory for each of them: the Władysławowo, Karczemki (ger. *Friedenau*) phase and the Pierzwin/Ulesie (ger. *Pürben/Waldau*) phases.

The basis for research on the relative chronology of clothes-fastening items was based on the analysis of the co-occurrence of this type of items at the level of cinerary urns, multiple burials and cemeteries; stylistic analysis of fibulae, pins and belt buckles as well as examination of the influx of imports, their scale and provenance (Kaczyński in print). During the research, it was noticed that items fastening clothes show greater variability over time than indicated in literature, which additionally turned out to be helpful in chronological studies (Fig. 3).

Research concerned clothing ornaments showed that it was possible to distinguish narrower, relative ranges for individual intervals. In the allochthonous zones of the Pomeranian culture, only two phases are represented: Karczemki (II) and Pierzwin/Ulesie (III). Each of them was additionally divided into three subphases (from A to C). For each phase, it was possible to identify artefacts with a specific, characteristic style and provenance. They correspond to the following intervals of the Hallstatt-La Tène chronology developed by Martin Trachsel (2004) with corrections (*e.g.*, Krause *et al* 2017: 120, 121), and late La Tène one by Ruppert Gebhard (1989): Karczemki IIA – HaD_1 (~630/620-560/550 BC), IIB – HaD_2 (~560/550-510/500), IIC – HaD_3 (~510/500-450), Pierzwin/Ulesie IIIA – early LTA (~450-375), IIIB – late LTA (~450-390), IIIC – LTB (~375-275).

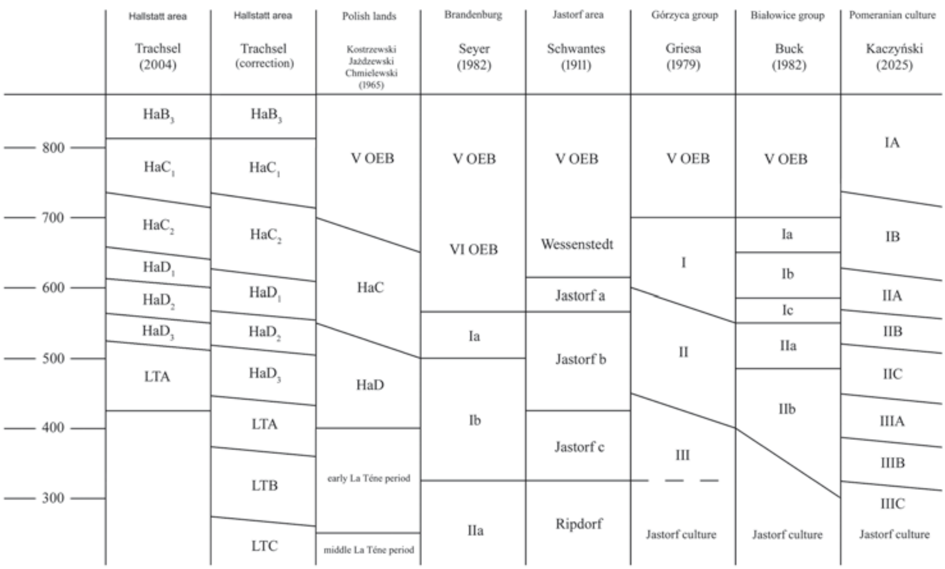

Fig. 3. Chronological system of items fastening the clothing of the Pomeranian culture against the background of the most important systems used in Central Europe in the Early Iron Age

KARCZEMKI PHASE

At the beginning of the Karczemki phase (IIA), falling around the middle of the 7th century BC, at a time when the main attributes of Pomeranian culture were already functioning in Pomerania (box burials, face cinerary urns, multi-piece bronze breast plates), representatives of this community were crossing the Noteć river line and the acculturation processes in northern and eastern Greater Poland began (Fig. 4: Phase IIA). In this barely perceptible phase, due to the small number of sufficiently diverse objects co-occurring, references to the Oder River area Lusatian Urnfields environment are observed. Mention should be made of a few bronze or iron pins in the late Hallstatt style with bowl-shaped

Fig. 4. Clothing fastening items characteristic of the Pomeranian culture for the phases IIA-IIIB. Graphic design by B. Kaczyński

and nail-like heads, equipped with, strongly swan-neck profiled necks (Kaczyński 2018, 274, fig. 4; Fig. 8: h). Artefacts of this type are grouped in the youngest parts of the Niederkaina cemetery, dated to HaD_1 (Heyd 1998 27-29, fig. 13). This phase also includes the use of the Strzebielinko type spectacle fibulae and the most common wearing of pins with spiral heads (most often made of a wire with a quadrangular cross-section), both in the community of the Pomeranian culture in Pomerania (Fig. 8: g) and in the communities of the Lusatian Urnfields in the Oder area (Gedl 2004, 65-68; fig. 8: a). In this phase, a small number of typical forms of pins of Hallstatt stylistics, widespread in Greater Poland, should be distinguished, *i.e.*, pins with stamp-like, grooved heads, which proves that the area under discussion in this initial Lusatian-Pomeranian transformation stage remained under the influence of the Oder River region.

In the middle Karczemki phase (IIB), falling in the developed HaD period, elements of the 'northern component' in northern and eastern Greater Poland and Kuyavia were recorded (Fig. 4: Phase IIB). At this time, a period of prosperity is visible in the cultural-and-exchange contacts with the middle Oder production centre in the Wicina area. The evidence of these influences were the typical forms of artefacts from this centre appearing in cemeteries with box burials, including: vase-shaped pins with grooved heads, conical headed pins with incised bases, equipped with strongly profiled swan necks (*e.g.*, Michalak 2010, figs. 29: 1, 3-5, 30: 1-4; Orlicka-Jasnoch 2013, fig. 7: 1-3). Their spatial distribution within Greater Poland proves that there was a route connecting the middle Oder region with Eastern Pomerania, leading through the Krajeńskie Lake District. In phase IIB, the first iron ornaments of the Pomeranian culture, inlaid with lamellas of non-ferrous metals appear and spread, *i.e.*, disc-shaped pins with swan necks, sharp-profiled (of Mrowino type) and cross fibulae inlaid with gold and copper alloy lamellas of Tłukomy type, which appeared in 'Pomeranian' environment in western Greater Poland and Krajna region, and at the end of the Karczemki phase. These items, along with the ongoing migration, spread to Lower Silesia, Masovia, central Poland, and Lesser Poland (Fig. 5: A; 8: i, j, m, n; Kaczyński 2015, fig. 6).

In the developed Karczemki phase (IIB), exotic hints of long-range influences from northern Italy are recorded, especially the areas of the Este and Golasecca cultures. Among the most unique imports from the HaD_1/HaD_2 phase are the *sanguisuga* fibula with a long foot decorated with coral inserts and the 'Schlangenfibel S1' fibula according to Günter Mansfeld (Fig. 8: b; Kostrzewski 1936, fig. 3; Kaczyński and Grzędzielska 2022, figs 1 and 2). Both types are grouped within the Veneto and the southern zone of the central Alps. This type of fibula most likely reached the areas of the Pomeranian culture along the route through the eastern Hallstatt areas by the agency of the Oder area Urnfield communities. Along the same route came pear-shaped pendants, originating from northern Italy. There, they are most common in the Golasecca IIB phase according to Raffael Carlo De Marinis (De Marinis 1981, 217), which, according to Trachsel's correlation, corresponds to the first half of the 6th century BC. These objects spread to the western areas of the Urnfield communities and the Pomeranian culture (Cassini and Chaume 2014, fig. 6).

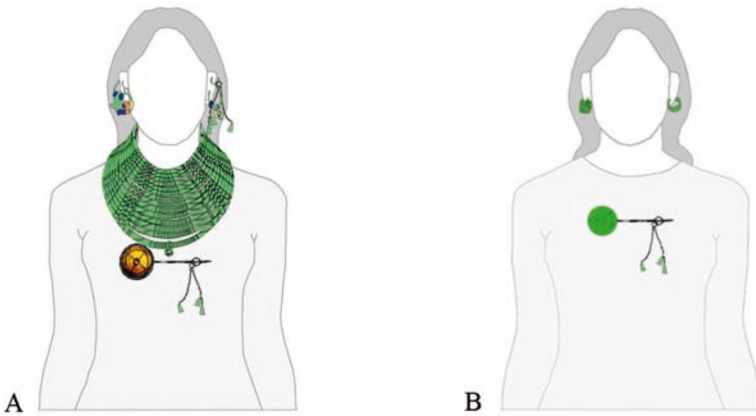

Fig. 5. A set of pins and body ornaments of women from Pomerania (A) and Brandenburg (B) in the middle part of the HaD phase. Graphic design by B. Kaczyński

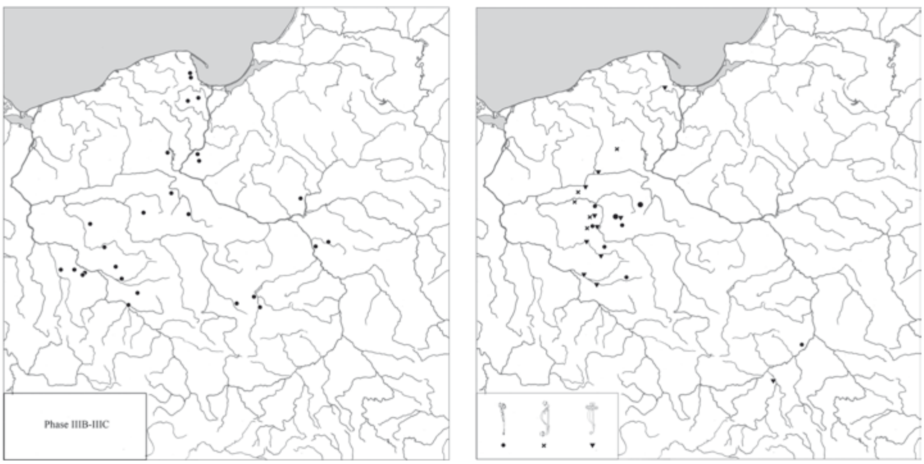

Fig. 6. Clothing fastening items characteristic of the Pomeranian culture for the phase IIIB-IIIC, and distribution of clothing fastening objects from Greater Poland from phase IIC (circles – bimetallic pins with heads decorated with cuts; crosses – Wymysłowo-Wróblewo brooches with elements decorated with cuts; triangles – the remaining Wymysłowo-Wróblewo brooches). Graphic design by B. Kaczyński

In phase IIB, fibulae with a decorative foot of Wicina type were taken over from the Odra River communities (Fig. 8k, l). The dating of these items requires correction from the HaD_3 period, *i.e.*, to HaD_2, which would be compatible with the dendrochronological dates of the fall of the hillfort in Wicina in the first half of the 6th century BC, but also with the dating of bronze items in hoards or, finally, with reception of elements of the Scythian area

(Grechko 2020, 598, 599, fig. 9; Krąpiec and Szychowska-Krąpiec 2013, 373-374; Maciejewski 2019, 69, 70). The discussed fibulae were distinguished by Georg Kossack (who has classified them as variant A2 – with massive, faceted in cross-section bows), were classified and discussed solely in terms of the bow shape and the appearance of the foot (Kossack 1987, 122, fig. 5: 4-8; Parzinger 1993, 514-516). Only Zenon Woźniak, based on the findings of Gunter Mansfeld and Martin Trachsel, pointed out that early specimens from the southwestern areas of Polish land are distinguished by mounting an iron spring axis on bronze items, which thus indicates the development of a different tradition of fibulae construction (Woźniak 2010, 48-50). It seems possible that the same was true of the Wicina type and typologically similar fibulae of Wojszyce type, which were rare in neighbouring areas (Kaczyński 2015, fig. 6). Probably the source of inspiration for the people of the Oder Lusatian Urnfields were not the areas of northern Italy and the eastern Hallstatt zone, where specimens modelled on the Certosa fibulae with single-coiled springs were commonly produced. It seems more likely to have been derived from the arched, navicella-type and bow brooches ('Bogenfibeln'), boat brooches ('Kahnfibeln') and 'Paukenfibeln' from the areas of Bavaria, where the crossbow-like construction appeared and became widespread already in HaD_2 (Mansfeld 1973, 26-28, 49-55; Trachsel 2004, 81-83).

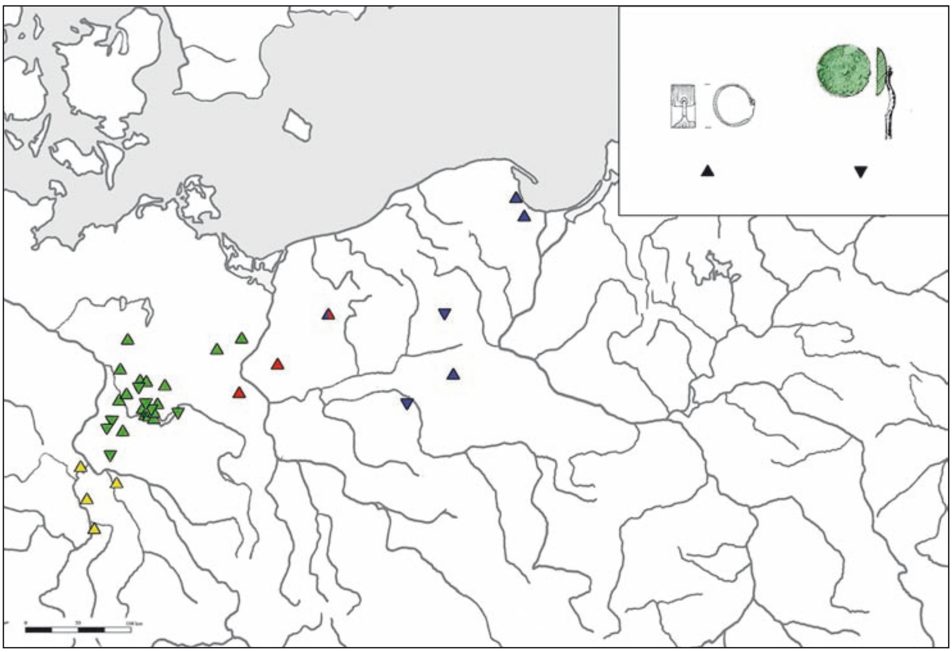

Fig. 7. Dispersion of band earrings (ger. *Bandohrringe*) and Zakrzewek type pins from the Early Iron Age in Central Europe. Blue triangles – Pomeranian Culture; red – Górzyce group; green – Jastorf Culture; yellow – Thuringia Culture; red/blue – Marianowo group. According to S. Griesa 1982; H. Seyer 1982; R. Müller 1985; R. Wołągiewicz 1979 with additions

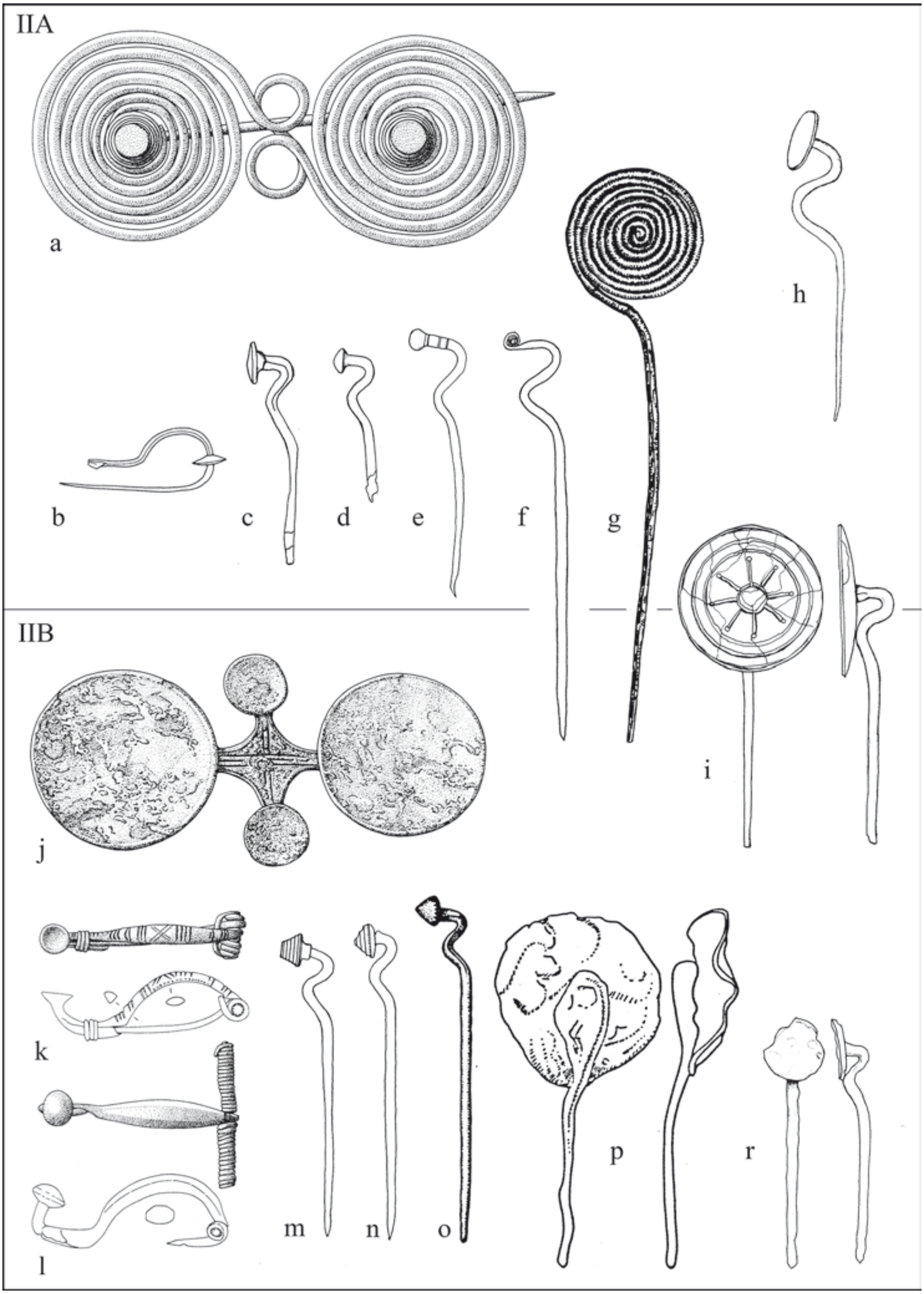

Fig. 8. Clothing fastening items characteristic of the Pomeranian culture in phase IIA and IIB. Graphic design by B. Kaczyński

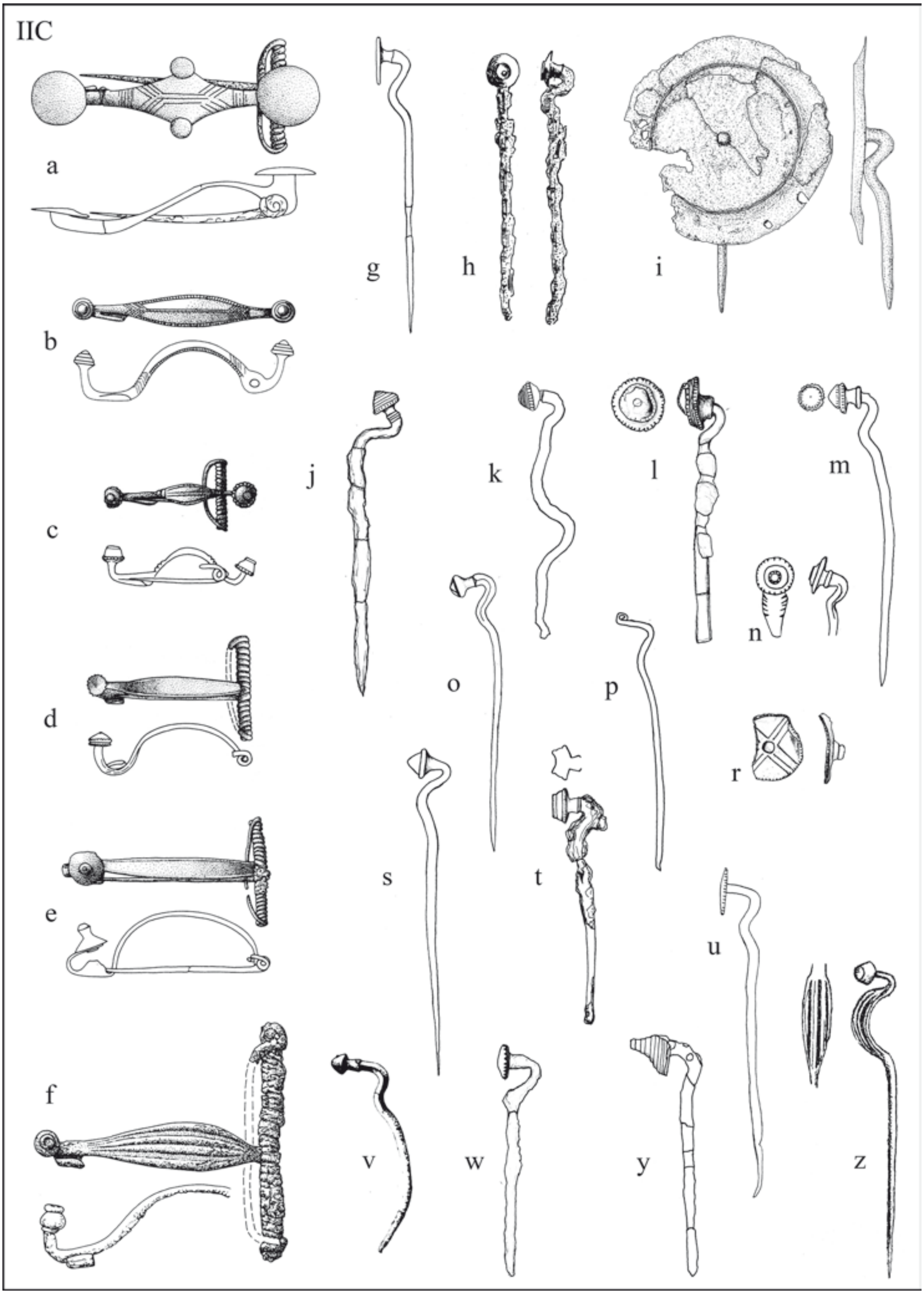

Fig. 9. Clothing fastening items characteristic of the Pomeranian culture in phase IIC. Graphic design by B. Kaczyński

In the final part of the Karczemki phase (IIC), dated to the second half of the 6th century, *i.e.*, in the period after the fall of the hillfort in Wicina and decline in the importance of the middle Oder River Urnfield community groups, a period of prosperity is observed in the production of garment-fastening items in the Pomeranian culture. The weakening of the discussed cultural zone contributed to intensification of the migration of the population of the Pomeranian culture on Polish Lowlands. At that time, elements of the 'northern component' appeared in most areas of the Polish Lowlands, with the exception of the central Odra region and areas south of the Odra, as well as parts of Lesser Poland, and probably some areas east and south-east of the Vistula (Fig. 4: Phase IIC).

In this phase, an abundance of original items of Pomeranian culture in the area of Greater Poland is observed, including fibulae with symmetrically arranged ornamental elements of the Wymysłowo-Wróblewo type and fibulae with cross-shaped bows of Sinołęka type – specimens modelled on basis of the earlier fibulae of Tłukomy and Strzebielinko type (Fig. 9a-c; Gedl 2004, 115-118, 133, pl. 60: 335-338, 61: 340-349, 66: 426-427). According to Zenon Woźniak, the doubling of ornamental elements in the case of Wymysłowo-Wróblewo fibulae was inspired by the early style of Celtic art, which was manifested by the doubling of ornamental elements (Woźniak 2010, 56). The presence of Sinołęka type fibulae with a cross-bow-like construction, which are undoubtedly later forms of cross-shaped fibulae and transitional forms of the Wymysłowo-Wróblewo type, may indicate that their development in the Pomeranian environment took place beyond external inspirations. Other forms typical of Greater Poland include bimetallic pins made in the late Hallstatt stylistics with heads shaped similarly to the knobs of the above-mentioned fibulae, as well as bimetallic conical, bowl-shaped and disc-headed pins, ornamented with constrictions, incisions and engraved strokes (Fig. 9: h, j, k, l, m, o, t, v, y; *e.g.*, Kaczyński 2017; 2020). The analysis of the spread of stylistically similar garment-fastening items in the Pomeranian culture brings interesting observations. As an example, we can mention the spread of Wymysłowo-Wróblewo fibulae with knobs ornamented with incisions, as well as bimetallic pins with similarly-constructed heads. Within the range of occurrence of these stylistically close items, two adjacent areas stand out, the first characterised by the use of pins, the second by wearing fibulas, which may indicate either regional fashion preferences of the inhabitants, the migration or acculturation process, or simply the area of activity of a specific manufacturer (Fig. 6: map on the right side).

Among forms of foreign provenance, mainly in southern Greater Poland, Lower Silesia and Lesser Poland, fibulae with a decorated foot ('Fußzierfibeln') modelled on the west Hallstatt forms F2 and F3 according to Mansfeld occur, referred to in Polish literature as the Kietrz, Grabonóg-Grzmiąca and Łuszkowo types (Fig. 9d-f; Z. Woźniak 2010). In the late Karczemki phase (IIC), an inflow of individual Jastorf imports from the middle Elbe basin is observed, *i.e.,* multi-element bimetallic disc-headed pins with bent stems (in the form of an animal's crop – hence the German name, 'Kropfnadeln') and band earrings (Figs 5B; 7; 8p). Their emergence can be interpreted as a manifestation of matrimonial contacts, as the items were part of women's equipment.

The phenomenon of the mass appearance of new, original forms of garment-fasteners coincides with the moment of the greatest spread of the Pomeranian culture elements. A similar situation can also be observed in other cultural units with a migration model developed in the southern Baltic zone and can be simply explained by the need to stand out and manifest their distinctiveness in the newly occupied areas.

PIERZWIN/ULESIE PHASE

At the beginning of the older pre-Roman period, which coincides with the beginning of the Pierzwin/Ulesie phase (IIIA), synchronised with the earlier part of the LTA (the first three decades of the 5th century BC), the preferences and style of items fastening garments in Pomeranian culture had changed. The occupation of the areas of the middle Oder River area and the areas south of the Oder by the discussed population resulted in the establishment of clear contacts with the La Tène and Jastorf world and resulted in the appearance of new original forms and a significant influx of imports. The centre of gravity of the native production of the Pomeranian culture moved from Greater Poland to Lower Silesia, and it cannot be ruled out that this was a group of craftsmen coming from the same environment. A characteristic feature of garment-fastening items at the beginning of the Pierzwin/Ulesie phase was that they were almost entirely made of iron. Bronze and bimetallic objects occurred sporadically, mainly in Greater Poland and central Poland (Fig. 4: Phase IIIA).

The distinctive fibulae forms noted in phase IIIA included specimens with band bows of the Andrea Lorentzen Type II and III, referred to as Kowalowice/Altmark fibulae, as well as of the Piekary Wielkie type (Fig. 10: a, b, d; Lorentzen 1992, 65, map 4; Gedl 2004, 122-131, pl. 63: 383-389, 64, 65; Grygiel and Orzechowski 2015, 172, 173, map 2). In the same centre, located near today's Wrocław, pins equipped with the so-called 'crop' (crooked stem) – modelled on specimens from the Elbeland areas were manufactured (Fig. 10: m, n, o). Their heads were usually flattened and rolled into an ear or a wide tube (Kaczyński and Sierant-Mroczyńska 2020, 146-147, fig. 8: c). Other characteristic forms, inspired by specimens of the Jastorf culture from Lower Saxony, Thuringia and Brandenburg, included multi-element, disc-headed iron pins with 'crop' of the Zakrzewek and Wytomyśl types, as well as pins with spade-shaped heads (Fig. 10e, g; Kaczyński 2015, 27; 2018, 267). Tongued belt buckles complemented the set of forms manufactured in Lower Silesia of Elbe origin. The distribution of the above-mentioned forms indicates existence of an exchange route between Lower Silesia and Eastern Pomerania, leading through the Krajeńskie and Poznań Lake Districts.

In the allochthonous zone of Silesia and Greater Poland, mass production began of iron pins with conical or flattened heads rolled into ears, and especially pins with disc-shaped heads, ornamented with incisions on the edges, with characteristic bidirectionally bent hooked necks, referred to as the Brzozówiec type, as well as more commonly recorded

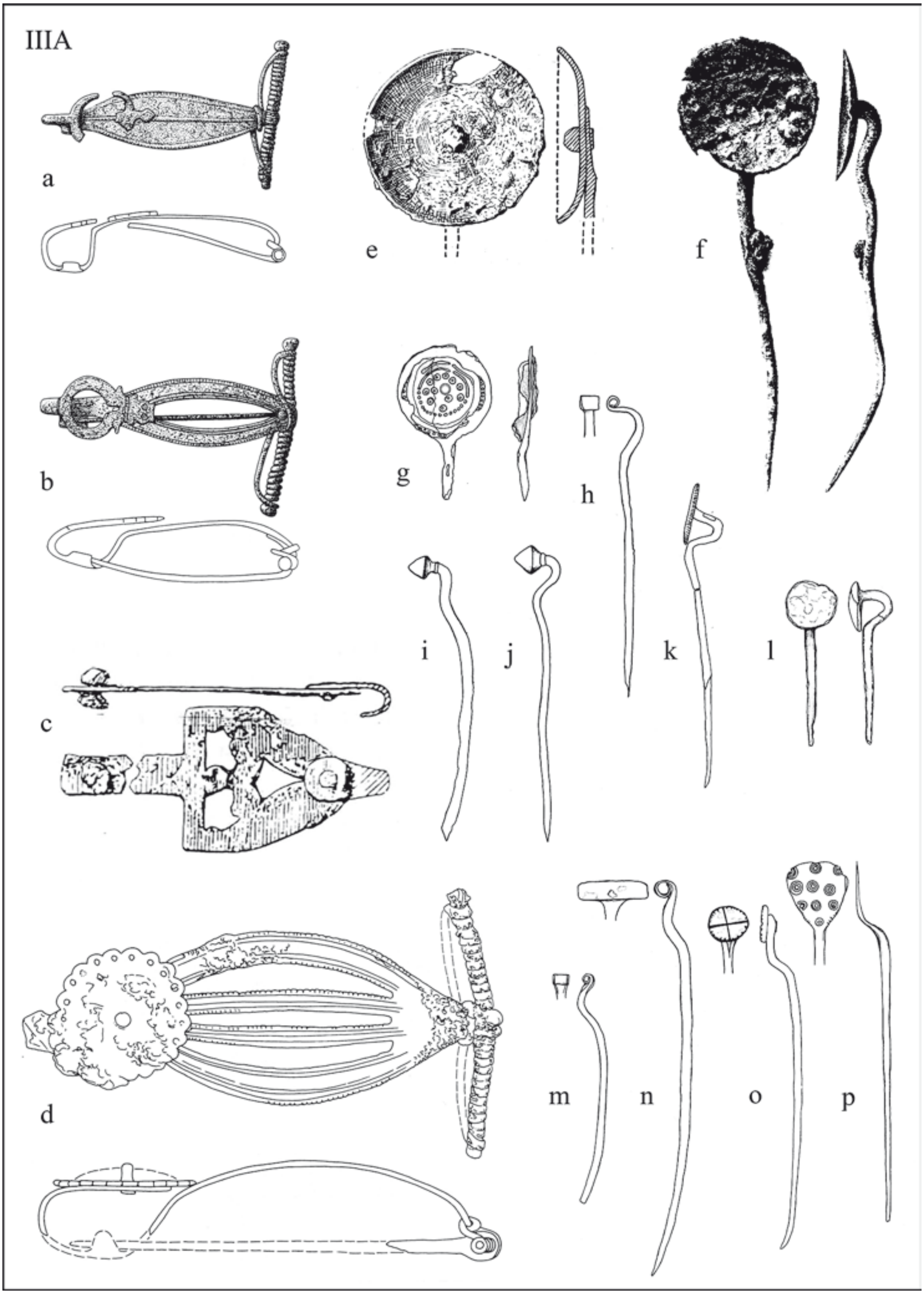

Fig. 10. Clothing fastening items characteristic of the Pomeranian culture in phase IIIA. Graphic design by B. Kaczyński

specimens without incisions belonging to the Skórcz type (Fig. 10: k, l); Kaczyński 2015, 27; 2018, 267; 2019, 62-64). The only variety of pins possibly produced in the south-eastern zone were iron specimens with hooked necks and flattened heads rolled into ears, which may be indicated by their greatest accumulation (Fig. 10: h; Kaczyński 2022, 172-174, fig. 14: c).

The analysis of the spread of forms typical of the final phase of Karczemki (IIC) and the initial Pierzwin/Ulesie (IIIA) phase allows for a hypothetical analysis of population changes taking place in some provinces of the Pomeranian culture (Fig. 4: Phase IIC, IIIA). The situation is most striking in Pomerania, as in the central and western parts there is a clear

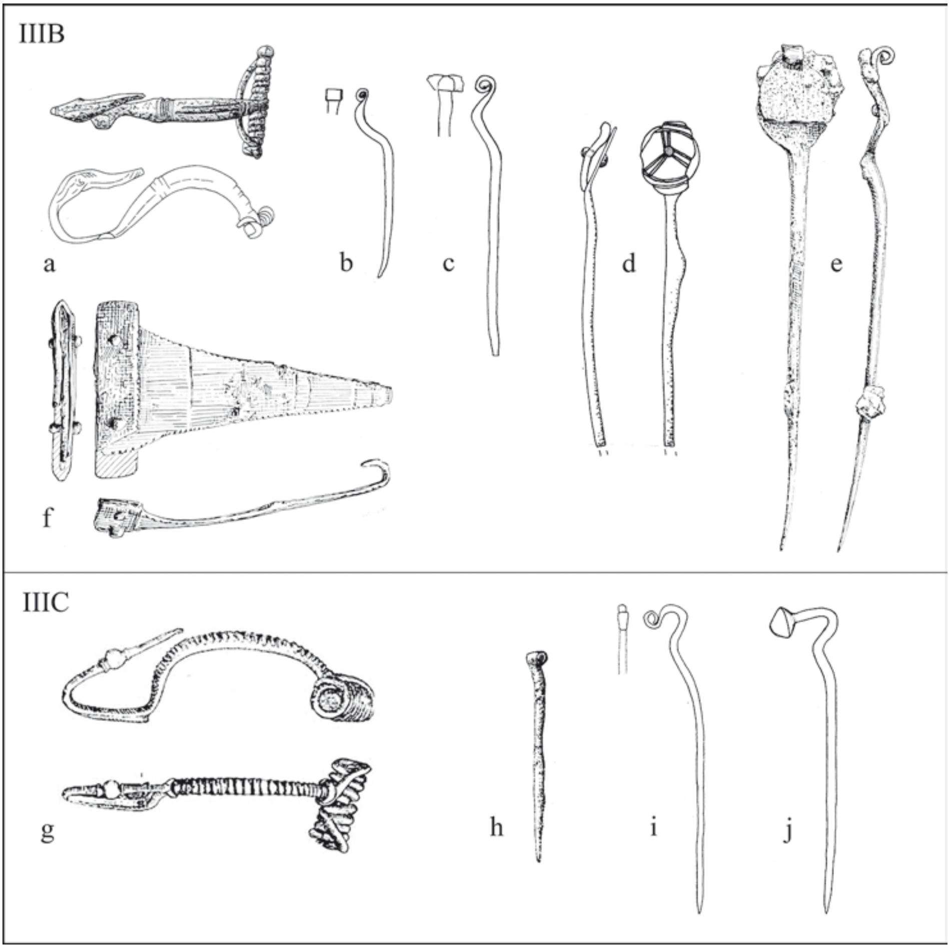

Fig. 11. Clothing fastening items characteristic of the Pomeranian culture in phase IIIB and IIIC. Graphic design by B. Kaczyński

lack of forms typical of phase IIIA. This phenomenon can be interpreted as due to depopulation caused by the ongoing migration of the Pomeranian culture to the south and south-east, as well as the ongoing shifts of the Jastorf culture community from the so-called Marianowo phase. The presence of iron pins typical of the discussed phase, as well as Celtic openwork belt buckles of the Hochscheid-Linz type (Megaw 2005; Woźniak 2010, 67, 68), prove the presence of the Pomeranian culture population in Eastern Pomerania, as well as the permanent functioning of the route towards Lower Silesia. It is also worth adding that iron products associated with the Lower Silesian centre are also recorded in central Poland, Lesser Poland and Masovia.

In the middle part of the Pierzwin/Ulesie phase (IIIB), corresponding to the horizon of occurrence of early La Tène construction fibulae, there is a clear decline in the production of new forms within the Silesian centre and an almost complete lack of new items within Greater Poland and the south-eastern zone. The main forms are iron fibulae of early La Tène construction with bird heads, found in Lower Silesia (Fig. 11: a; Woźniak 2010, 72-74). In this phase, pins with a crop and a tendency to greater neck deviation, with the head flattened and rolled into an ear are still produced (Fig. 11: b, c). The new forms include later varieties of multi-element pins of the Wytomyśl type, modelled on the Jastorf culture tutulus pins from Thuringia, as well as single imports from Gotland – pins with sail-like formed 'crop' shaped stems (Fig. 11: d, e; Kaczyński 2015, 27; 2018, 267, 268, fig. 1; Kaczyński and Sierant-Mroczyńska 2020, 148). The phase in question is the last one in which original metal products of the Pomeranian culture are observed. At that time, settlements in the south-western zone became more dispersed, probably related to the infiltration of the Jastorf milieu, and the route connecting Eastern Pomerania with the Lower Silesia and further the La Tène zone ceased to function (Fig. 4: Phase IIIB). The last moment of the community of the Pomeranian culture, indicating the functioning of native garment-fasteners was the horizon of early La Tène construction Duchcov type fibulae (Fig. 11: g; Grygiel 2018, 18-21, 354, fig. 167), marking the last recognisable part of the Pierzwin/Ulesie phase (IIIC). The occurrence of this fibulae type in pit and cinerary urn burials indicates the presence of Pomeranian culture communities exclusively in the south-eastern zone (Fig. 6: Phase IIIC). The scatter of these fibulae from the upper and middle Bug basin and from areas of Masovia indicates the existence of Pomeranian-La Tène contacts, probably focused on the amber trade. The co-occurrence of Duchcov type fibulae with other items used to hold clothes together at the level of small cemeteries in the south-eastern zone proves that in this phase pins in the late Hallstatt style with conical, flattened heads and heads rolled into an ear were still used, in other words, forms that appeared at the beginning of the Pierzwin/Ulesie phase (Fig. 11: h-j). They should be considered the last traces of the use of swan's neck pins in central Europe.

CONCLUSIONS

In this work, focus was on the diversity and chronology of the Pomeranian culture in the allochthonous zones. It was indicated that the adaptation of the 'Pomeranian' cultural model took place to a different extent in the Oder Lusatian Urnfields area and in the areas occupied by the Masovian Lusatian Urnfields. The south-western zone, distinguished on the basis of the characteristics of the source materials, was characterised by a greater number of 'late Hallstatt' elements, characteristic mainly of Lower Silesia and the middle Oder region. The Pomeranian-Lusatian acculturation process took place in a different way in the allochthonous south-eastern zone, occupied by Masovian communities of Lusatian Urnfields. The material culture in this zone was characterised by a marked impoverishment of inventories and a homogeneity of sources. Throughout the entire period of its operation, influences from the eastern, nomadic zone were recorded.

The main problem hindering the dating of Pomeranian culture materials in allochthonous areas was the lack of a uniform internal relative chronology. The existing schemes developed for Polish lands from the 1970s and 1980s, based on Paul Reinecke's proposals from the first decade of the last century, no longer fulfilled their function due to being outdated in the light of the new approaches concerning central Europe. The presented system of relative chronology for items fastening clothes is a new useful tool for dating, especially in allochthonous areas. Within them, two phases were distinguished: Karczemki (IIA – HaD_1, IIB – HaD_2, IIC – HaD_3) and Pierzwin/Ulesie (IIIA – early LTA, IIIB – late LTA, IIIC – LTB). The system requires expansion to include other categories of material sources.

At the beginning of the Karczemki phase, falling in the mid-7th century BC, there was a slow process of settling Greater Poland by the communities of the Pomeranian cultural model and the establishment of quite intense relations with the Billendorf culture of the middle Oder area – constituting an intermediary in contacts with the Hallstatt zone. In the middle phase of Karczemki falls the appearance of the first original forms of pins and fibulae, produced in the workshops of Greater Poland craftsmen. Many of the indigenous forms were transformed and developed by craftsmen of the Pomeranian culture from products of the types manufactured in the hillfort in Wicina. The period of prosperity of this community's production took place at the declining Karczemki phase, where the production of indigenous bimetallic forms penetrating the areas of Pomerania, the Silesian-Greater Poland border (with the border on Barycz river) and central Poland is observed. The reason for the development was regress of the Billendorf culture and probably taking over contacts with the Hallstatt-La Tène world.

The beginning of the Pierzwin/Ulesie phase brought a shift of the centre of gravity of production from Greater Poland to Silesia and the almost complete domination of iron over bronze forms. At that time, a thriving production centre developed near Wrocław, whose producers drew inspiration from the La Tène and Jastorf world. At that time, there was a complete lack of forms typical of the discussed phase in western and central Pomerania, which could be related to population movements of the Jastorf culture, as well as depopulation caused by the progressive migration of the Pomeranian population towards the south and south-east. In the category of pins, only Jastorf references to areas of Lower Saxony, Brandenburg and Thuringia are observed. The developed Pierzwin/Ulesie phase at the end of the LTA was a time of rapid decline in new, original forms, which foreshadowed a progressive cultural change. In the last noticeable phase, falling in the LTB phase, not very intensive contacts with the eastern Celtic world are observed – the horizon of Duchcov fibulae, while in the production of pins only the continuation of local late Hallstatt traditions is noticeable. In phase IIIC, the Pomeranian culture was present only in the south-eastern zone.

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FIELD SURVEY AND MATERIALS

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THE METALWORK HOARD FROM CZARKÓW, GLIWICE DISTRICT, SILESIAN VOIVODESHIP: DISCOVERY CONTEXT, ELEMENTAL COMPOSITION, AND WEAR ANALYSIS

ABSTRACT

Nowak K., Sych D., Badura B. and Derkowski P. 2025. The metalwork hoard from Czarków, Gliwice District, Silesian Voivodeship: discovery context, elemental composition, and wear analysis. *Sprawozdania Archeologiczne* 77/1, 235-265.

The Czarków hoard, discovered accidentally in 1875, probably during agricultural work, comprised 21 bronze artefacts and ceramic vessel fragments, presumably the original container. The assemblage includes socketed axes of Lusatian and Middle Danubian types, a tanged sickle, and a spearhead.

Metallurgical analysis indicates the use of tin bronze with low tin and trace levels of arsenic, antimony, nickel, silver, and lead. Both local and non-local artefacts share similar metal compositions.
Use-wear and manufacturing traces confirm that all axes underwent finishing and use, with evidence of blade hammering and socket edge modification, particularly on the Lusatian types. Transverse grinding traces suggest resharpening prior to deposition.

Comparative studies date the hoard's inventory to the Late Bronze Age HB2-HB3 phases (*ca*. 1000-750 BC).

Keywords: Bronze Age, Metalwork Hoard, elemental data, use-wear
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INTRODUCTION

The Lusatian Urnfield cultures are characterised by a distinctive set of features that define its archaeological identity (*e.g.*, Kaczmarek 2017). Similarities in ceramic and metal artefact assemblages, economic practices, construction methods, funerary rites, and symbolic behaviours enable delineation of the territory inhabited by communities associated with the Lusatian Urnfield culture.

Within the Lusatian urnfields, a range of regionally specific bronze artefacts emerged, including socketed axes and knobbed sickles characteristic of the Lusatian tradition (*e.g.*, Gedl 1975, 59; 1985, 128; 1995, 49; Kuśnierz 1998, 25). Among the most emblematic metal objects are Lusatian-type socketed axes, typically featuring a loop and vertical rib decoration (Sprockhoff 1950, 77). Researchers working on Lusatian Urnfield assemblages frequently encounter Czarków-type socketed axes. Despite their prevalence, the eponymous hoard from Czarków has not yet been the subject of a comprehensive study or publication.

This article presents new research findings concerning this significant metal deposit associated with the Lusatian Urnfield cultures. We discuss the history of the hoard's discovery and present the results of detailed analyses of its inventory. Particular emphasis is placed on the Lusatian socketed axes of the Czarków type, including aspects of their production technology, the selection of metal alloys used in their casting, and the artefacts' biographies, as reconstructed through wear analysis.

Our results allow us to include the Czarków hoard within the research on metal hoards and their deposition during the Late Bronze Age.

MATERIALS

The Czarków Hoard: Two Similar but Divergent Accounts of Its Discovery

The hoard from Czarków, Gliwice District, Silesian Voivodeship (Fig. 1) was discovered in 1875, and details regarding its find were published relatively soon thereafter (Kuschel 1881; Mertins 1896, 362-365). In the academic literature, the hoard appears under at least four different names: der Verwahrfund von Ottmuchow, Tost-Gleiwitz (present-day Otmuchów), Langendorf (present-day Wielowieś), Scharkow (present-day Czarków), and Czarków (in Polish-language publications). These variations reflect shifts in cadastral boundaries prior to the Second World War, as well as the significant changes in national borders and place names that occurred in the post-War period. The name Scharkow continues to appear in post-war German-language publications (*e.g.*, Sprockhoff 1950, 128; von Brunn 1968, 304), further contributing to the ambiguity surrounding the hoard's provenance.

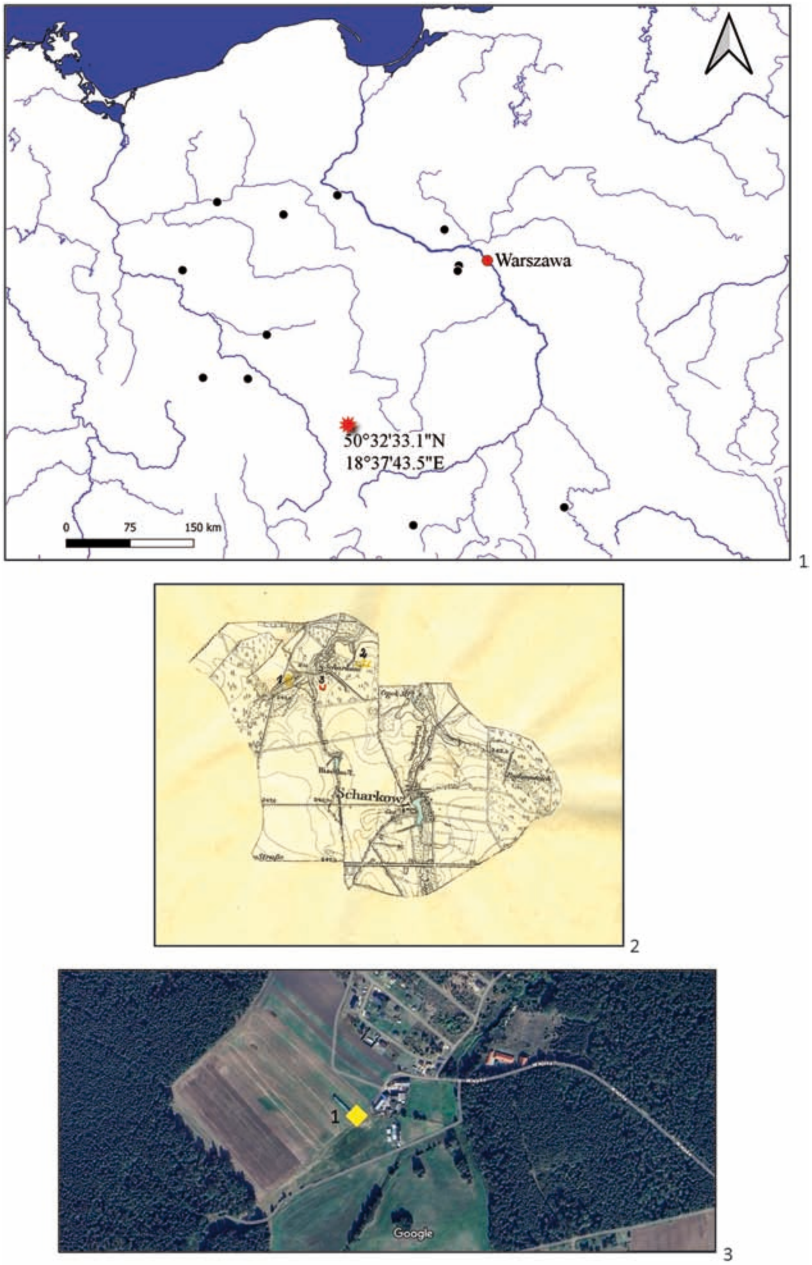

Fig. 1. Location of the Czarków hoard: 1 – On a contemporary map of Poland marked with an asterisk. Black dots mark the sites with elemental analysed socketed axes mentioned in the text, 2 – On the archival *Messtischblatt* map from the collection of the Upper Silesian Museum in Bytom, 3 – An approximate location marked on the contemporary Google map file

Two slightly differing versions of the circumstances surrounding its discovery exist. Moreover, discrepancies are evident in both the reported location and the composition of the deposit across various sources in the literature and archival records.

According to the earliest accounts (Kuschel 1881, 35, 36, with commentary signed 'D. R.'), the hoard was discovered by chance on a dirt track leading to an arable field. In brief, the finder, an employee named Franz Zientek, reported that on 18 June 1875, he noticed a shiny object protruding from the ground in the middle of a rural track. Using a wooden stick, he easily extracted four objects. On 22 June 1875, he returned to the site with the landowner, Mr Gollor, and together they excavated a further 17 objects. According to their report, these items were found at a depth of approximately 20 cm (8 Zoll). In the same location, approximately 15 cm deeper (6 Zoll lower), fragments of a grey ceramic vessel were also uncovered. The report notes that the road in question had previously passed through woodland, which was subsequently converted to arable land (Kuschel 1881). The commentary accompanying the original account specifies that the hoard comprised 21 artefacts in total, and that 17 of the socketed axes originated from a single casting mould.

A similar description was published some years later by Mertins (1896), who also noted that the hoard, referred to as the Ottmuchow hoard, was donated by Gutsbesitzer Kuschel of Langendorf (present-day Wielowieś) to the Museum Schlesischer Altertümer in Breslau (modern-day Wrocław).

A differing version of the hoard's discovery was later published by Seger in 1936, under the name *Scharkow, Kr. Tost-Gleiwitz* (Seger 1936, 143, 144). This account is based on a field report by Otto Hanske, a museum technician and preparator, who visited the site and interviewed the landowner in 1935. According to the second version of events, Franz Zientek – this time identified as a trader (Händler) – was walking behind a plough during agricultural work carried out by Freigärtner Gollarz in his field, when the plough suddenly unearthed four objects. Zientek retrieved them and, upon seeking advice in a nearby town (Kruppamühle, now Krupski Młyn in the Silesian Voivodeship, Tarnowskie Góry District), was informed that the finds were prehistoric artefacts and that further items were likely to remain at the site. Subsequently, Zientek and the landowner returned to the field and excavated the remaining objects.

Based on the above-cited sources, it can be reasonably concluded that the hoard from Czarków was discovered by chance on 18 June 1875 and further explored by non-specialists – namely Mr Zientek and Mr Gollor – a few days later, on 22 June 1875. The assemblage, which included 19 socketed axes, one sickle, and one spearhead, had been deposited at a shallow depth (ca. 20 cm) within a ceramic vessel. Given that the four axes were discovered first, it may be inferred that the uppermost layer of the hoard consisted of this category of artefact. As Seger (1936, 144) notes, however, it remains challenging to reconstruct the hoard's original composition with certainty.

THE INVENTORY OF THE HOARD – A LONG HISTORY

Most of the aforementioned sources agree that the inventory of the Czarków hoard comprised 21 objects: 19 socketed axes, one spearhead, and one sickle. However, there is some inconsistency in the historical record. Notably, Kaleffe (1888) refers to the hoard from Langendorf, but mentions only the sickle and the 19 socketed axes, omitting any reference to the spearhead.

Interestingly, both H. Kurtz (1929) and H. Seger (1936) refer to a total of 21 artefacts in their respective texts; however, the accompanying plate – identical in both publications – depicts only 20 objects. These include 16 socketed axes of the Lusatian type, two socketed axes of the Middle Danubian type, one sickle, and one spearhead (Kurtz 1929, 32, 33 and unnumbered plate; Seger 1936, pl. 13: 3).

In subsequent years, Sprockhoff referenced the Czarków hoard (referred to as Scharkow) in his publication 'Lausitzer Tüllenbeil', in which he catalogued only 16 socketed axes of Lusatian type (Hauptform) within the assemblage (*cf.*, Sprockhoff 1950, 128). In later post-War literature, while the correct total number of artefacts in the hoard – 21 items – is often acknowledged, illustrations typically depict only 20 specimens. This discrepancy is evident, for example, in Gedl (1962), where a photographic reproduction of Seger's (1936, pl. 13: 3) plate, previously published by Kurtz (1929, unnumbered plate), is reused. The omission of one axe in the visual documentation raises the question of why Kurtz – and subsequently Seger and other authors – excluded a single specimen from their respective presentations of the hoard.

The apparent discrepancy in the number of Lusatian-type axes associated with the Czarków hoard can be clarified through archival records and a note in Arndt's 1925 publication. Arndt explicitly states that of the 17 Lusatian-type socketed axes identified initially, one was held in the collection of the Museum zu Beuthen (today the Upper Silesian Museum in Bytom), while the remaining specimens were deposited in the Museum Schlesischer Altertümer in Breslau (present-day Wrocław; Arndt 1925, 36). This explains the omission of a single axe from the photographic documentation reproduced by Hans Seger (1936) and later by Gedl (1962), as it was housed separately from the primary assemblage and thus probably unavailable during the preparation of those publications.

The most comprehensive and up-to-date assessment of the current composition of the Czarków hoard is provided by Kuśnierz in the volume 'Prähistorische Bronzefunde' dedicated to socketed axes (Kuśnierz 1998). On page 33, Kuśnierz records 16 Lusatian-type socketed axes from Czarków, corresponding to the initially documented number of this type of artefact in the hoard. Notably, he identifies one of these axes – inventory number 7092 – as being housed in the collections of the Upper Silesian Museum in Bytom. However, it is catalogued there under the incorrect provenance of Wielowieś (formerly Langendorf) (Kuśnierz 1998, 33; pl. 11:176; pl. 50 with complete inventory of the hoard).

Readers of this article may understandably wonder why we have devoted such extensive attention to the history of the discovery and inventory of the Czarków hoard. We do this in our defence. Namely, the Czarków hoard, given to us for research, contains 20 artefacts (excluding the aforementioned axe, number 7092). The current museum numbering is continuous (B.801/4054:58-B.820/4073:58), which is why our vigilance was somewhat 'lulled', even though we knew from the beginning that number 7092 was missing. Based on the archival numbering preserved on the surfaces of the axes (see Fig. 2), axe no. 7092 should be positioned between B.801/4054 (old no. 7091) and B.802/4055 (old no. 7093). However, we did not pursue this discrepancy immediately, assuming that either the archival numbering was erroneous or, more likely, that the missing axe had been irretrievably lost shortly after the hoard's discovery. Thanks to Kuśnierz's research, we now know the axe was not lost, and we assure our readers that we will revisit the matter of axe no. 7092 in a future publication, where additional information will be provided.

The Czarków Hoard – A Summary

The Czarków hoard consists of 21 metal artefacts (Figures 2 and 3) and was initially deposited within a ceramic vessel that unfortunately has not survived; nothing more is known about it. As previously noted, the vessel was not retrieved at the time of discovery in 1875. The hoard comprises two Middle Danubian-type socketed axes with stepped cutting edges ('Tüllenbeile mit abgestuftem Schneidenteil', Kuśnierz 1998, 17, 18), seventeen Lusatian-type socketed axes of Czarków type (Kuśnierz 1998, 33), one tanged sickle featuring a rib parallel to the back ('Zungensichel mit einer Rückenparallelen Rippe'; Gedl 1995, 80), and one spearhead with a triangular blade ('Lanzenspitze mit dreieckigem Blatt'; Gedl 2009, 56). The detailed characteristics of these artefacts are presented in Table 1.

The relative chronology of the Czarków hoard has been addressed in several studies, and we would like to briefly summarise these viewpoints. J. Kuśnierz (1998, 20), citing sources such as von Brunn (1968, 304), suggests that the hoard should be dated to HaB1, at the end of the IV Bronze Age Period, or, at the latest, to the transition from the IV to the V Bronze Age Period. Kuśnierz points out (1998, 41) that all the Lusatian socketed axes from the Czarków hoard belong to variant A, i.e. the oldest variant of the Czarków type. M. Gedl, drawing on the analogy of the sickle found in the hoard, assigns it to the V Bronze Age Period (Gedl 1995, 82), while also dating the spearhead to the transitional phase between Period IV and V or the early V Bronze Age (Gedl 2009, 56). W. Blajer, on the other hand, dates the hoard to HaB2-B3, *i.e.* the V Bronze Age Period (*ca.* 1000-750 BC; Blajer 2001, 20, 342).

Fig. 2. Inventory of the Czarków hoard, excluding axe no. 7092
(photo: W. Szołtys)

Fig. 3. Inventory of the Czarków hoard, except axe no. 7092 (photo: W. Szołtys)

METHODS

The chemical composition analyses

Chemical analyses were performed on all the artefacts from the Czarków hoard to determine the elemental composition and separate possible raw material groups. Metal samples were obtained using a micro-drill and HSS drills with a diameter of 1-2 mm. Samples were taken from the least visible place. In the case of axes and spearheads, it was the inside of the socket, and in the case of the sickle, on the flat side in the middle of the length. In the first step, the patina layer was removed with a drill. Then, changing to a new drill, a hole was drilled to obtain the required amount of metal core. The obtained material was collected in Eppendorf polypropylene containers. The operation was repeated, each time changing the drill to avoid contamination of the samples. The sampling spots have been restored and are barely visible to the naked eye.

The chemical composition was determined at the Polish Geological Institute – National Research Institute in Warsaw using a Cameca SX-100 electron microprobe analyser (EPMA). Drilling chips or small pieces weighing approximately. 0,01 g per sample was mounted in epoxy resin on 1-inch-diameter discs. Samples were polished with water-free diamond paste (to avoid oxidation) and then carbon-coated to obtain electrical conductivity. Analytical conditions of the microprobe were set to 15kV of accelerating voltage and 20 nA beam current for major elements (Si, Al, S, Cu, Fe, Sn) and 200 nA for trace elements (Zn, Ni, Co, Cd, Ag, Pb, Au, Se, As, Sb, Mn, Bi, Hg). The diameter of the electron beam (spot size) was set to 10 μm. Due to the variable composition at the μm-scale, approximately 15 areas were analysed per sample, each lasting 20 minutes. The following standards were used, and corresponding X-ray lines were used: Si Kα Wollastonite, Al Kα Orthoclase, S Kα Arsenopyrite, Cu Kα Cu metal, Sn Lα Cassiterite, Ag Lα Proustite, Sb Lα Stibnite, Bi Mβ Bi metal, Pb Mβ Galena, Zn Kα ZnS, Se Lβ ZnSe, As Lβ FeAsS, Ni Kα Pentlandite, Co Kα Skutterudite, Fe Kα Haematite, Au Mα Au metal, Mn Kα Rhodonite, Cd Lα CdS, Hg Mα Cinnabar.

Wear analyses

Wear analysis represents an effective method for examining the surfaces of metal artefacts, particularly for distinguishing between treated and untreated surfaces and for classifying objects according to their use-wear status, such as used, unused, repaired, or fragmented. The methodological foundations of this approach have been extensively discussed in the literature (Gutiérrez Sáez and Lerma, 2014; Dolfini and Crellin 2016; Molloy *et al.* 2016; Sych *et al.* 2020). Its limitations and new perspectives have recently been highlighted in Polish and international literature (*e.g.*, Caricola *et al.* 2022; Kasprowicz 2022; Nowak and Sych 2024).

Metalwork wear analyses of copper-alloy axes, as well as related experimental studies conducted in recent years, have considerably expanded our knowledge of these objects, both in terms of production technology and use (Kienlin and Ottaway 1998; Roberts and Ottaway 2003; Dolfini *et al.* 2023; Nowak *et al.* 2023).

The artefacts from the Czarków hoard were subjected to microscopic analysis to identify surface traces associated with both production and use. The primary objective of this examination was to determine whether the objects may have been deposited following a specific pattern related to their condition, such as evidence of wear, repair, or fragmentation. Observations were conducted using a portable Dino-Lite digital microscope and a Zeiss Stemi 2000-C stereomicroscope, equipped with a Delta Optical DLT-Cam PRO 2MP digital camera. The analyses were conducted post-conservation. It is worth noting that the hoard was discovered in 1875, and the post-depositional history of the artefacts – including their treatment and storage prior to museum acquisition – remains partially undocumented.

RESULTS AND DISCUSSION

Elemental composition

The literature indicates that, based on similarities in shape and dimensions, the majority of Lusatian-type socketed axes in the Czarków hoard could have been cast in a single mould (*e.g.*, Mertins 1896, 362, 363; Kuśnierz 1998, 33). All the Lusatian-type axes are typologically analogous variants. Their dimensions and weights are also similar, with some slight differences (Table 1). The average weight is 218 g, of which 9 axes weigh between 210 and 220 g. Three axes are lighter (195-208 g), and five weigh >220 g (222-247 g). The Lusatian-type axes are usually much heavier than the Middle Danubian axes. The lengths of the axes are also basically similar, as 15 axes measure 113-119 mm. Only two are shorter (7092 – 111 mm; B.803/4056 – 114 mm). Slight differences in the weight and length of the artefacts may be related to casting defects – holes in the surfaces (as in the case of axe no. B.803/4056, weighing 205 g) or broken off fragments, as in axe no. B.811/4064 weighing 195 g or a different level of surface treatment, hammering, which could slightly lengthen the artefacts. Axe 7092 clearly stands out from the rest of the collection. With a relatively high weight (235 g), it is the shortest item (111 mm).

As outlined above, the Lusatian-type socketed axes display close similarities in form and dimensions, suggesting a high likelihood that they were produced using the same casting mould, or, at most, from two or three nearly identical sets, possibly derived from a single model (in case of the ceramic and metal moulds) employed for their manufacture. The objective of the elemental composition analyses was to characterise the alloying components employed in the production of these artefacts and to evaluate whether the Lusatian-type axes could have been cast from a single metal batch during one production cycle.

Table 1. Characteristics of the Czarków hoard inventory: L – Lusatian axe type; MD – Middle Danube axe type. The archival inventory numbers are visible in Figures 2 and 3. Weights (g) and some dimensions (mm) as cited in Kuśnierz 1998, 17, 33; Gedl 1995, 80; Gedl 2009, 56

Inv. No.	Item	length	blades' width	width in the middle part	sockets' depth	sockets' diameter (outside)	sockets' diameter (inside)	weight
B.801/4054	Axe [L]	117	42	25	82	38	19	215
B.802/4055	Axe [L]	115	40	25	8	36	17	208
B.803/4056	Axe [L]	114	40	25	82	37	21	205
B.804/4057	Axe [L]	116	40	24	80	37	20	218
B.805/4058	Axe [L]	116	39	25	81	37	18	216
B.806/4059	Axe [L]	117	40	25	82	38	19	215
B.807/4060	Axe [L]	115	39	25	81	37	17	218
B.808/4061	Axe [L]	117	43	20	75	37	20	210
B.809/4062	Axe [L]	115	38	23	68	38	18	247
B.810/4063	Axe [L]	116	41	25	81	37	19	230
B.811/4064	Axe [L]	113	40	24	79	37	20	195
B.812/4065	Axe [L]	115	40	25	80	37	18	228
B.813/4066	Axe [L]	115	39	24	83	37	18	222
B.814/4067	Axe [L]	119	42	24	81	37	20	215
B.815/4068	Axe [L]	115	40	24	80	37	18	220
B.816/4069	Axe [MD]	105	53	25	50	32	11	166
B.817/4070	Axe [L]	117	42	24	82	38	21	214
B.818/4071	Axe [MD]	109	58	25	50	33	13	152
B.819/4072	Spearhead	98	34	-	-	22	6	65
B.820/4073	Sickle	128	31	18	-	-	-	61
7092	Axe [L]	111	-	-	-	-	-	235

Furthermore, the study aimed to assess potential compositional relationships between locally produced artefacts and those of non-local (imported) origin, as such correlations may reflect shared metallurgical sources or recycling practices.

The chemical analyses revealed that the artefacts from the Czarków hoard were manufactured from a copper-based alloy intentionally containing tin – *i.e.*, tin bronze. The alloy also contains varying trace concentrations of arsenic, antimony, nickel, bismuth, and lead (Table 2), elements commonly associated with prehistoric bronze metallurgy and copper ore deposits used (*e.g.*, Pernicka 1999).

The group of Lusatian-type socketed axes from Czarków shows a relatively wide variation in tin (Sn) content (Table 2). Four specimens exhibit a particularly low tin concentration, not exceeding 1% (0.41% to 0.68%). Such values may reflect the tin loss through volatilisation during repeated melting and casting cycles (*e.g.*, Kuijpers 2008, 25). The

Table 2. Chemical composition (EPMA): L – Lusatian type of axe; MD – Middle Danube-type of axe. Results are in weight%: values in italics are below the limit of detection; results for Au and Zn in all the samples are below the detection limit. The table presents selected measured elements

Inv. Number	Artefact type	Cu	Sn	As	Ni	Ag	Sb	Pb	Bi	Co	Fe
B.803 4056	Socketed axe [L]	97.52	0.61	*0.08*	*0.08*	*0.04*	0.47	*0.04*	*0.02*	*0.01*	0.10
B.807 4060	Socketed axe [L]	97.10	0.41	0.15	0.19	0.44	0.81	*0.01*	*0.00*	*0.01*	*0.02*
B.809 4062	Socketed axe [L]	96.94	0.68	0.49	*0.05*	*0.02*	0.30	*0.00*	*0.00*	*0.00*	*0.02*
B.817 4070	Socketed axe [L]	97.39	0.48	0.28	0.13	*0.08*	0.75	*0.05*	*0.02*	*0.01*	*0.02*
B.801 4054	Socketed axe [L]	96.29	1.11	0.21	0.18	*0.08*	0.43	0.41	*0.00*	*0.02*	0.21
B.802 4055	Socketed axe [L]	96.02	1.87	0.15	0.20	0.21	0.97	*0.04*	*0.01*	*0.01*	*0.02*
B.806 4059	Socketed axe [L]	96.78	1.31	0.10	*0.08*	*0.07*	0.77	*0.02*	*0.01*	*0.01*	*0.03*
B.808 4061	Socketed axe [L]	94.21	1.43	0.73	0.14	*0.08*	0.66	*0.00*	*0.01*	*0.02*	0.16
B.810 4063	Socketed axe [L]	96.41	1.48	0.13	0.15	*0.08*	0.60	*0.05*	*0.01*	*0.03*	*0.05*
B.811 4064	Socketed axe [L]	95.48	1.37	0.24	0.12	*0.07*	1.42	*0.02*	*0.01*	*0.02*	*0.09*
B.813 4066	Socketed axe [L]	92.41	1.10	0.15	*0.02*	0.10	2.99	0.42	*0.03*	*0.01*	*0.02*
B.805 4058	Socketed axe [L]	94.80	2.72	0.16	*0.09*	0.09	0.89	*0.02*	*0.01*	*0.01*	*0.05*
B.814 4067	Socketed axe [L]	95.23	2.01	0.38	*0.07*	0.05	0.98	0.15	*0.02*	*0.01*	0.19
B.815 4068	Socketed axe [L]	96.04	2.35	*0.07*	*0.01*	*0.03*	0.66	*0.09*	*0.03*	*0.00*	*0.03*
B.804 4057	Socketed axe [L]	94.37	3.63	0.16	0.12	*0.04*	0.61	*0.03*	*0.01*	*0.01*	0.13
B.812 4065	Socketed axe [L]	93.66	3.88	0.12	0.12	*0.06*	0.56	*0.05*	*0.01*	*0.01*	0.15
B.816 4069	Socketed axe [MD]	93.40	2.81	0.22	0.10	0.11	1.39	0.17	*0.02*	*0.01*	0.10
B.818 4071	Socketed axe [MD]	94.93	2.62	0.19	0.11	*0.09*	1.21	0.20	*0.02*	*0.01*	0.10
B.819 4072	Spearhead	90.84	4.89	0.32	*0.04*	0.10	2.93	*0.01*	*0.03*	*0.01*	*0.07*
B.820 4073	Sickle	93.25	4.42	0.16	0.12	*0.08*	1.00	*0.01*	*0.00*	*0.02*	0.25

most significant subset comprises axes with low tin content (n = 7), ranging from 1.10% to 1.87%. A further three axes display moderately elevated tin levels of 2.01%-2.72%, while two specimens contain higher concentrations, exceeding 3% (3.63% and 3.68%, respectively).

The Middle Danubian-type socketed axes are characterised by a relatively consistent tin content of 2.62-2.81%. The highest tin concentrations within the entire assemblage were identified in the spearhead (4.89% Sn) and the sickle (4.42% Sn), distinguishing these artefacts from the rest of the hoard.

The concentrations of other trace elements – including arsenic (As), antimony (Sb), nickel (Ni), silver (Ag), and lead (Pb) – which typically occur as natural impurities in the copper ore used for smelting, are generally low across the assemblage, but there are visible differences. These elements are considered indicators of the original copper source, as their concentrations are largely unaffected by metallurgical processes such as remelting (Pernicka 2015, 254), unlike tin, which can be diminished by repeated thermal treatment.

Arsenic content is generally minor, averaging 0.22%, with trace levels noted in two artefacts (0.08% As in B.803/4056 and 0.07% As in B.815/4068). Lead and bismuth contents mostly fall below the detection limit of the analytical method employed, with slightly elevated Pb values observed in samples B.801/4054, B.813/4066, B.814/4067, B.816/4069, and B.818/4071. Silver concentrations are consistently low across the assemblage, averaging 0.10%. In fifteen artefacts, Ag content falls within the trace range (0.02-0.09%), while the remaining samples exhibit slightly higher values (0.10-0.44%). Among the analysed elements, antimony shows the most significant variability and reaches the highest concentrations recorded among the suite of natural ore-related impurities. The average Sb content across the assemblage is 1.02%. Elevated values were noted in two Lusatian axes (1.42% Sb in B.811/4064 and 2.99% Sb in B.813/4066), two Middle Danubian type axes (1.39% Sb in B.816/4069 and 1.21% Sb in B.818/4071), the spearhead (2.93% Sb in B.819/4072), and the sickle (1.00% Sb in B.820/4073).

The foregoing data confirm that the artefacts from the Czarków hoard were produced from tin bronze characterised by a relatively low tin content and a generally low level of natural ore impurities. The exception is the increased level of antimony in six artefacts – two Lusatian axes, two Middle Danubian type axes, the sickle and the spearhead.

To assess compositional similarities and identify potential correlations or distinctions within the assemblage, the concentrations of trace elements – specifically arsenic (As), silver (Ag), nickel (Ni), and antimony (Sb) – were plotted on double-logarithmic scatter diagrams (Fig. 4). The diagrams reveal a cluster of artefacts sharing comparable levels of Ni, As, and Ag, suggesting a degree of homogeneity in the metallurgical raw materials used in their production.

The majority of the analysed artefacts from the Czarków hoard form a coherent compositional cluster, characterised by low to very low nickel concentrations and consistent Ni/Ag, Ni/As, and Ni/Sb ratios (Fig. 4). This compositional group encompasses a substantial

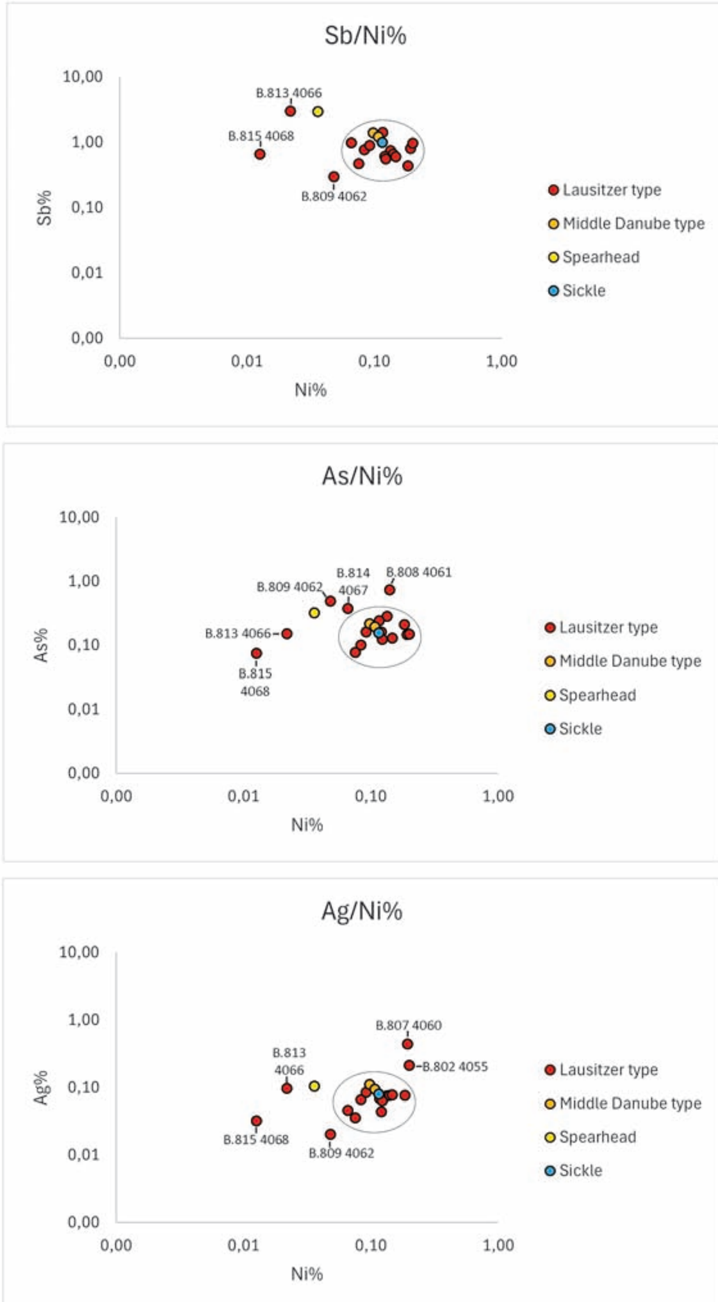

Fig. 4. Double logarithmic diagrams illustrating a distinct cluster of artefacts, both stylistically local and foreign, with comparable values for antimony-nickel, arsenic-nickel, and silver-nickel ratios

number of Lusatian-type socketed axes, as well as both Middle Danubian axes and the tanged sickle. A small number of artefacts deviate from this primary cluster. These include several Lusatian-type axes and the spearhead. Notably, spearhead no. B.819/4072 exhibits the second-highest antimony concentration within the assemblage, while its nickel content falls below the range observed in the leading group. Two Lusatian axes – B.813/4066 and B.815/4068 – consistently fall outside the defined cluster across all comparative diagrams. Axe B.815/4068 displays the lowest concentrations of both nickel and arsenic among the artefacts, whereas axe B.813/4066, while having the second lowest nickel content, possesses the highest recorded antimony concentration (Fig. 4).

Chemical analyses of trace elements facilitate the comparison of artefacts within the assemblage and, ideally, allow the identification of initial clusters that may indicate a shared metallurgical background and/or familiar raw material sources (Gavranović *et al.* 2021). The results of the elemental analysis of the Czarków hoard artefacts suggest that the majority of the Lusatian-type axes were manufactured from a similar base metal. Interestingly, items of foreign origin – namely the Middle Danubian axes and the tanged sickle – also fall within this compositional group.

It remains plausible that both local and non-local axes were produced at their respective production sites using metal derived from a common source. However, these findings may also provide indirect evidence for the recycling of imported objects. It is conceivable that foreign artefacts were reworked into locally styled objects, such as Lusatian-type axes. This transformation of foreign objects into local forms could be supported by the higher tin content observed in the Middle Danubian axes (B.816/4069, B.818/4071) and the sickle. Nonetheless, this pattern is not definitive and further detailed research is necessary to explore this hypothesis in more depth.

Based on published data and information from the available literature, we have endeavoured to correlate the elemental data obtained for the Czarków hoard with those of socketed axes discovered in Poland, spanning from the HA1 phase to the end of the Bronze Age and the beginning of the Early Iron Age (HB2-HC). The results are presented in double logarithmic diagrams in Figure 5.

The distinct cluster of artefacts from the Czarków hoard shows a correlation with assemblages from hoards such as Rosko, Brudzyń, Karmin IV, and the axe from Cierpice, particularly in terms of comparable trace element contents, notably antimony-nickel and arsenic-nickel ratios. These hoards, dated primarily to the Late Bronze Age (HB2-HB3), exhibit similarities in elemental composition. However, the Czarków assemblage diverges from older hoards, such as those from Nowa Górna, Paszowice, Falejówka, Wilamowice, and Gole (HA1-HB1). The lack of correlation is most evident in the antimony-nickel comparison, where, for example, artefacts from Nowa Górna, Wilamowice, and Gole are characterised by a low antimony content. At the same time, the Falejówka axe displays a high level of this element. In the arsenic-nickel comparison, only a subset of the objects aligns with the separated group (Fig. 5).

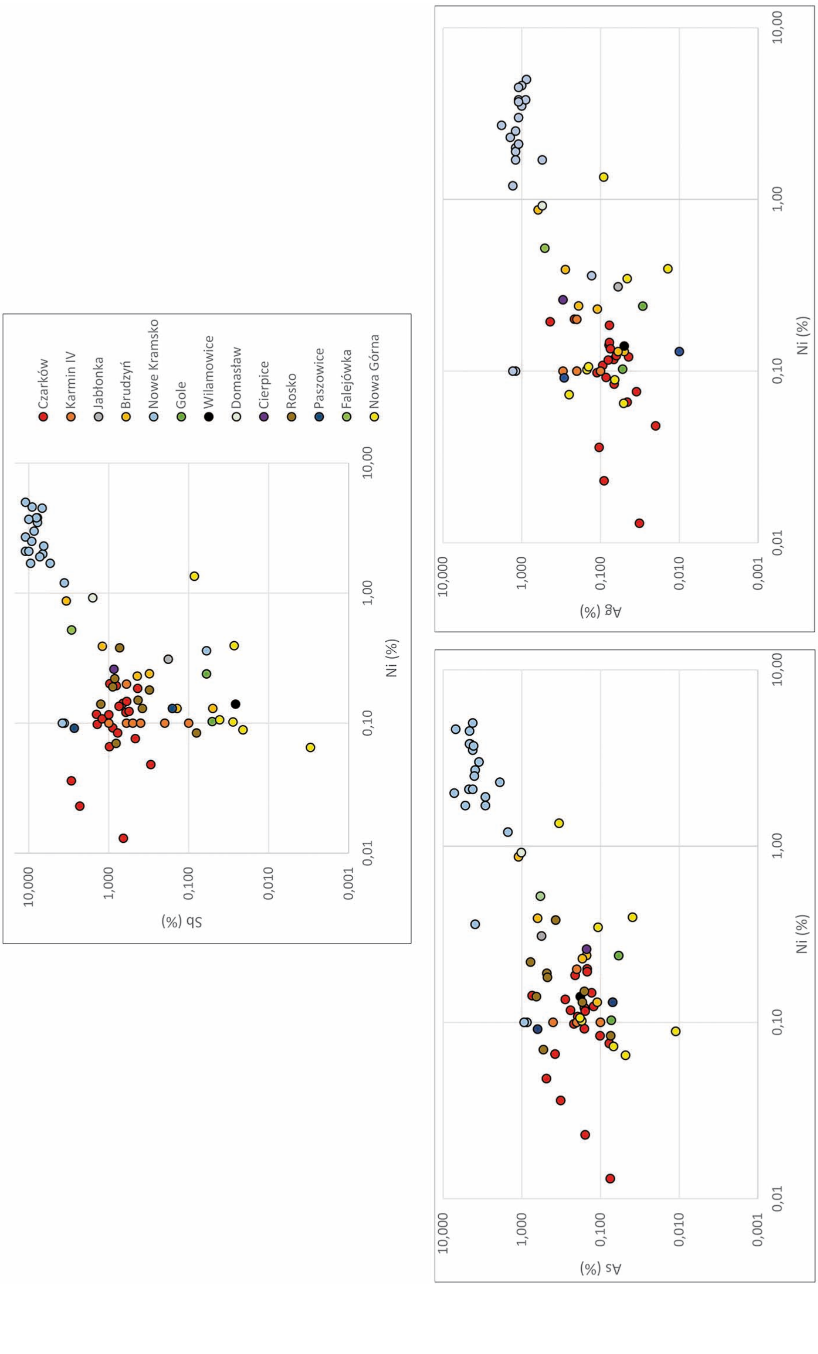

Fig. 5. Trace element correlation for selected socketed axes discovered in Poland (HA1-HC), compared with the results for the Czarków hoard (whole assemblage). The legend applies to all graphs. Elemental data are from: Sałat *et al.* 2006; Biborski 2017, table 1; Garbacz-Klempka *et al.* 2018, Table 1; Baron *et al.* 2019, table 5; Kowalski and Garbacz-Klempka 2019, table 2; Garbacz-Klempka and Kowalski 2020, table 1; Orlińska 2020, table 1; Blajer *et al.* 2022, table 1; Gackowski *et al.* 2023, table 1; Nowak *et al.* 2023; Gan 2024, table 2

A compact cluster, distinct from the rest, is evident in the assemblage from Nowe Kramsko (Fig. 5). Dated to HB2-HB3, it clearly indicates the use of a different metal type for the production of local axes. This metal is marked by a high concentration of impurities in the alloy, including antimony (up to 11%), arsenic (up to 7.2%), silver (up to 1.8%), and nickel (up to 5%). Notably, both Lusatian-type and Middle Danubian axes were crafted from this alloy.

In the case of several artefacts from Czarków, as well as axe no. 15 from the Karmin IV, axe no. 6 from Brudzyń, axe no. 19 from the Paszowice deposit, the antimony level reaches 1-2% or more, while the silver and arsenic content is low (Baron *et al.* 2019; Garbacz-Klempka and Kowalski 2020; Nowak *et al.* 2023). Differences in the content of elements such as antimony, arsenic, silver and bismuth indicate the use of different types of copper ores to produce the copper from which these objects were cast. Artefacts with very low antimony, arsenic, silver and bismuth contents come from smelting chalcopyrite ores, while those with elevated levels of these elements come from fahlore ores. The best example of the use of fahlore ores in axe production, among others, in the Late Bronze Age is the hoard from Nowe Kramsko (Kowalski and Garbacz-Klempka 2019).

Typical copper from chalcopyrite ores, such as those from the Mitterberg, Kelchalm, or Mauk outcrops, has very low impurity contents, while fahlore ore from mines such as Schwaz-Brixlegg contains significant impurities (*e.g.*, Lutz and Pernicka 2013; Tropper *et al.* 2019). For example, the average antimony content in fahlore copper raw material is 6.7 mass%, compared to 0.02 mass% in chalcopyrite (Grutsch *et al.* 2019). In the case of the artefacts we examined from Czarków, the elevated antimony levels are remarkable, with most cases falling within the levels indicated above. The elevated antimony content for six artefacts, including two Lusatian-type axes, two Middle Danubian-type axes, a sickle, and a spearhead, combined with low silver and arsenic content, is also engaging. This may indicate the use of 'diluted fahlore copper' in the production of these artefacts, *i.e.*, a metal derived from mixing metal from fahlore and chalcopyrite ores or from smelting copper from mixed polymetallic ores (Grutsch *et al.* 2019). The frequently cited research by Grutsch *et al.* (2019) indicates that this type of metal is abundant in the Late Bronze Age, which corresponds to the chronology of the Czarków hoard.

Finally, it is worth noting the variation in tin content. While this may seem overly simplified and obvious, it cannot be conclusively stated that a single pattern of tin addition was used across Lusatian urnfields. However, a noticeable trend emerges: older artefacts (from sites such as Nowa Górna, Gola, and Jabłonka) often contain higher tin levels, ranging from 10% to 17%. In contrast, contemporaneous and younger artefacts, such as those from Czarków, Karmin IV, Nowe Kramsko, and Cierpice, typically have lower tin content, usually around 1-3%, and rarely exceeding 5%. The Rosko and Brudzyń hoards stand out, as their examined axes (analysed with the ARL 3460 emission spectrometer for Rosko and ED-XRF Spectro-MIDEX for Brudzyń) show tin levels of 7-11% and 6.3-9.5%, respectively, with one Brudzyń sample containing 3.2% tin.

The reduction in tin content in artefacts dating to the Late Bronze Age is a noticeable phenomenon, but the cause remains unclear. Hypotheses have been put forward regarding a decline in tin transport, which could also have influenced the return to fahlore deposits, rich in elements that, to some extent, could compensate for the tin shortage (Grutsch *et al.* 2019; Baron *et al.* 2020). Experimental studies show that using a high-tin bronze alloy for axe production significantly improves the durability of the object when working with wood compared with using low-tin bronze (Dolfini *et al.* 2023; further literature therein). Therefore, the use of low-tin bronze (minimum 0.41% Sn, maximum 3.88% Sn in the case of Lusatian-type axes in the Czarków hoard) in the production of axes does not appear to have been dictated by a deliberate action aimed at obtaining a product with ideal parameters. The axes were likely made from a low-tin alloy due to the aforementioned shortages of raw materials and limited access to tin. Our research hypothesis assumed that imported artefacts, containing higher levels of tin, could have been fragmented and added to tin-poor bronze to enhance its functional value. In the case of Czarków, this could have been true for axes with very low tin content. However, several Lusatian axes have tin levels similar to or even higher than those found in the Middle Danubian axes, which instead rules out the possibility of fragmentation and the addition of tin-rich fragments to a tin-poor alloy. This, instead, suggests the remelting of entire artefacts to produce new, locally stylistic ones.

Metalwork Wear Analysis

We have analysed all of the objects from the Czarków Hoard (excepting for axe 7092) for wear and divided them into the following categories associated with different stages of their 'lives':

● Production traces related to the casting process, such as casting seams, porosities, shrinkage cavities, or surplus material,

● Preparation for use, mainly actions performed to remove casting evidence and shape the objects, such as regular striations from grinding and hammering marks,

● Use-related wear connected to the direct usage of objects, such as striations on the cutting edges, blunting, chipping of blade tips, asymmetry of the body and the blade, fractures, and breakages.

We also identified a separate category for modern traces, associated with sampling, as well as corrosion, which hinders observation. The results of our observations are presented in detail in Table 3.

The casting seam is present on all 16 socketed axes; in ten cases, it has been removed from the blade sides, and in three, it has been additionally hammered. Traces of diagonal grinding are also present in these parts (Fig. 6: 1). Metal shrinkage cavities were observed on five objects, mainly in the central part of the blade. Material deficit in the form of holes is present on eight objects, mainly on the body below the loops (on two objects)

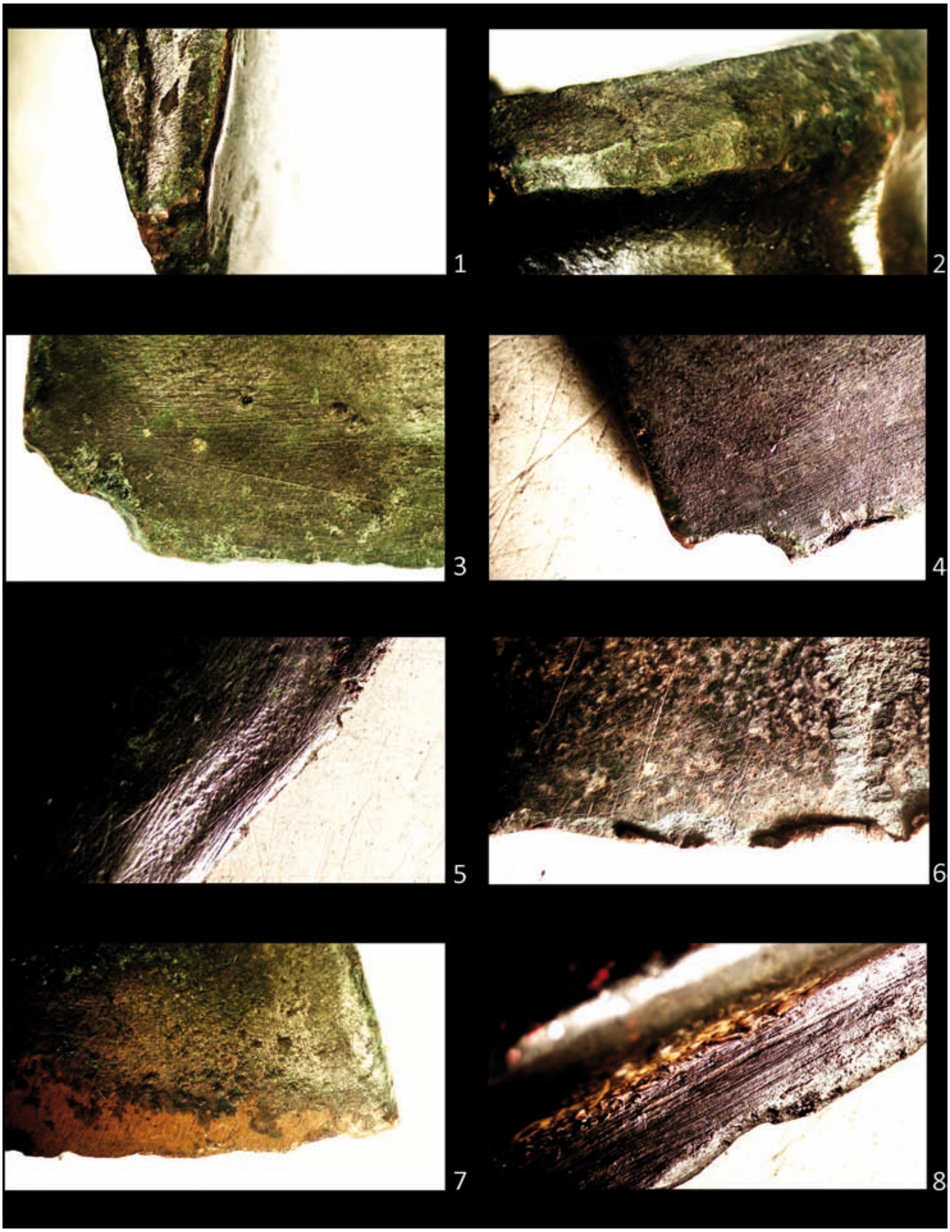

Fig. 6. Manufacture and use-wear traces observed on the artefacts from the Czarków hoard:
1 – worn casting seams on the side of the axe with traces of diagonal grinding; 2 – traces of hammering the edge of the socket; 3-4 – broken edge of the blade and transverse striations (grinding); 5 – minor diagonal striations and fractures in the edge of the blade; 6 – wrapped metal of the edge of the blade; 7 – regular diagonal striations accompanied by worn patina and exposed metal core as a result of modern activities; 8 – striations on the spearhead and fracture of the leaf (photo: K. Nowak, prep. D. Sych)

Fig. 7. Traces of hammering observed on the blade, side and socket on the Axe no. B.809.4062 from the Czarków hoard (photo: K. Nowak, prep. D. Sych)

Fig. 8. Traces of the modern use of Axe no. B.811.4064, indicated by the lack of patina and a visible metallic core – a blunt blade resembling the edge of a narrow hammer (photo: K. Nowak, prep. D. Sych)

and in the socket area (on six objects). Porosity from casting on sockets has been recorded on three axes.

Traces related to preparation have been recorded on all 16 objects. On ten axes, hammering marks were recorded around the socket rim area (Fig. 6: 2) and on six on the blade (Fig. 7). Parallel striations associated with grinding were observed in 12 cases, mainly around the blade area (Fig. 6: 3, 4). However, it must be noted that other finishing processes, such as polishing or corrosion, can obscure both hammering marks and grinding striations.

Use-related wear is present on eleven socketed axes. One of the most common types of damage is chipping of one or both blade tips, which occurred six times (Fig. 6: 3, 4). It is also possible that the chipping is related to the activities associated with fragmenting the axes. Blunting of the tip was observed in one case. Parallel striations on the blade, which could be the result of use and (re)sharpening, were recorded on three objects. A fracture of the blade tip was recorded once. Breakage of the socket and central part of the cutting edge occurred once too (Fig. 6: 5). In one case, the metal on the blade tip was folded (Fig. 6: 6). Only one of the socketed axes displays an apparent asymmetry of the blade from intense use and (re)sharpening in the past. As with grinding and hammering, some use-related wear can be obscured by patina and corrosion concretions. Wear patterns observed on the axes are consistent with timber working (Kienlin and Ottaway 1998; Roberts and Ottaway 2003; Dolfini *et al.* 2023; Nowak *et al.* 2023). However, the possibility of working with other materials cannot be excluded.

Modern traces can usually be recognised by the lack of patina or a different patina colour (Fig. 8). Drilled holes from sampling inside the socket, in the upper part, are barely visible in 15 cases. In four instances, unpatinated striations were recorded, probably from modern cleaning (Fig. 6: 7). Other modern damage includes chipping of blade tips in four cases, as well as notches in another three, blunting of the cutting edge in three, and flattening of the cutting edge in one.

Two socketed axes of Middle Danube type from the assemblage exhibit casting evidence in the form of residual casting seams and short fills on the sockets. One of the axes is distinctly asymmetrical, likely due to past (re)sharpening and use. The cutting edge of the second axe appears to have been cleaned, making it difficult to determine whether the visible traces are original or the result of later interventions.

The tanged sickle with a rib exhibits a single casting-related feature, a short fills on the tang. Pronounced striations running in various directions suggest that they were formed during the (re)sharpening process. The presence of a folded cutting edge and micro-notches indicates wear consistent with intense past use.

The socketed spearhead displays use-related wear in the form of notches and longitudinal striations on the blade from (re)sharpening (Fig. 6: 8). However, the cutting edges are affected by corrosion, making it uncertain whether some of the observed damage resulted from post-depositional processes.

Table 3. Results of use-wear analyses

Inv. No.	Production	Preparation	Use-wear	Modern traces	Add Inf
B.801:58/4054	**Casting Seams** preserved on both sides. **Deficit Material** two holes in the body below the loop.	**Grinding** striations on the blade, oblique to the cutting edge (partially obliterated). **Hammering** of the blade (more visible on the sides).	N/A	N/A	**Corrosion** Cutting edge heavily corroded.
B.802:58/4055	**Casting Seams** preserved on both sides, removed from the blade.	**Hammering** of the blade (more visible on the sides) and socket's rim. **Grinding** striations on the blade parallel to the cutting edge.	**Chipping** one of the blade's tips.	**Sampling** hole inside the socket (preserved).	**N/A**
B.803:58/4056	**Casting Seams** preserved on both sides. **Deficit Material** hole in the socket. **Porosity** on the socket.	**Hammering** of the blade (on the sides more visible).	N/A	**Striations** perpendicular to the cutting edge. No patination on the cutting edge points to modern origin. **Chipping** one of the blade tips. **Blunting** of the blade edge. **Removing of patina** cuttng edge **Sampling** hole inside the socket (preserved)	
B.804:58/4057	**Casting Seams** preserved on both sides, partially removed from the blade and hammered. **Casting** shrinkage cavity in the middle of the blade (obliterated).	**Grinding** striations on the blade parallel to the cutting edge (front, back and sides). **Hammering** of the blade and the socket's rim.	**Chipping?** one of the blade's tips.	**Sampling** hole inside the socket (preserved)	

B.805:58/4058	**Casting Seams** preserved on both sides, removed from the blade. **Deficit Material** hole in the socket.	**Hammering** of the blade (more visible on the sides) and socket's rim. **Grinding** parallel striations on the blade.	**Chipping** one of the blade's tips.	**Chipping** one of the blade's tips. **Blunting** of the blade's edge. **Sampling** hole inside the socket (preserved)	**Corrosion** Cutting edge heavily corroded.
B.806:58/4059	**Casting Seams** preserved on both sides, removed from the blade. **Deficit Material** irregular hole in the socket. Shape suggests it has been also cracked.	**Hammering** of the blade and the socket's rim.	N/A	**Sampling** hole inside the socket (preserved)	**Corrosion** Cutting edge heavily corroded
B.807:58/4060	**Casting Seams** preserved on both sides, removed from the blade. **Casting** shrinkage cavity in the middle of the blade (obliterated). **Porosity** on the socket.	**Hammering** of the blade (on the sides more visible) and socket rim. **Grinding** striations on the blade parallel to the cutting edge.	**Strations?** Oblique to the cutting edge (near edge) - resharpening?	**Notches** on the cutting edge **Sampling** hole inside the socket (preserved)	
B.808:58/4061	**Casting Seams** preserved on both sides, removed from the blade. **Casting** shrinkage cavity in the middle of the blade.	**Hammering** of the blade (front, back and sides). **Grinding** striations on the blade, parallel to the cutting edge.	**Blunting** of the blade's tip.	**Sampling** hole inside the socket (preserved)	**Corrosion** Cutting edge heavily corroded

Inv. No.	**Production**	**Preparation**	**Use-wear**	**Modern traces**	**Add Inf**
B.809:58/4062	**Casting Seams** preserved on both sides, removed from blade.	**Hammering** of the blade and the socket's rim. **Grinding** striations on the blade, parallel to the cutting edge	**Asymmetry of the cutting edge** due to use and (re)sharpening.	**Sampling** hole inside the socket (preserved)	**Corrosion** Cutting edge heavily corroded
B.810:58/4063	**Casting Seams** preserved on both sides, removed from the blade.	**Hammering** of the blade and the socket's rim.	N/A	**Notches** on the cutting edge **Sampling** hole inside the socket (preserved)	**Corrosion** Cutting edge heavily corroded
B.811:58/4064	**Casting Seams** preserved on both sides, removed from the blade. **Deficit Material** one hole in the socket.	**Grinding** striations on the blade, parallel to the cutting edge. **Hammering** of the blade (almost obliterated).	**Chipping** one of the blade's tips.	**Striations** perpendicular to the cutting edge. No patination on the cutting edge points to modern origin. **Flattened** cutting edge. **Chipping** one of the blade's tips. **Sampling** hole inside the socket (preserved)	It is difficult to distinguish modern traces from prehistoric ones **Elemental composition** EMPA
B.812:58/4065	**Casting Seams** preserved on both sides, hammered on the blade. **Casting** shrinkage cavity in the middle of the blade. **Deficit Material** two holes in the socket.	**Hammering** of the blade and the socket's rim.	N/A	**Striations** perpendicular to the cutting edge (modern resharpening?). No patination on the cutting edge points to modern origin. **Sampling** hole inside the socket (preserved)	**Elemental composition** EMPA

B.813:58/4066	**Casting Seams** preserved on both sides, removed from the blade.	**Grinding** striations on the blade parallel to the cutting edge. **Hammering** of the blade and the socket's rim.	**Chipping** one of the blade's tips. **Fracture** one of the blade's tips. **Striations** irregular (perpendicular and oblique to the cutting edge).	**Sampling** hole inside the socket (preserved).	**Corrosion** Cutting edge heavily corroded. **Elemental composition** EMPA
B.814:58/4067	**Casting Seams** preserved on both sides. **Deficit Material** hole in the socket. **Casting** shrinkage cavity in the middle of the blade. **Porosity** on the socket.	**Hammering** of the blade (on the sides more visible).	**Striations** oblique and perpendicular, erased by transverse striations (grinding/sharpening) near the cutting edge.	**Chipping and blunting** one of the blade's tips. **Sampling** hole inside the socket (preserved)	**Elemental composition** EMPA
B.815:58/4068	**Casting Seams** preserved on both sides, removed from the blade.	**Hammering** of the blade and socket's rim. **Grinding** striations on the blade parallel to the cutting edge.	**Breakage** part of the socket. middle part of the cutting edge.	**Notch** may be modern due to lack of patination. **Sampling** cut for metallography(?); hole inside the socket (preserved).	**Elemental composition** EMPA
B.817:58/4070	**Casting Seams** preserved on both sides, removed from the blade. **Deficit Material** hole in the socket.	**Hammering** of the blade and the socket's rim. **Grinding** striations on the blade parallel to the cutting edge (highly obliterated by obligue striations).	**Chipping** one of the blade's tips.	**Sampling** hole inside the socket (preserved)	**Elemental composition** EMPA

Overall, the socketed axe assemblage from the Czarków hoard displays fairly uniform wear patterns related to its production, preparation, and use. Most casting traces were only partially removed through grinding and hammering, sufficient to ensure the tools' functionality, while aesthetic considerations appear to have been secondary. The tools were either minimally used or regularly maintained in the past, as suggested by the limited damage observed on their cutting edges. However, some traces of wear may have been obscured by corrosion or conservation processes (Sych *et al.* 2020). All Lusatian-type axes underwent plastic working (hammering) to enhance the hardness and durability of their blades, intended for demanding tasks such as timber work. These procedures caused deformation of the lower blade sections, whereas the upper parts of the axes remained largely unmodified. Macroscopic observations reveal a high degree of similarity among these axes in the shape of the upper socket, loop, and ornamentation. Notably, a recurring concavity is visible on one side of most Lusatian-type axes, located just below the ornament (Figs 2 and 3). This feature may result from insufficient molten metal volume during casting or from design errors in the pouring system. In terms of manufacturing quality, the axes are well-made and fully functional, aside from isolated casting defects in the socket or loop areas. Some blades exhibit distinct damage, particularly at the edges, including broken tips. This is observed in several Lusatian-type axes and one Middle Danube-type axe. Additionally, broken loops are present on the Middle Danubian specimens. Damages are likely due to intentional fragmentation, possibly related to deposition rather than use. Transverse striations, commonly located in the lower blade sections, suggest that many axes were sharpened shortly before deposition, imparting or restoring their functional properties just prior to being buried. This supports the interpretation that these were usable tools, deliberately removed from circulation and placed into the ground.

CONCLUSIONS

One of the main types of Lusatian socketed axes was named after the hoard from Czarków. The research presented in this article contributes to a deeper understanding of the hoard, offering valuable data on the deposited artefacts and their individual biographies.

The Czarków hoard comprises a significant assemblage of metal artefacts from the Late Bronze Age. It was discovered accidentally in an agricultural area and, according to the discoverers, included 21 artefacts deposited within a ceramic vessel, which has not survived to the present day. This study is the first to examine in detail the circumstances of the hoard's discovery. Beyond typological and chronological classification, the metal objects discovered in 1875 have not previously been subjected to detailed elemental or metalwork-wear analyses.

Our research indicates that the artefacts were manufactured from tin bronze with a low tin content and in many cases similar levels of impurities (As, Ag, Ni, Sb). The elemental composition and correlations among specific elemental ratios (Sb-Ni, As-Ni, Ag-Ni) suggest that some typologically local artefacts – Lusatian-type socketed axes – and stylistically foreign objects may have been produced from a similar alloy, probably from copper of common origin. However, this cannot be conclusively confirmed with the analytical methods used. Our next step will be to conduct stable lead isotope analysis (using Multi-collector Inductively Coupled Plasma Mass Spectrometry – MC-ICP-MS) to determine the source of the copper, which will allow us to draw more specific conclusions about the metal's origin.

A highly plausible, though still open, hypothesis is that foreign artefacts may have been recycled to produce the stylistically local axes. Such a practice would not have been exceptional in prehistory. The cargo of the Langdon Bay shipwreck in the United Kingdom contained objects dated to the Middle Bronze Age (1300-1100 BCE). Most belonged to types typical of northern France and southern England, or to types unknown on the British side of the Channel. It is presumed that the metal was transported as complete objects and fragments and subsequently remelted according to local patterns (Garrow and Wilkin 2022, 26-218). Should this hypothesis be confirmed by the study of further assemblages, it could be suggested that locally-styled axes, such as those from the Czarków hoard, had the capacity to contribute to the construction of both personal and collective identity.

The similarity in the dimensions and weights of the objects, which may indicate casting using the same mould, implies deliberate selection, a conclusion further reinforced by their chemical composition. Moreover, the alloy used to produce the axes was not optimal for everyday tasks in terms of physical properties. This may have resulted from either tin shortages or limited casting expertise. It must also be considered that we may be projecting modern scientific expectations onto past societies, and that such factors may not have been as crucial to them as they appear to us.

Detailed wear analysis has enabled the reconstruction of the production process and an assessment of the functionality of the artefacts. All exhibit evidence of casting in a bivalve mould and finishing by hammering. They also show traces of use, such as notches on the cutting edge, transverse striations, and (re)sharpening striations. These used axes, and in some cases partially restored (via grinding), were withdrawn from circulation for reasons known only to those responsible for their deposition. Wear traces, both production- and use-related, are comparable to those observed on socketed axes of the Czarków type from other contemporary hoards, such as Karmin I-IV (Baron *et al.* 2019).

Observations from both specialist analyses and experimental studies clearly demonstrate that axes – not only those of the Late Bronze Age but also earlier examples – were versatile tools, a kind of Swiss Army knife of their time. They had the capacity to transform the landscape, being used both for clearing woodland and for more precise work with wood, bone, and antler, underlining their ability to transform matter. The literature also suggests their use in metallurgy as anvils (Fregni 2014, 69). Nor should it be forgotten that axes were among the finds from the battlefield on the River Tollense – palstaves have been identified at this Late Bronze Age site in Germany (Inselmann *et al.* 2024). This allows us to argue that they were also successfully used as weapons.

The picture that emerges is of axes as objects with capacities to transform matter and the landscape, to inflict violence, and to contribute to the creation of identity. This renders them truly exceptional and important for prehistoric communities and makes the Czarków hoard itself even more significant than previously thought.

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GEOMETRIC MORPHOMETRIC DIVERSITY OF BRONZE AXES FROM THE LUSATIAN URNFIELD CULTURES HOARD FROM ROSKO (NORTH GREATER POLAND)

ABSTRACT

Pawlina A., Hałuszko A. and Maciejewski M. 2025. Geometric morphometric diversity of bronze axes from the Lusatian Urnfield cultures hoard from Rosko (north Greater Poland). *Sprawozdania Archeologiczne* 77/1, 267-284.

The hoard from Rosko (Site 47, Wielkopolskie Voivodeship, Czarnków-Trzcianka district) contained at least 71 bronze artefacts, mainly socketed axes, and is dated to HaB2-HaB3. This study focuses on analysing the shape of the axes, evaluating their morphological differenc Geometric morphometric diversity of bronze axes from the Lusatian Urnfield cultures hoard from Rosko (north Greater Poland) Afiliacja Haluszkoes, and assigning these artefacts to the currently accepted typological classification by Kuśnierz. Absolute measurements and photographic documentation were required for geometric morphometric method (GMM) analyses, conducted on 66 axes. A key objective of the study was to compare the outcomes of GMM analyses using the landmark and outline methods. The results revealed intra-typological differences among the Czarków type axes, variant C, suggesting that the casts were likely made using more than one mould. Variations in shape, production techniques, and usage indicated that the axes could not be unanimously traced back to a single casting mould.

Keywords: hoards, Bronze Age, Lusatian Urnfield cultures, geometric-morphometric method, socketed axes
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INTRODUCTION

The conventional approach to describing archaeological artefacts and establishing their typologies is based on factors such as length, width, angles and shape in general (*e.g.*, oval, triangular) (Wilczek 2017, 19). Such classifications, however, are often subjective and inconsistent, with feature descriptions remaining vague. The geometric morphometric method (GMM) was initially developed in the biological sciences (Brandt *et al.* 2023). It involves analysing shape variables and processing these data (Slice 2005, 5) using either two-dimensional or three-dimensional input. Statistical procedures for testing and visualising shape differences (Rohlf and Marcus 1993, 129) offer insights distinct from those derived through absolute measurements. GMM should not replace typology but serve as a tool to test typological findings in specific cases.

The current classification of socketed axes is based on typological analyses of approximately 900 bronze items discovered within modern-day Poland (Kuśnierz 1998). In his work, Kuśnierz highlights subtle differences in collar height between the Czarków and Przedmieście type axes, illustrating the challenge of distinguishing between types with only minor variations. Key features enabling differentiation include the shape of the cutting edge, the width of the socket mouth, and the shape (Dąbrowski 1968, 35; Kaczmarek 2002, 96). Kuśnierz's (1998) classification also considers variant-specific characteristics, such as the ornamentation of these artefacts. The Przedmieście type axes, for instance, are divided into eight variants (A–H) based on this criterion, *i.e.* features like straight or fan-shaped groove arrangement (Kuśnierz 1998, 48, 49).

This study aimed to determine whether 2D GMM analysis enables the identification of inter- and intra-typological variation in the Rosko axes. Key features of these axes, including the cutting edge, loop, and socket mouth, were closely examined to assess any significant morphological differences. Additionally, the study sought to identify which axes were most similar to each other, potentially indicating production from the same casting mould. It also explored whether variations in the shapes of the cutting edges could result from the use of the axes. The largest groups of axes, the Czarków type, variant C, and the Przedmieście type, variant E, were analysed to determine if any other distinctions beyond collar height and grooved decoration could be used to differentiate these two types. Another research objective was to assess the comparability of results obtained through different 2D GMM analysis methods, specifically the landmark and outline approaches. The Rosko hoard was chosen for study due to the large number of similar and metrically consistent artefacts found within a single assemblage.

MATERIALS AND METHODS

The starting point for the 2D GMM analyses was the measurement and photographic documentation of axes held in the Stanisław Staszic Regional Museum's collection in Piła. Typological classification was based on the monograph of the assemblage (Machajewski and Maciejewski 2006). A total of 66 axes were published, which belong to: Czarków type, variant C (44 pcs), Czarków type referring to variant B (1 pc.), Czarków type, variant K (1 pc.), Kopaniewo type , variant A (1 pc.), Przedmieście type, variant D (1 pc.), Przedmieście type, variant E (17 pcs) and an axe with a heavily reduced cutting edge and richly decorated sides, variant A (*Tüllenbeile mit reich verzierten Breitseiten*; 1 pc.; similar artefacts are named differently in the various volumes of the *Prähistorische Bronzefunde* series: *e.g., Tüllenbeile mit öse und reicher leisteverzierung* in the case of Slovakia (Novotná 1970), *Tüllenbeile mit winkel- oderbogenverzierrung* in the publication of axes from Austria (Mayer 1977), for Hungary a complete typological division of this type of artefact has not yet been proposed) (Fig. 1). The styles of the individual axe types indicated their provenance from various regions of Central Europe, but most are typical in Greater Poland and Silesia (Machajewski and Maciejewski 2006, 143).

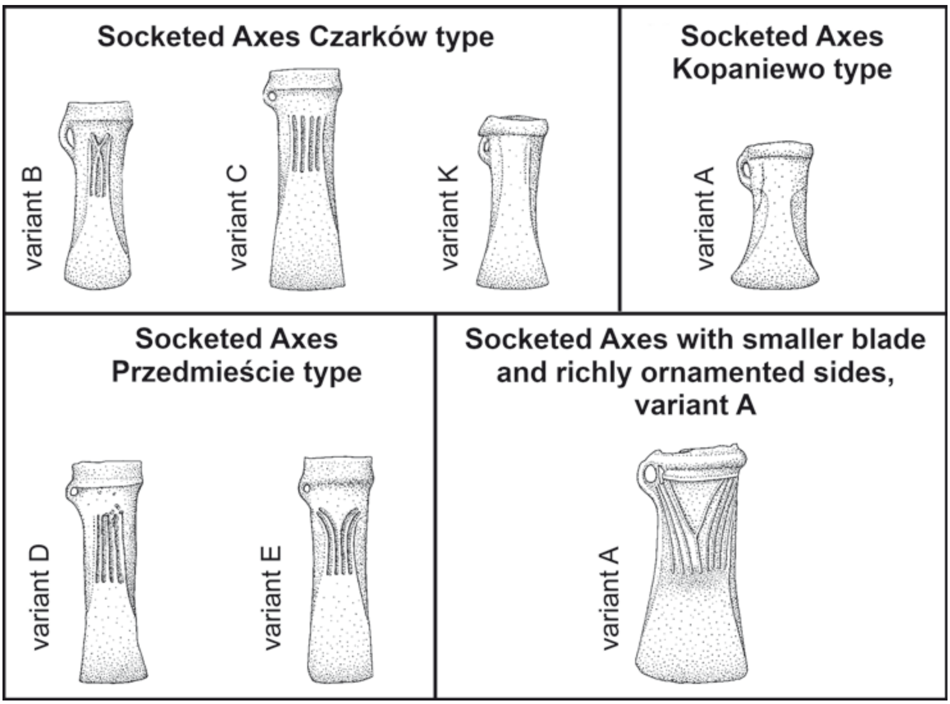

Fig. 1. Types and variants of Rosko axes included in the 2D GMM analysis (drawing by J. Kędelska; graphic editing by A. Pawlina)

Before conducting the 2D GMM analyses, all axes were measured with digital calliper to an accuracy of 0.02 mm. The measurements included the length and widths at various points along the axes. A total of 11 measurements were taken: the most excellent axe length (H), top width (S1), bottom width (S2), socket width (S3), width above the loop (S4), the section from the outermost part of the loop (S5), below the loop (S6), above the ornament (S7), the smallest axe width (S9), below the ornament/ribs (S8) and cutting-edge width (S10) (Fig. 2). Variations in absolute measurements and indices were statistically analysed for the most numerous axe types: Czarków type, variant C, and Przedmieście type, variant E. The nonparametric Mann-Whitney U test for two independent samples was used in the study. Single specimens represented the remaining axe types and were therefore excluded from these statistical analyses.

Only complete axes and those without significant damage were subjected to 2D GMM analysis, as their preservation status could affect the results. Three axes were excluded from further study due to their poor state of preservation: two of the Czarków type, variant C, and one of the Przedmieście type, variant E. These artefacts were the most damaged and incomplete. Following these exclusions, 63 axes were selected for analysis. The analyses employed both the landmark and outline methods, based on photographic documentation of the artefacts.

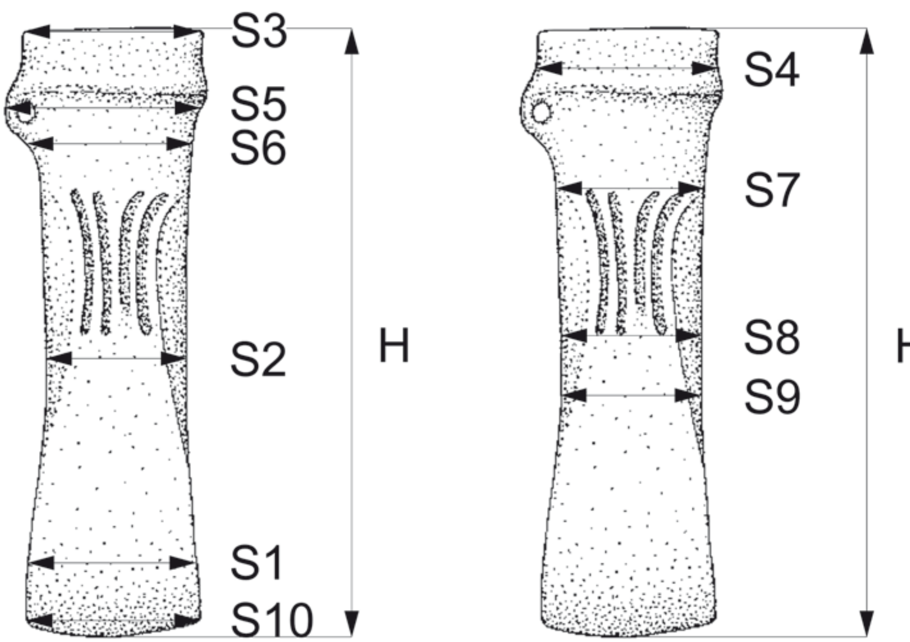

Fig. 2. Schematic representation of the applied absolute measurement method (drawing by J. Kędelska; graphic editing by A. Pawlina)

Fig. 3. Landmark configuration on Rosko axes used in the 2D GMM analysis (photo by M. Maciejewski; graphic editing by A. Pawlina)

Table 1. Landmark number 7. Description Central point at the top of the flange, located along the vertical axis of the axe, corresponding to their arrangement in Fig. 3

Landmark number	Description
1	Central point on the distal (cutting) edge of the blade, located at its midpoint. Serves as the primary reference for symmetry and as the starting point for outline-based shape analysis.
2,13	Lateral extremities of the cutting edge, marking the sharp tips of the blade. Define the maximum transverse extent of the edge.
3,12	Narrowest lateral points on the blade body, corresponding to the minimal width of the axe. These points reflect the medial constriction of the implement.
4	Point located directly below the socket loop, at the junction between the loop and the axe body. Marks the lower attachment of the loop.
5	Lateral-most point on the outer margin of the socket loop. Indicates the maximum projection of the loop from the axe body.
6,9	Upper lateral margins of the socket rim, corresponding to the widest part of the socket opening. Delimit the transverse extent of the mouth.
8	Central point at the base of the flange, positioned along the vertical axis of the axe. Defines the deepest part of the socket transition.
10	Lateral extremity of the flange's outermost contour, indicating the maximal outward projection of the flange.
11	Inferior point on the flange margin, located below point 10. Marks the lower termination of the flange.

The first step in the 2D GMM process involved digitally aligning the axes with respect to their axis of symmetry, with the cutting edge positioned downward and the loop on the left, following the standard methodology for 2D GMM (Serwatka 2020, 224; Wiśniewski *et al.* 2015, 13). The images were then converted into TPS files, and landmarks and outlines were applied using the open-access software TpsUtil and TpsDig2 (Rohlf 2021; 2022). A total of 13 landmarks were identified at characteristic points on all studied objects (Fig. 3, Table 1). These landmarks were selected based on their ease of localisation, consistent presence, and unambiguous placement across all axes. According to established guidelines in geometric morphometrics, landmarks should be homologous, reliably identifiable, and provide adequate coverage of the object's morphology (Bookstein 1997; Cardillo 2010).

Additionally, an outline of 100 points was created, starting from a point at the centre of the cutting edge. The raw data were further analysed statistically in the PAST programme (Hammer *et al.* 2001), beginning with a Procrustes transformation relative to the principal axis (Adams *et al.* 2004, 14,15; Serwatka 2020). This transformation standardised the sizes of the objects (Figs. 4 and 5), allowing for a comparative analysis of their shapes (Cooke and Terhune 2015, 6; Masojć *et al.* 2020, 27-32; Serwatka 2020, 225; Wiśniewski *et al.* 2015, 13). The final step in the process was to perform a principal component analysis (PCA).

All measurements and landmark points used for GMM analyses have been made publicly available on the Zenodo platform under DOI 10.5281/zenodo.16634500.

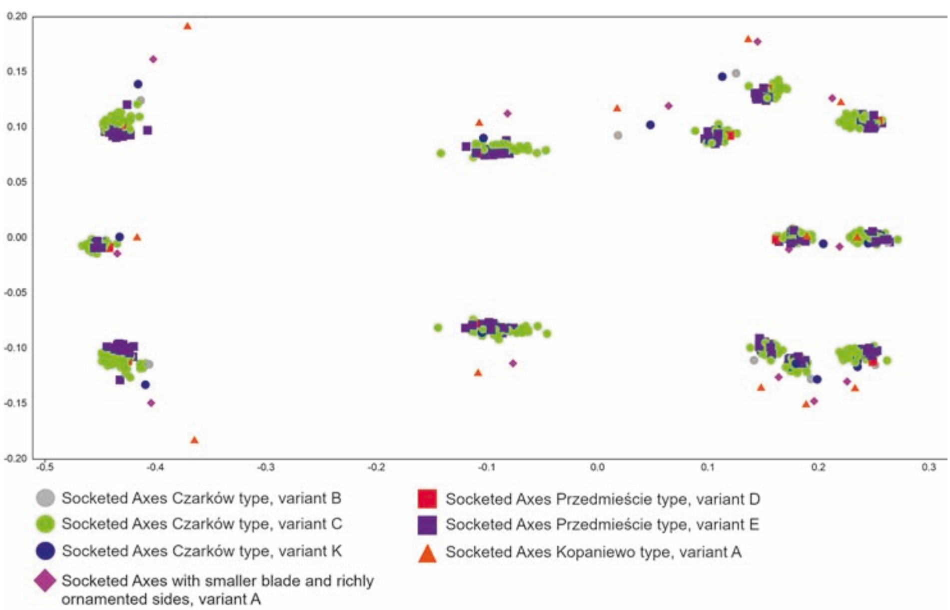

Fig. 4. Data processed by the landmark method after applying Procrustes transformation

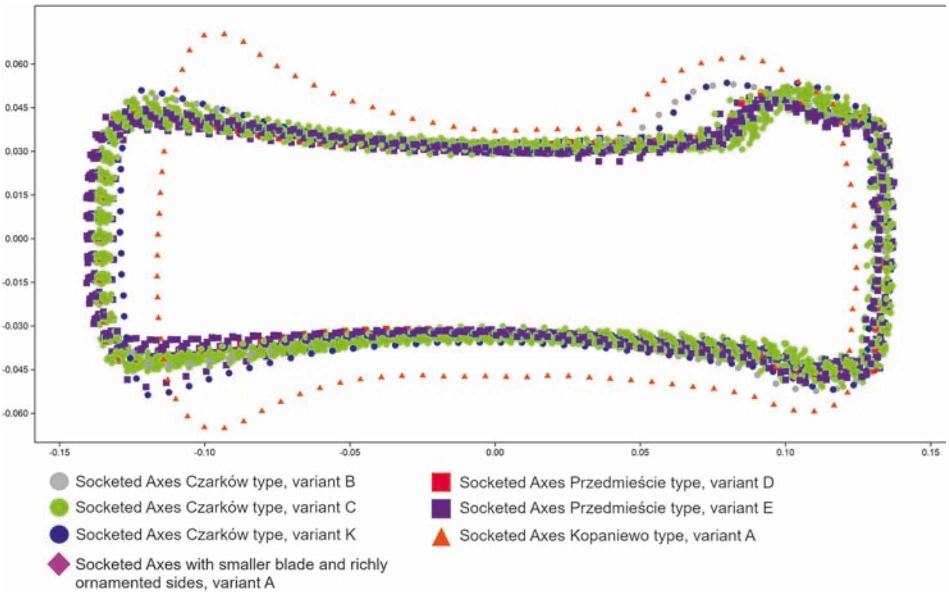

Fig. 5. Data processed using the outline method following Procrustes transformation

RESULTS

The tables summarising the absolute measurements for the Czarków type, variant C, and the Przedmieście type, variant E, indicate that the most significant differences in mean values between the two groups pertain to the S10 measurement, *i.e*. the cutting edge width (Table 2). Some standard deviation values are notably high. The highest standard deviation is observed for the height parameter (sd = 5.63 mm) in the Czarków type axes, variant C. At the same time, a lower value for the exact measurement is recorded for the Przedmieście type axes, variant E (sd = 3.32 mm). In addition to the height parameter, the standard deviation for S10 is high in both groups. The data show that, for most measurements, standard deviation values are lower for the Przedmieście type axes, variant E. However, exceptions include measurements S5 and S10, where the values are lower for the Czarków type, variant C. Regarding the median, the most significant differences between the two types are observed for measurements H, S2, S5, and S10. The highest values for measurements S1-S10 are found in the Czarków type axes, variant C, while the Przedmieście type axes, variant E, have higher results than the Czarków type only in the measurement of axe length. For width and length indices, the averages are consistently higher for the Czarków type axes, variant C (Table 3). Most standard deviation values are also higher for the Czarków type, variant C, except for the S2/H and S10/H indices. Notably, the highest standard deviation values are observed for S3/H (4.25 mm) and S4/H

Table 2. Absolute measurements [mm] for axes of the Czarków type, variant C, and the Przedmieście type, variant E. Abbreviations: n – number of observations; M – mean; sd – standard deviation; Me – median; min – minimum value; max – maximum value

Measured dimensions											
Czarków type, variant C											
	H	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
n	44	44	43	44	44	44	44	44	44	44	43
M	98.54	24.30	29.94	30.75	33.21	33.55	26.97	26.36	24.03	23.83	31.46
sd	5.63	0.58	0.92	1.32	1.29	1.12	0.85	0.85	1.52	0.74	1.55
Me	99.05	24.24	29.86	30.58	33.27	33.41	26.91	26.38	23.94	23.97	31.62
min	65.45	23.10	27.93	28.54	28.42	31.96	25.50	24.94	22.02	22.12	23.74
max	106.39	25.55	31.97	38.06	38.64	38.30	30.05	29.68	32.71	25.20	34.33
Przedmieście type, variant E											
	H	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
n	17	17	17	16	16	17	17	17	17	17	17
M	99.79	23.58	28.64	30.00	32.14	31.82	26.51	25.40	23.05	23.13	28.85
sd	3.32	0.52	0.78	0.37	0.45	1.89	0.64	0.61	0.43	0.39	1.86
Me	100.69	23.61	28.42	30.01	32.18	32.10	26.78	25.33	23.09	23.12	28.69
min	88.09	22.14	27.85	29.44	31.33	24.92	25.48	24.50	21.99	22.55	26.21
max	102.30	24.68	30.80	30.60	32.82	33.40	27.42	26.44	24.08	24.01	34.56

Table 3. Proportional indices of width and length for socketed axes of the Czarków type, variant C and the Przedmieście type, variant E. Abbreviations: n – number of observations; M – mean; sd – standard deviation; Me – median; min – minimum value; max – maximum value

Width and length indices										
Czarków type, variant C										
	S1/H	S2/H	S3/H	S4/H	S5/H	S6/H	S7/H	S8/H	S9/H	S10/H
n	44	43	44	44	44	44	44	44	44	43
M	24.76	30.16	31.43	33.92	34.25	27.53	26.91	24.47	24.27	31.99
sd	1.90	1.00	4.25	4.09	3.87	2.97	2.99	2.21	1.71	1.51
Me	24.51	29.95	30.84	33.61	33.73	27.04	26.45	24.08	24.11	31.87
min	22.99	28.40	28.27	28.38	31.97	25.15	24.63	22.01	21.77	29.27
max	36.03	32.73	58.15	59.04	58.52	45.92	45.35	34.31	34.07	36.27
Przedmieście type, variant E										
	S1/H	S2/H	S3/H	S4/H	S5/H	S6/H	S7/H	S8/H	S9/H	S10/H
n	17	17	16	16	17	17	17	17	17	17
M	23.64	28.76	29.85	31.98	31.87	26.59	25.48	23.12	23.21	28.98
sd	0.75	1.79	0.61	0.74	1.30	1.14	1.08	0.79	0.89	2.68
Me	23.50	28.16	29.69	31.86	31.85	26.57	25.23	22.98	22.97	28.47
min	22.84	27.53	28.97	30.83	28.29	25.10	24.43	22.11	22.22	26.04
max	25.76	34.45	31.84	34.24	34.47	29.87	28.39	25.14	25.59	36.08

(4.09 mm) in the Czarków type axes. Median values, too, are generally higher for the Czarków type, variant C.

For the absolute measurements, as well as the width and length indices for the Czarków type axes, variant C, and the Przedmieście type axes, variant E, a non-parametric Mann-Whitney U test was conducted for two independent samples (Tables 4 and 5), as only these artefacts were represented by more than one specimen. No significant statistical differences were observed only for absolute measurements for H and S6 (Table 4). For width and length indices, all differences were statistically significant. However, it is essential to interpret the statistically significant results in the context of the low and varied sample sizes, as well as the typologically significant variations in the absolute measurements of the two axe types.

The PCA performed on the data collected using landmarks produced a total of 26 principal components (PCs), with the first four PCs accounting for 90% of the variance (Table 6). The first two PCs described the majority of the variance (75.55%). A graph was generated for the data after the Procrustes transformation, on which all test objects substantially overlay each other (Fig. 4). The analysis highlights that particular axes stand out due to their distinct shapes: the Kopaniewo type, variant A, the axe with a significantly reduced cutting edge and richly decorated sides, variant A, and the Czarków type, variant K. These axes exhibit greater variance compared to other types, as indicated by their positions on the graph, appearing as outlier points spread out from other objects. The remaining axes form clusters at the designated landmarks, represented by the Czarków type, variant C and the Przedmieście type, variants E and D, whose variances are similar to each other. Significant differences are observed between the studied objects in specific elements, including the cutting edge, the socket mouth area, and the loops.

The PCA results obtained using the landmark method show that the majority of the Czarków type axes, variant C, and the Przedmieście type axes, variant E, are distributed along the axis of the second principal component (Fig. 6). Specimens located in the area of positive PC1 and negative PC2 values stand out from the other bronzes in this deposit. These include the axe with a strongly reduced cutting edge and richly decorated sides, variant A; the Czarków type axes, variants K and B; and the Kopaniewo type axe, variant A. A broader cutting edge, loop, or socket mouth characterises these specimens. This graph section also contains three Czarków type axes, variant C, and one Przedmieście type axe, variant E. The majority of Czarków type axes, variant C, are distributed along negative PC2 and positive PC1 values, as well as along positive values for both components. In contrast, most Przedmieście type axes, variant E, are positioned within the negative PC1 and positive PC2 value ranges. Additionally, the point representing the Przedmieście type axe, variant D, is located along the positive values of the PC2 axis.

PCA of the data collected using the outline method generated a total of 60 PCs, with the first four accounting for 90% of the variance (Table 7). The first two PCs filled 80.656% of the variance, prompting further analyses to focus exclusively on these components. The

Table 4. Non-parametric Mann-Whitney U test for absolute measurements of Czarków type, variant C axes (n=44) and Przedmieście type, variant E axes (n=17)

Width and length indices										
	S1/H	S2/H	S3/H	S4/H	S5/H	S6/H	S7/H	S8/H	S9/H	S10/H
U-Mann-Whitney	3.8447	4.3032	3.8369	4.3274	4.7295	2.1475	3.6357	3.9013	3.7805	4.3514
p-value	0.000121	1.68E-05	0.000125	1.51E-05	2.25E-06	0.031752	0.000277	9.57E-05	0.000157	1.35E-05

Table 5. Non-parametric Mann-Whitney U test for width and length indices of Czarków type axes, variant C (n=44) and Przedmieście type, variant E axes (n=17)

Width and length indices										
	S1/H	S2/H	S3/H	S4/H	S5/H	S6/H	S7/H	S8/H	S9/H	S10/H
U-Mann-Whitney	3.8447	4.3032	3.8369	4.3274	4.7295	2.1475	3.6357	3.9013	3.7805	4.3514
p-value	0.000121	1.68E-05	0.000125	1.51E-05	2.25E-06	0.031752	0.000277	9.57E-05	0.000157	1.35E-05

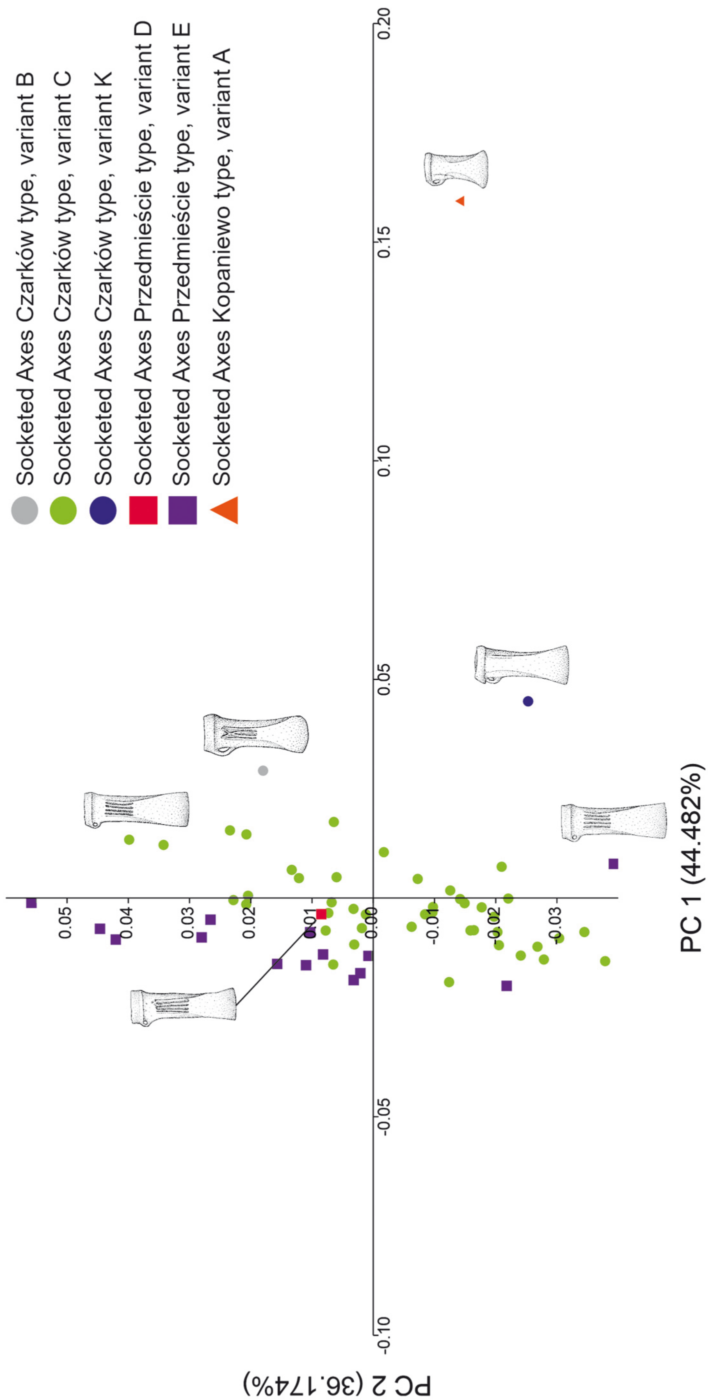

Fig. 6. Scatter plot of the first two principal components (PC1 and PC2) obtained using the landmark method

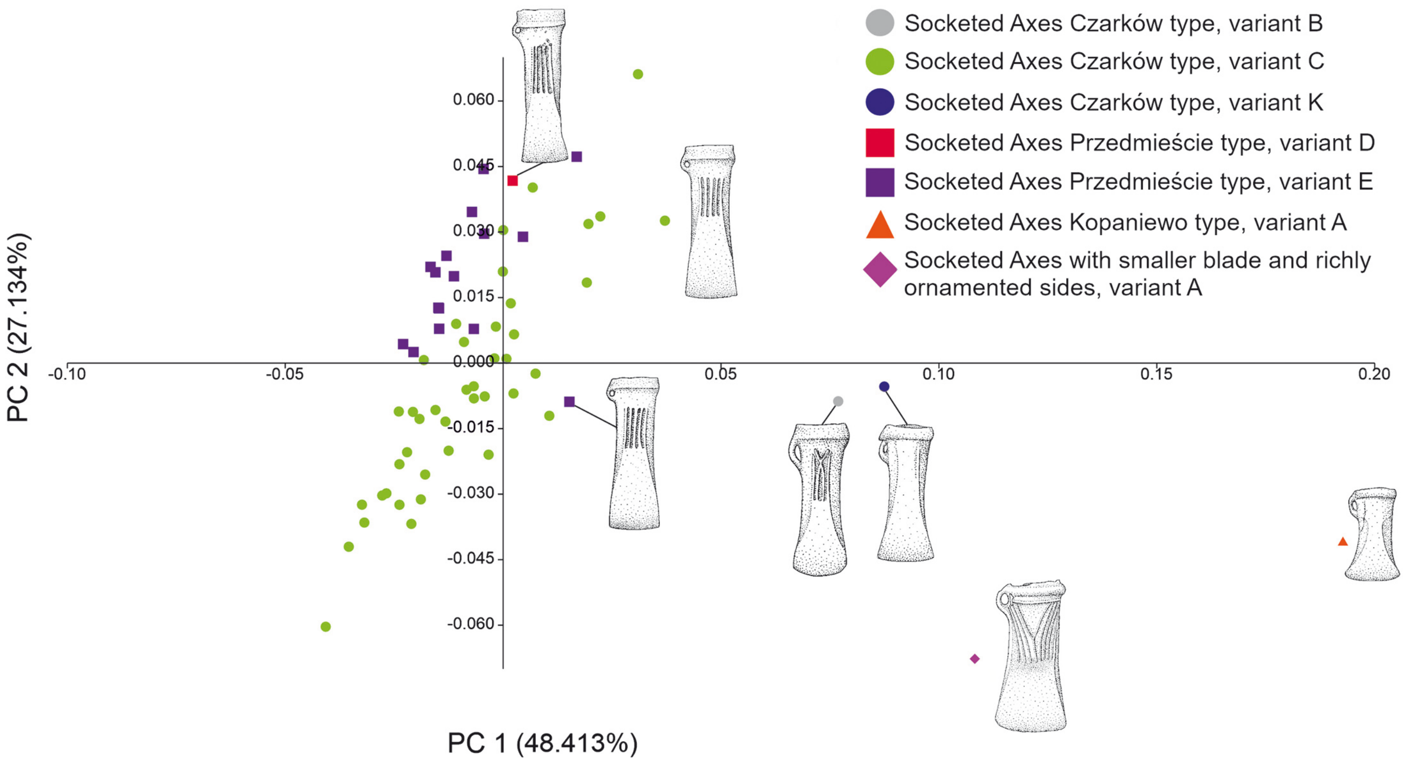

Fig. 7. Scatter plot showing the first two principal components (PC1 and PC2) derived from the outline method

Table 6. Percentage distribution of variance for the first 10 components from the entire dataset for the landmark method

PC	Eigenvalue	% of variance	% of cumulative variance
1	0.00130953	48.413	48.413
2	0.000733959	27.134	75.55
3	0.000289184	10.691	86.24
4	0.000127982	4.7314	90.97
5	4.59341E-05	1.6982	92.67
6	4.28205E-05	1.5831	94.25
7	3.42749E-05	1.2671	95.52
8	2.50288E-05	0.92531	96.44
9	1.79219E-05	0.66257	97.11
10	1.38117E-05	0.51061	97.62

Table 7. Percentage distribution of variance for the first 10 components from the entire dataset for the outline method

PC	Eigenvalue	% of variance	% of cumulative variance
1	0.000565763	44.482	44.482
2	0.000460091	36.174	80.656
3	8.14316E-05	6.4024	87.0584
4	4.45769E-05	3.5048	90.5632
5	3.22546E-05	2.5359	93.0991
6	1.87498E-05	1.4742	94.5733
7	1.0624E-05	0.83529	95.40859
8	8.81168E-06	0.6928	96.10139
9	7.69188E-06	0.60476	96.70615
10	7.41535E-06	0.58301	97.28916

outline method-based PCA revealed that particular axes exhibited significantly different shapes compared to other specimens (Fig. 7). As in the case of the landmark method, these are the following axes: the Kopaniewo type, variant A, with a strongly reduced cutting edge and richly decorated sides, variant A, and the Czarków type, variant K. The Czarków type, variant C and the Przedmieście type, variant E, share comparable features, though some differences are evident. Minor variations occur in the shape of the cutting edge, while more pronounced differences are observed in the loop area. For the Czarków type axes, the loop is slightly higher, and the transition from the loop to the socket mouth is smoother. Analysis of data concentration based on the first two PCs for the outline method shows the following patterns: axes of the Kopaniewo type, variant A and the Czarków type, variant K, are scattered apart from other specimens along the positive values of the PC1 axis. The Czarków type, variant C axes are primarily distributed along the PC2 axis, particularly at the negative values of PC1. Bronzes of the Przedmieście type, variant E, are positioned along the positive values of PC2. Notably, the axes of the Kopaniewo type, variant A, and Czarków type, variant K, appear in the lower part of the graph, along the positive values of PC1, and are positioned away from other axes. The Czarków type, variant B, is located in the upper part of the graph. The Przedmieście type axe is centrally positioned above the PC2 axis, amidst the axes of the Czarków type, variant C and Przedmieście type, variant E.

DISCUSSION

The results of the GMM analyses of the Rosko axes allowed us to answer the research questions posed at the beginning of the article.

The answer to the question regarding morphological differences in the characteristic points of the studied objects is twofold. The first part pertains to the following axes: Czarków type, variants B and K, Kopaniewo type, variant A, and the axe with a strongly reduced cutting edge and richly decorated sides, variant A. These specimens are represented by individual objects that stand out from the rest of the deposit. They feature wider cutting edges and socketed mouths. The point distribution on scatter diagrams from both the landmark (Fig. 6) and outline (Fig. 7) methods confirms their distinctly different shapes compared to the other artefacts. Notably, the Czarków type, variants B and K, despite belonging to the same type, do not resemble the Czarków type, variant C. The differences are evident in their socket decorations, which vary between variants, as well as in the distinct shapes of their loops and socket mouths. The second part of the answer concerns the differentiation among the remaining axes: Czarków type, variant C and Przedmieście type, variants E and D. The first two groups differ in several aspects. Apart from the previously mentioned socket ornamentation and collar height, the Czarków type, variant C axes have a visibly wider cutting edge and slightly greater width at the narrowest point. In contrast, the Przedmieście type, variant D axe closely resembles the Przedmieście type, variant E axes, differing mainly in ornamentation, which justifies their classification within the same type. Graphs generated after Procrustes transformation for both the landmark method (Fig. 4) and the outline method (Fig. 5) illustrate that the Przedmieście type, variant E and the Czarków type, variant C axes show variability within their respective types, with individual specimens differing significantly. This explains the scattered distribution of points in the scatter diagrams for both the landmark and outline methods. Notably, the Czarków type, variant C axes exhibit greater variation compared to the other groups.

The analysis of the axes concerning their potential production from the same casting mould should primarily focus on the Przedmieście type axes, variant E, and the Czarków type axes, variant C, as multiple specimens represent these groups. Two key features to consider are their external shapes and the ribs on the sockets, which vary between variants. The PCA scatter plots indicate that no points overlay altogether; some overlay only partially, making it impossible to conclusively determine whether the axes were produced in a single casting mould. Discrepancies are also evident in the absolute measurements of individual variants. These variations could have been influenced by post-casting modifications, such as the removal of sprues or seams, as well as the use of the axes. Analysis of the two most numerous axe groups revealed a high standard deviation for the measurements of the Czarków type, variant C, and a lower standard deviation for the Przedmieście type, variant E (Table 2), indicating greater dispersion of results around the mean for the former. Similar patterns were observed for width and length indices, with the Czarków type, variant C, showing higher standard deviation values compared to the Przedmieście type, variant E. PCA results confirm these differences between the two groups in both absolute measurements and indices, which explains the scatter of axes in the diagrams. An interesting feature highlighted in the PCA landmark analysis (Fig. 4) is the variation in flange height. As with other landmarks, this variation is reflected in the greater scatter of data points for the Czarków type axes, variant C.

The landmark and outline diagrams indicate that the shape of the cutting edge is characteristic of specific variants and is consistent for most of the Czarków type, variant C, and Przedmieście type, variant E axes (Figs 4 and 5). While some axes show damage to their cutting edges, this damage was probably not caused by use. The absence of significant similarities between the artefacts from both the Czarków type, variant C and the Przedmieście type, variant E, indicates that the axes from these groups were cast from more than one mould. Differences in their shapes were likely influenced primarily by post-production processes, such as the removal of casting overflows and casting jets, or the cold hammering of the cutting edges (*cf.*, Nowak 2018, 120). Notably, Przedmieście type axes were produced locally. In contrast, the Czarków type is characteristic of finds from Lower Silesia, indicating that communities from these two regions maintained contacts and suggesting that populations from the vicinity of modern Rosko were also part of this network (Machajewski and Maciejewski 2006, 144). This connection, however, is unsurprising given the intensity of interactions between Silesia and Greater Poland documented in various categories of archaeological sources (Kaczmarek 2012). Despite the observed overlap between the Czarków type, variant C, and the Przedmieście type, variant E series, it is essential to note that the 2D GMM analysis did not account for variations in socket ornamentation. This factor can significantly influence the typological classification of these artefacts.

The diagrams show (Figs 4, 5) that the shapes of the Przedmieście type axes, variant E, and the Czarków type, variant C – in addition to those noted by Kuśnierz (1998, 33-53) – also differ in the width of their cutting edge, which is narrower for the Przedmieście type, variant E axes. Additionally, the transition from the loop to the socket mouth is distinct between the two types. This section is straight for the Czarków type, variant C, whereas the Przedmieście type exhibits a gentler, curved shape. The internal variation within these types presents challenges. Landmark method analysis of the Przedmieście type axes (Fig. 4) indicates greater homogeneity within this group, as the points on the diagrams are closely clustered. In contrast, the Czarków type, variant C, demonstrates more variation in the assigned landmark points. Outline method analysis of the overall shapes (Fig. 5) indicates that some axes feature a lower loop position and a differently shaped sleeve orifice. The greater variation in the Czarków type, variant C, is confirmed by the high standard deviation values for absolute measurements, as well as width and length indices (Tables 2 and 3). By comparison, these values are generally lower for the Przedmieście type, variant E. The issue of internal variation, particularly for the Czarków type, variant C, requires further investigation. A study involving a larger sample of artefacts from other sites of this period would be essential to resolve these questions.

The obtained results were made comparable by applying both the landmark and outline methods. Using the landmark method, 13 specifically located points were identified (Fig. 3), enabling a direct analysis of the characteristic features of the investigated objects. In contrast, the outline method allowed for the examination of individual artefacts as a whole set, facilitating the observation of overall shape similarities (Fig. 5).

The analysis yielded a different number of principal components, reflecting the morphological variation of the axes. PCA scatter plots confirm the distinctly different shapes of the Kopaniewo type, variant A axes, an axe with a strongly reduced blade and richly decorated sides, variant A, and the Czarków type, variants B and K. The differences between these and the other objects were also evident in absolute measurements (Machajewski and Maciejewski 2006). These specimens consistently appear apart from the clusters representing the more numerous artefacts. The Czarków type, variant C and Przedmieście type, variant E axes do not form specific, compact clusters in the diagrams, which may indicate internal variation within these variants. This variability complicates their assignment to particular types and variants, suggesting the influence of both technological processes and subsequent use. Some points on the scatter diagrams are very close to each other or partially overlap, indicating a high degree of similarity in certain features.

It should also be noted that post-production processes, such as the removal of casting seams shortly after moulding, may already introduce shape modifications perceptible to the highly sensitive GMM method. Furthermore, prolonged use, resharpening, or damage repair may lead to additional morphological alterations that accumulate over time. In the case of artefacts from Rosko, analyses of traces of production and use were also carried out. We plan to devote further publications to the integration of this data. In future studies based on substantially larger samples, these factors may prove to have a more pronounced impact, helping to disentangle production-related variation from use-related transformation. Such research is essential to refine our understanding of formal variability among socketed axes and to contextualise GMM results within the full life cycle of these tools.

The method chosen for conducting a 2D GMM analysis should be determined by the state of preservation of the investigated objects (Wilczek 2017, 24) and the study's objectives. In this case, the application of the landmark and outline methods enabled a 2D morphological analysis of the axes as complete artefacts, as well as a focused study of the points defining the height of the collar. A notable limitation of the 2D GMM approach was the exclusion of certain parts of the axes that could have distorted the final results. This issue affected only three artefacts in this study. Future research is planned using 3D scans and traceological analyses.

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MANUFACTURING TECHNOLOGY OF BANDED PSEUDO-SPIRAL BRACELETS IN THE LIGHT OF EXPERIMENTAL STUDIES AND COMPUTED TOMOGRAPHY

ABSTRACT

Sokół A., Maciejewski M., Szczepański Ł., Kosiński T., Tracz M. 2025. Manufacturing technology of banded pseudo-spiral bracelets in the light of experimental studies and computed tomography. *Sprawozdania Archeologiczne* 77/1, 285-303.

Knowledge of manufacturing technology of items from various raw materials not only allows for a better understanding of the spheres of human culture associated with their production but also provides a basis for further conclusions on the functioning of prehistoric communities. Copper-alloy objects might be examined using a wide range of archaeometallurgical methods. In this paper, we would like to focus on the manufacturing technology of banded pseudo-spiral bracelets, using an archaeological experiment, macro- and microscopic analyses of traces on copper-alloy items and computed tomography of artefacts from the Lubnowy Wielkie hoard, dated to the Late Bronze Age, Montelius' V period, as well as their reconstructions made during the experiment.

Keywords: Late Bronze Age, Early Iron Age, archaeological experiment, computed tomography (CT), use-wear analysis
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INTRODUCTION

Archaeological experiments have recently been gaining popularity as a tool for enhancing our understanding of past technological processes. Studying copper-alloy objects is no exception. In the literature, numerous examples of successful experiments can be found that reconstruct procedures used at various stages of production or that elucidate the technological traces visible on artefact surfaces. Observations of the technology used to make metal objects can also provide insight into contacts between particular areas, reconstruct methods of knowledge and skill transfer, and reveal the social role and position of those possessing the know-how. Such studies are part of the archaeology of skills strand (Gener 2011; Kuijpers 2018; Nørgaard 2018; Nowak and Sych 2024).

The archaeological experiment described below aimed to clarify and understand the process of making banded pseudo-spiral bracelets (Fig. 1: 1-6). Various nomenclatures regarding the investigated artefact category occur in the subject literature. The objects in question have sometimes been called banded pseudo-spiral and longitudinally-grooved bracelets (Podgórski 1982, 228). The possibility of forge welding has been suggested for similar (although not identical) accessories (Blajer and Chochorowski 2015, 46; Bugaj *et al.* 2017, 22). Forge welding, also called fire welding, is defined as a solid-state welding process that joins two pieces of metal by heating them to a hot-working temperature range and then creating enough pressure to cause plastic deformation at the weld surfaces (Sharma 2014, 369). Metals such as copper, bronze and brass do not forge weld readily. Although it is possible to forge weld copper-based alloys, it is often with great difficulty due to copper's tendency to absorb oxygen during the heating. To date, no evidence exists of this technique being available in the Late Bronze and Early Iron Age (LBA-EIA) in the area occupied by the Lusatian Urnfield cultures. Above all, it requires the use of substances that prevent the formation of oxides on the heated metal's surface, which would hinder two or more pieces from welding together. These findings suggest searching for a solution by using another technology.

The literature also indicates that items of this type were cast and that the imitation of coiling was intended to refer to earlier wire specimens (*e.g.*, Kaczmarek *et al.* 2021, 99). However, a deeper reflection on the details of this process is lacking.

It was, thus, reasonable to attempt to reconstruct the *chaîne opératoire* leading to the final product and examine the traces indicating the solutions used at the object's various manufacturing stages.

The idea to experimentally verify the hypothesis that banded pseudo-spiral bracelets were made using the lost wax technique and that the wire-like form was obtained using long and thin wax rods came about during one of the meetings of the 'Working group on the phenomenon of mass goods deposition' ('Zespół badania zjawiska masowego deponowania dóbr' – for details on this working group, see Maciejewski *et al.* in press). The inspiration came from the cross-sections generated using computed tomography (CT).

Fig. 1. Lubnowy Wielkie hoard, banded pseudo-spiral bracelets (1-6), and their reconstructions cast for research (7-10), ribbed neck-ring (11), cuff bracelet (12), and binocular pendant (13). 1-2, 11-13: drawn by N. Lenkow, 3-6: photos by M. Maciejewski, 7-10: photos by A. Mazurek

They strongly resembled the structure of interconnected wires. The scans were made as part of the project: Techniques of Ornamentation on Late Bronze Age Metal Objects Based on Artefacts from the Lubnowy Wielkie Hoard (Cast or Applied?) ('Techniki wykonywania ornamentów na ozdobach z późnej epoki brązu na przykładzie zabytków ze skarbu z Lubnowy Wielkich (odlewane czy aplikowane?') carried out as part of the second call for projects for access to the MOLAB/FIXLAB PL research infrastructure offered by the E-RIHS PL consortium (Maciejewski 2017).

Based on images generated during the CT scans, it has been hypothesised that the bracelets were produced using the lost-wax casting method, partly employing long, thin rods that mimic wires. To verify this hypothesis, an experiment and accompanying analyses were planned.

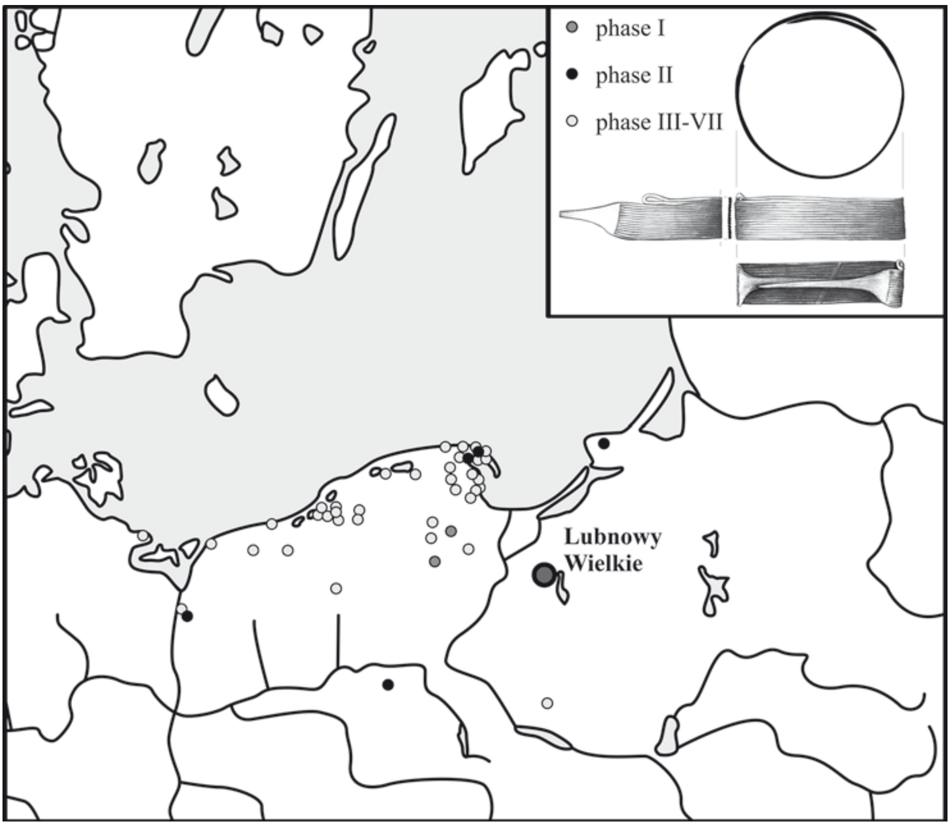

Fig. 2. Map of the distribution of banded pseudo-spiral bracelets. Based on Fogel 1988, with additions. Drawn by M. Maciejewski

NOT ONLY BRACELETS – A SHORT PRESENTATION OF THE LUBNOWY WIELKIE HOARD

The bracelets whose manufacturing technology constitutes the focus of this study formed part of the Lubnowy Wielki hoard, which has not yet been published; therefore, only the most essential information is presented here. The hoard was discovered in late April 2017 during a metal detector survey conducted under a permit issued by the Voivodeship Heritage Protection Officer. The place of its discovery is located in Powiśle, near Ostróda, NE Poland. This is approximately 30 km east of the Vistula, which at that time constituted a significant boundary between cultural traditions, although various traditions intermingle in this area (Bukowski 1998; 2020; Żórawska 2000, 63). The artefacts were handed over to the Museum in Ostróda. The hoard comprised five items, found at a depth of *ca*. 50 cm and arranged in a way suggesting their intentional deposition. The assemblage may be dated to Montelius' V period (see below) and may have been a set of dress accessories belonging to one or two individuals. They have parallels in the South Baltic area, particularly in Pomerania. A comprehensive research programme has been designed for the hoard, including typical work such as conservation, the creation of graphic records, and typological analysis, as well as several other recording and research activities. Attempts were made to carry out three-dimensional recording using photogrammetry, analyse the chemical composition of the alloys from which the artefacts were made, and conduct microscopic documentation before and after conservation (*cf*., Sych *et al*. 2020), as well as analyse these images. The list is completed by examinations with a CT scanner and a settlement analysis of the area around the hoard discovery site. Of course, the presented experimental studies also became part of this informal project. The overall conclusions of this study have not yet been published.

Banded pseudo-spiral bracelets are relatively common in Pomerania and adjacent areas. They are meant to imitate earlier bracelets made of double wire, which were coiled. These simple items occur in various regions. Some specimens from Pomerania, mainly western Pomerania, may have been imported from the Nordic area (the Oder variant). At the same time, in eastern Pomerania, they were thought to have been developed locally (the Vistula variant). In connection with this, banded pseudo-spiral bracelets may have been developed, and their earliest forms are known only from the Kashubian Lake District (Fogel 1988, 20-29). This bracelet type was described in a work on Nordic imports of the Montelius V period (Fogel 1988), but it is not an import. According to Fogel's (1998, 24) division, specimens from the Lubnowy Wielkie hoard might be classified as originating from the second Wielkawieś development phase (Fig. 1: 1-6; 2).

In addition to the bracelets discussed above, the hoard also comprised three further ornaments. The first of these is an oblique ribbed neck-ring (*der steilen, gerippten Halskragen*; Fig. 1: 1 1). Fogel (1988, 59-61) described the Polish specimens as belonging to a single group. Nørgaard (2011, 73-76), however, proposed distinguishing three types according to the number of ribs. Within this typology, the artefact from Lubnowy Wielkie can be classified as a Quedlinburg type. Both authors date these ornaments to Polish territory and to Montelius' Period V. Comparable artefacts are known from both northern Poland and northern Germany. Scholarly debate has raised different views concerning the origins, inspirations, and possible local development of the stylistic traits of these ornaments in Pomerania (see Fogel 1988, 56-61; Nørgaard 2011, 73-76). Definitive statements remain difficult, not least because such items are relatively rare and no identical forms are known. Overall, they belong to the broader tradition of massive neck ornaments widespread in the South Baltic area during the Bronze Age (see Nørgaard 2011).

The hoard also included a rather unique cuff bracelet (Fig. 1: 12), which is stylistically akin to the neck-ring but markedly different from the Nordic cuff bracelets of the Bronze Age (*e.g.*, Baudou 1960, 65, 66, pl. 13). Only a single comparable artefact is known, although it has since been lost, and the surviving drawing is not sufficiently precise to confirm any unmistakable resemblance. This concerns the bracelet from the Szylina Wielka hoard, which has been dated to Montelius' Period VI (*e.g.*, Dąbrowski 1968, pl. 18: 14; Dąbrowski 1997, 66).

The final element of the assemblage is a binocular pendant (Fig. 1: 13), a relatively common artefact in the Bronze Age and Early Iron Age (Dąbrowski 1968, 82, 83; Waluś 2014, 52, 53), which has no chronological value. Interestingly, it had been fastened onto one of the banded pseudo-spiral bracelets.

Taking all this into consideration, we suggest that the assemblage can be dated with considerable confidence to Montelius' Period V.

METHODS

The research methodology applied consists of an experiment in which replicas were produced (as described in greater detail below), a comparison of CT scans of the original artefacts and the replicas, and a comparison of traces observed on the artefacts and the replicas.

The archaeological experiment was conducted as a laboratory study, employing modern methods for mould firing and metal melting. A standardised copper alloy with specific parameters was also used – bronze designated as B10, which, according to the standards (norm EN 1652), should not contain, apart from tin, any additional elements exceeding 0.3% of the composition. The choice of these procedures was motivated by the desire to focus on a specific technological aspect – to confirm or falsify the hypothesis regarding the use of the lost-wax method in the production of the model. Efforts were also made to exclude variable factors that could occur in a field experiment and potentially disrupt observations and conclusions, *e.g.*, those related to the causes of defect formation, which could result from a lack of experience in using the reconstructed foundry workshop rather than the method of designing the model and the mould.

As previously mentioned, the inspiration for conducting the archaeological experiment stemmed from the CT results of the original artefacts. These investigations were conducted at the National Centre for Nuclear Research in Świerk using the Nikon Metrology XT H 225 ST, an instrument designed for detailed quality control. X-ray CT scans were also performed on specimens made during the experiment. In this case, a medical device (Toshiba Astelion TSX-034A) was used, with less power and resolution than the device from Świerk. The study was conducted under the current academic cooperation agreement between the Chair and Department of Forensic Medicine at the Medical University of Lublin and the Institute of Archaeology at the Maria Curie-Skłodowska University.

Microscopic observations of the surfaces of the original artefacts were carried out using a Dino-Lite portable digital microscope at magnifications of ×20-40, both before and after conservation. Photographic documentation was produced with a Canon EOS 100D (18 MPx APS-C sensor) with a Canon EF-S 18-55 mm f/3.5-5.6 IS lens.

The replicas of bracelets produced during the experiment were examined to identify traces of casting defects and post-casting metalworking treatments. A Nikon SMZ800N reflected light stereomicroscope was used for this purpose, equipped with a Plan Apo 1x WF WD: 70 mm lens, providing low magnifications (×10-30). The traces on the bracelets at each stage of production were documented using a Sony α7 camera with a SONY FE 90 mm f2.8 Macro G OSS lens.

EXPERIMENT

The experiment's starting point was macro-observations of traces visible on two specimens of banded pseudo-spiral bracelets from the Lubnowy Wielkie hoard. These were assessed as indicative of lost-wax technology (*e.g.*, casting defects in the form of excess material; Fig. 5: 2, 4, 6), but the artisan attempted to imitate a structure resembling welded wire while forming the model. The two examined specimens might be considered a pair, as they are, in a way, mirror images of each other in terms of the placement of the imitation of the wire loop. However, significant differences can be seen in the working of the inner surface. In one case, it is smooth, while in the other, it mimics welded wire on the outside. It was therefore decided to replicate the manufacturing stages for both specimens (Fig. 1).

At the very beginning of the experiment's planning, problems with raw material selection for models occurred. In archaeological literature, beeswax (meaning the secretion of the bees' wax glands used to build slices in the hive) is often mentioned rather generally as an obvious raw material used in the lost-wax technology, also known as *cire pardue* (Garbacz-Klempka *et al.* 2018; Armbuster and Meyer 2024; Bartz *et al.* 2024; Nordez 2024). However, there have also been discussions about the use of additives (including fats, natural resins, and charcoal dust) that impart specific properties to the raw material (such as stiffness, elasticity, ductility, *etc.*), which allow the shaping of complex models (Rønne and

Bredsdorff 2008, 67-69; Auenmüller *et al.* 2019, 144). Attention is also drawn to the possibility of completely replacing beeswax (Sperlin and Trommer 2024). To better understand the broad possibilities and the influence of the availability of local raw materials, the authors often refer to ethnographic analogies or to contemporary artisans practising traditional production methods (Rønne and Bredsdorff 2008, 69; Martinon-Torres 2015). Modern analytical methods (*e.g.*, fourier-transform infrared spectroscopy or gas chromatography with flame ionisation and mass-selective detection) enable the identification of beeswax residues on tools used for casting (Nadmar *et al.* 2008; Baron *et al.* 2014; 2015). However, the residues and the context of their discovery do not always directly indicate the use of wax as a model-making material; instead, there is ongoing discussion about the possibility that wax may have been employed as an ingredient in a protective paste for the mould surface – serving to improve the quality of the casting and to facilitate the removal of finished objects from the mould (Baron *et al.* 2014, 335, 336; 2015). These observations are especially valuable in the context of metal casting moulds, where wax may additionally have served as a preservation material. Due to the lack of definitive conclusions on the use of specific recipes for materials made from beeswax, as well as challenges in identifying differences in archaeological materials, it was decided to use pure beeswax. Nevertheless, its properties enabled the achievement of the desired model shape. The author's previous observations and experience suggest that additives could be beneficial in achieving the desired properties of the raw material; however, it was decided to limit factors that might detract from the main subject of consideration. The issue of using various recipes and their potential identification in archaeological materials definitely warrants a separate experimental approach. Since this is not the central issue of our discussion, we only signal it here and intend to develop it in future studies.

The actual work on creating bracelet replicas began with preparing long, thin, wire-like rods made of wax mass. They were then arranged side by side to form a band (Fig. 3 : 1). An imitation of the wire loop was also formed at this stage (Fig. 3: 2). The narrowing terminals were formed by squeezing and fusing, giving them a smooth surface (Fig. 3: 2). On the outside, efforts were made to join the rods at a single point, creating a clear transition towards the smooth terminals (Fig. 3: 3). The terminals were left thickened, and no excess wax was removed to facilitate their proper casting and further working.

Next, the rods inside the band were fused, and this is where the first differences between the bracelets became apparent. One of them is smooth on the inside, so during wax model creation, the rods were joined almost entirely, resulting in a uniform surface (Fig. 4). The procedure was performed using a bronze blade heated to the correct temperature, which melted the wax and facilitated shaping. In the second bracelet type, where the inner side also shows separate rods imitating wires, they were joined only in a few places (imitating the original) by making a narrow, band-like fusion (Fig. 4). At this point, it should be added that the wax mass at room temperature (18-25°C) is viscous. The rods can be joined by pressure alone, but such a joint is unstable, and local dislodgement may occur during later processing. Therefore, it is justified to use a welding procedure by over-melting the wax to strengthen the whole.

The sequence of operations presented so far may have been different, as it did not leave traces that would allow for its exact reproduction. For example, the joining of the rods forming the band might have occurred before the ends were formed, but the result and the possibility of capturing the traces would have been identical.

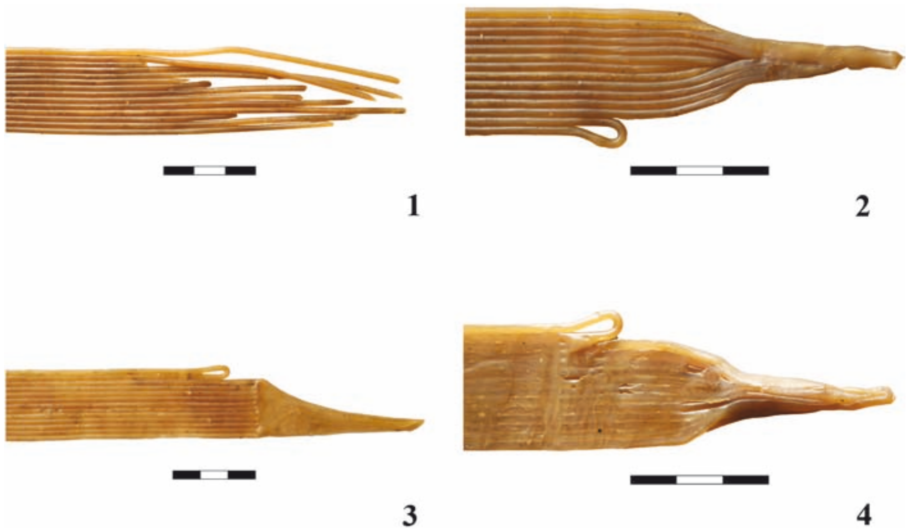

Fig. 3. Selected stages of preparation of wax models; 1 – forming a band by connecting wire-like rods made of wax mass; 2 – forming terminals by squeezing and fusing wax rods; 3 – creating a clear transition towards the smooth terminals; 4 – carefully finishing the inner surface of the rod connections. Photos by A. Sokół

Fig. 4. Differences in the inner surface of bracelet models of both types. Photos by A. Sokół

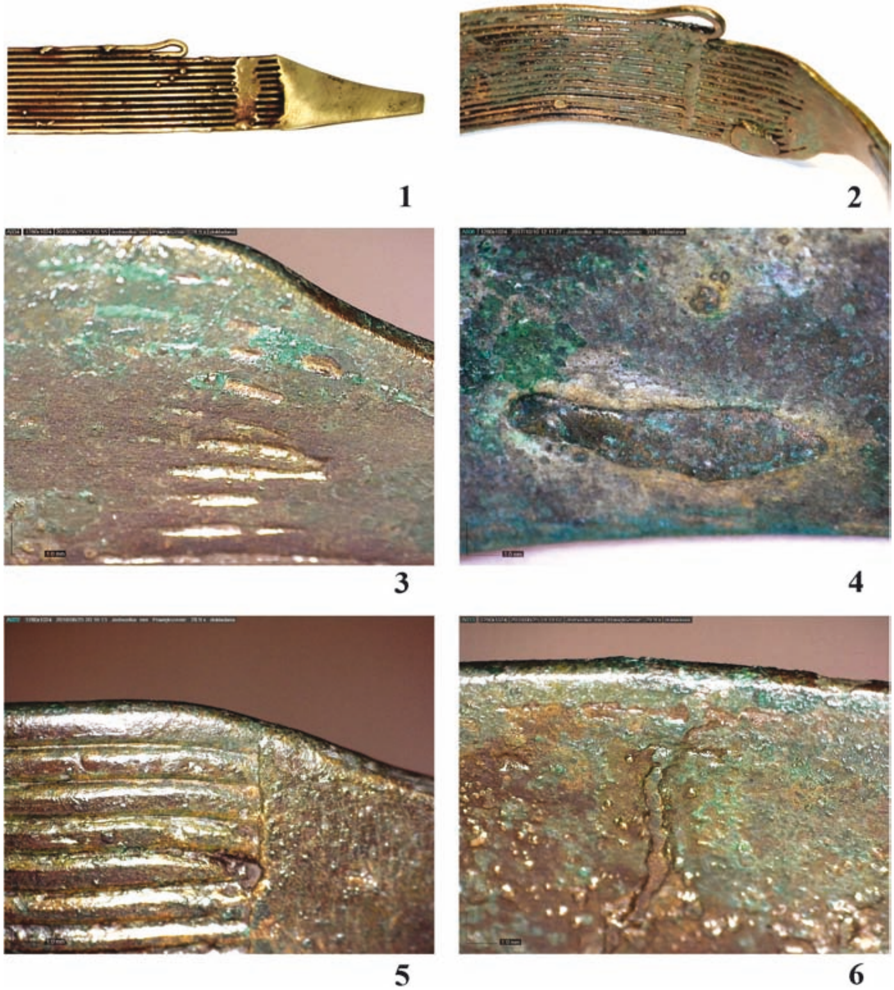

Fig. 5. Traces or defects indicating the use of the lost-wax method:
1 – traces visible on the replica; 2 – various traces visible on the inner surface of the bracelet; 3 – carelessly finished inner surface of rod connections; 4 – surplus material; 5 – cavities; 6 – furrow-shaped lines of surplus material. 1: photos by A. Sokół, 2-6: photos by M. Maciejewski

The next step was preparing a ceramic casting mould. For this purpose, a general knowledge of the technology used to produce metal objects from melted wax models was employed. The information is based on the analysis of artefacts related to Bronze and Early Iron Age metal casting (production waste, such as mould fragments, removed casting jets) coming from several Polish sites (*e.g.*, Piaskowski 1957; Stolarczyk and Baron 2014; Makarowicz 2016; Nowak and Stolarczyk 2016; Stolarczyk *et al.* 2020). Valuable finds in this regard are clay moulds from the Juszkowo site, which Podgórski (1982, 228,

229) interpreted as moulds for casting banded pseudo-spiral bracelets from the same phase as those from Lubnowy Wielkie. The experiment used a ceramic mass with a high temper, *i.e.*, sand and organic additives derived from horse manure. These additives were intended to reduce mass shrinkage during drying and firing significantly. Moreover, after heat treatment, the organic temper imparted the finished moulds with the desirable porosity, which is crucial for casting long, thin-walled objects.

The moulds were dried in a cool and unheated place for two weeks. After this time, firing took place. To control the conditions, the process was conducted in a modern kiln. In the first stage, the moulds were preheated to 90°C for 4 hours to melt the wax mass, and then a systematic heating was performed up to 750°C. A bronze with a tin content of 10% was used to pour into the moulds. Before casting, the ceramic mould was heated to 300°C to ensure that no moisture remained inside it and that the metal stayed molten long enough to fill all the spaces. To extract the as-cast metal product, the mould had to be broken.

The post-casting treatment of the as-cast item included removing the pouring cup by controlled break-off, preceded by chisel cuts. This was followed by shaping the narrowing bracelet's terminals by cold hammering to make them slenderer. The specific hammering stages were preceded by annealing the material to make it easier to form and to prevent breaks during subsequent modifications. Further work included grinding the product on sandstone whetstones with different grain sizes. The final effect was achieved by polishing using ground charcoal applied using animal leather.

Finally, the band was bent to the target shape of the bracelet. This was not done earlier since a flat band was easier to work with and polish. The bracelet's bent shape makes it challenging to access the inner part.

RESULTS – CT SCAN

The CT imaging of the original artefacts provided the impetus for undertaking the experiment described here. We therefore begin the presentation of the research results with a discussion of these observations. As noted, the scanning was performed using equipment designed for the quality control of industrial components. Although metal substantially attenuates X-rays, the images obtained are nonetheless highly detailed (Fig. 6: 1; 7: 1).

In the case of the bracelets under consideration, the cross-sections occasionally reveal distinct oval shapes that resemble the sections of metal wires. This is particularly evident in the bracelet whose inner surface imitates the structure of fine wires. The construction of the loop likewise convincingly imitates a wire form, both in macroscopic observation and in the CT scans (Fig. 6: 1).

These images lend themselves to various interpretations. One possibility was the welding of wires combined with the casting of terminals using the cast-on technique (Überfangguss), as seen, for example, in case bronze pins (Armbruster 2000, 85-87). However, first, no traces of overcasting were visible on the CT scans, and second, welding or soldering – as noted above – poses significant technological difficulties. A second potential method, which was tested during the experiment, involved producing the bracelets from wax models designed to imitate a structure composed of separate wires.

The next stage of the research involved performing CT scans of the bracelet replicas produced during the experiment. Unfortunately, it was not possible to use the same

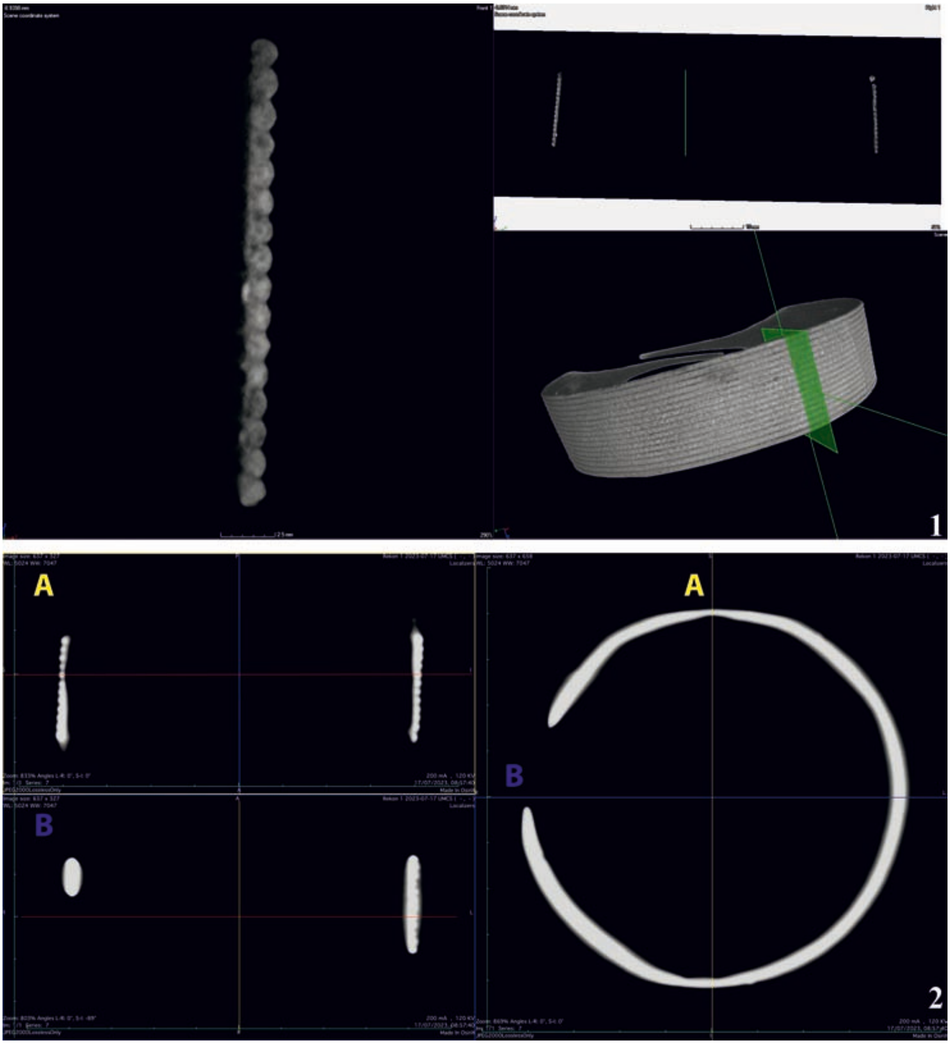

Fig. 6. A so-called bracelet with a smooth inner surface (Figs. 1: 1, 3, 5): computed tomography of the original artefact (1 – CT using Nikon Metrology XT H 225 ST) and the reconstruction (2 – CT using Toshiba Astelion TSX-034A). 1: compiled by T. Kosiński; 2: compiled by M. Tracz

scanner; instead, a medical device was employed, which offered lower resolution and power. As a result, the scans differ markedly in quality (Figs 6 and 7). Nevertheless, in both cases – and once again most clearly in the bracelet whose inner surface imitates a wire-like structure (Fig. 6: 2; 7: 2) – the cross-sections reveal oval shapes resembling those observed in the CT scans of the original artefacts.

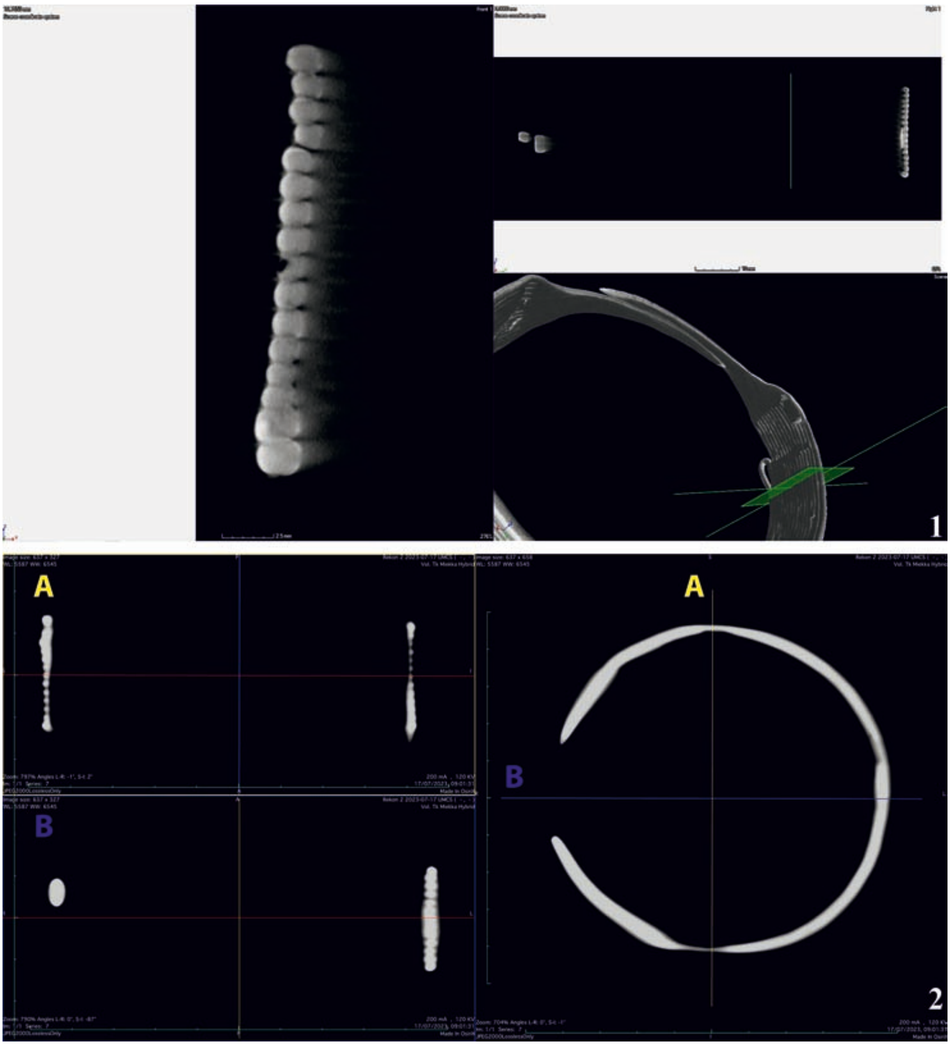

Fig. 7. A so-called bracelet with an inner surface imitating welded wires (Fig. 1: 2, 4, 5): computed tomography of the original artefact (1 – CT using Nikon Metrology XT H 225 ST) and the reconstruction (2 – CT using Toshiba Astelion TSX-034A).
1: compiled by T. Kosiński; 2: compiled by M. Tracz

RESULTS – COMPARISON OF TRACES OBSERVED ON THE ORIGINAL BRACELETS AND EXPERIMENTAL SPECIMENS

The experiment enabled the creation of bracelet replicas and the observation of macro-traces left by the technological operations described above. Many of these traces correspond to those identified on original artefacts.

On the inner side, traces of fusing the wax rods were observed, consistent with both bracelet specimens. In the specimen with visible rods, these are revealed as narrow, smooth bands resulting from the melting of the wax in contact with a heated metal tool (Fig. 5: 1, 2). They were not removed during the working of the item surfaces. On the inner side of these bracelets, a slight flattening of the rods is also visible, which might result from the model adhering to the working surface while it was formed (Fig. 5: 1, 2). Similarities are also noticeable in the specimens with smooth surfaces. Traces of the terminals' manufacture and attempts at smoothing match well. Careless execution of this procedure caused some surface fragments to be left unworked so that the rod structure is visible in places, particularly in the case of the specimen with the flat inner side (Fig. 3: 4; 5: 3).

The numerous casting defects are particularly distinctive traces of the use of the melted model technology. Among these, the most common are variously sized areas with surplus material, resulting from an inaccurate coating of the model with clay mass, leaving additional space for liquid metal (Fig. 5: 1, 4). In this case, the traces should be interpreted cautiously, as they may be mistaken for similar areas formed from wax during the model-making stage. Further defects include cavities or misruns, usually caused by the accumulation of excess casting gases in a given area, preventing the mould from being thoroughly filled with liquid metal (Fig. 5: 5). This trace is particularly distinctive, as it is difficult to imagine using metal rods with cavities to form such bracelets. High-quality products (excellent casts) were used to manufacture the rods and wires, as any defects in the material would have led to cracks during the drawing process.

Defects in the form of furrow-shaped lines of surplus material were only observed on the original bracelets (Fig. 5: 6). They most likely result from cracks in the wax model's ceramic coating. Such cracks might develop from drying the mould too quickly or improper firing. They may also result from using inappropriate or insufficient temper, which results in insufficient shrinkage of the ceramic mass. Cracks may also form during the pouring of metal into the mould due to thermal shock caused by the heated metal and pressure from casting gases. Finally, cracks might result from mechanical damage or dropping the mould. Regardless of the cause, the space thus created is filled with liquid metal, leaving a positive impression of the crack on the finished product's surface. The absence of such traces on the experimental replicas may indicate that the mould was well-made. The fine furrows of surplus material may have been removed during the grinding procedure, especially on the inside of the bracelets.

CONCLUSIONS AND TECHNOLOGICAL OBSERVATIONS

The experiment confirmed the hypothesis derived from the analysis of technological traces on archaeological artefacts and CT scans. They indicated the use of melted wax models and suggested a similar *chaîne opératoire* to produce finished items. By reconstructing the process, it was possible to create replicas with properties resembling those of the original objects. Traces observed on the experimental specimens correspond very well with those identified on the original artefacts. Particularly distinctive were traces of joining wax rods and forming narrow terminals. Equally valuable are casting defects, especially those resulting from imprecise manufacturing of the ceramic mould, such as areas with surplus material, cavities or traces of mould cracking. The above observations provide a clear picture of the process and the range of techniques used to form banded pseudo-spiral bracelets. Additionally, a catalogue of characteristic traces may prove helpful in studying similar items. Not only does it apply to other specimens of banded pseudo-spiral bracelets, but also to objects where specific procedures were used to imitate the use of metal wire, rods or the welding and soldering procedures (*e.g.*, other objects from the Lubnowy Wielkie hoard).

The above-mentioned issues could be resolved through specialised metallurgical studies, such as ToF-ND, which has recently gained popularity in the non-invasive investigation of metal artefacts (Tarbay *et al.* 2023; Nagler *et al.* 2019). By analysing scattered neutrons, data can be obtained on the crystal structure, phase composition, and texture of the material – that is, the arrangement of grains – which allows, for example, distinguishing objects produced by casting, forging, or rolling (Cereser *et al.* 2017). Such analyses enable the documentation of metalworking treatments that can be used to identify the processes applied to the discussed categories of artefacts. Together with the described experiment, this would lead to a precise understanding of the entire manufacturing process. A problematic issue remains the shape of the final model and its position while pouring. Based on initial unsuccessful attempts, it was decided to cast a flat strip vertically, using gravity to fully fill all gaps. This required intensive metalworking treatments of the cast semi-finished product, including forging and bending, which involved the risk of damage. The application of TOF-ND could confirm or exclude whether these treatments were truly applied. The findings of the previously mentioned bracelets from Aleksandrowice, based on models shaped as closed strips, may suggest that they were cast in their final form (Blajer and Chochorowski 2015). The detailed surface preparation makes it impossible to locate potential casting and venting channels using macro observation. However, an analysis of casting defects, porosity, and shrinkage using computer modelling and reverse engineering could prove helpful in dispelling doubts (Garbacz-Klempka *et al.* 2017; 2018, 1334).

The production of banded pseudo-spiral bracelets is an arduous task that testifies to the high skills of the metallurgists. This complex process involved multi-stage preparations, requiring a deep understanding of the appropriate wax mixture, the ceramic mass for the mould, the design of gating systems, and the selection of the optimal alloy composition. Additionally, possessing sufficient manual skills and maintaining good work hygiene are crucial, especially when working with wax, which can easily become contaminated in unsuitable conditions. The very shape of bracelets, being thin-walled and long, generates many difficulties and requires incredible precision in handling. The problematic nature of the process is evident from several unsuccessful castings made during the preparatory stage of the actual metallurgical experiment.

The course of the experiment highlighted the problem of insufficient knowledge and inadequate analysis of the key details of the process of creating copper-alloy objects. Different types of bee wax-based pastes have already been mentioned above. Similarly, the composition and method of making the clay paste for mould-making may vary widely. Such factors affect the cognitive value of the experiment, and further research focusing on the variables mentioned should be a solution. The possibility of identifying wax residues in casting moulds offers hope for the development of analytical solutions that could, in the future, shed light on the use of various wax mixtures. Supported by experimental research, it would be possible to trace the impact of specific formulations on particular effects, such as surface quality or the accuracy of the model's reproduction in the final product.

The studies demonstrated the value of CT methods in archaeology. It must be noted that the nature of the CT method makes the investigation of objects made of high-density raw materials, such as copper alloys, challenging. However, in both cases, the devices were possible. Clearly, there is a difference between the CT results of the two instruments. Nevertheless, it can be concluded that using the more common medical CT scanners makes sense if the National Health Service is not burdened with financing the examinations.

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BAST CORDS FROM THE LATE BRONZE AGE AND EARLY IRON AGE IN POLAND, ON THE EXAMPLE OF FINDS FROM SUSZ, IŁAWA DISTRICT

ABSTRACT

Przymorska-Sztuczka M. 2025. Bast cords from the Late Bronze Age and Early Iron Age in Poland, on the example of finds from Susz, Iława district. *Sprawozdania Archeologiczne* 77/1, 305-316.

Artefacts made of organic materials from the 1st millennium BCE in Poland are relatively scarce, and products made of tree bast are even rarer than fabrics. There is limited evidence in the archaeological record for the production and use of bast cordage during this period. Tree bast cords have been preserved mainly in association with metal objects, like in the case of finds from Żelazo or Jodłowno. The remains of bast cordage were also identified among the hoard of bronze artefacts from Susz in northeastern Poland, which is the richest collection of bast cords in the region to date.

Keywords: bast cord, organic materials, Late Bronze Age, Early Iron Age
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INTRODUCTION

Recent years have brought new discoveries of deposits of bronze artefacts along with the organic remains preserved with them. These residues are increasingly attracting the attention of both archaeologists and biologists. Collaboration between researchers from these two very different fields often yields spectacular results. They are as valuable as the

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metal artefacts with which they have been preserved. These remains can be divided according to the origin of the raw material into plant and animal. These are both remnants of organic containers in which metal objects were deposited (*e.g.*, Papowo Biskupie, Gackowski *et al.* 2024, 2), such as birch bark baskets, leather or textile sacks/bags, and also plants themselves, *e.g.*, mosses, bark, leaves, grasses or straw, sometimes constituting additional protection for hidden objects, or the lining of the pit or vessel in which they were buried, as in the case of the finds from Cierpice, Jodłowno and Sanok (Noryśkiewicz and Kamiński 2022, 145; Kotowicz 2022, 17, 18; Gackowski *et al.* 2023, 663; Nowak *et al.* 2023, 97). There are also cases where individual metal artefacts were wrapped or tied, as in Brudzyń (Przymorska-Sztuczka 2020, 173) or Jodłowno (Nowak and Gan 2023a, 341). Organic material is also discovered inside objects, *e.g.*, in metal sleeves wrapping cords, as in the deposit from Susz (Przymorska-Sztuczka *et al.* 2024, 4) and Wola Sękowa (Kotowicz 2022, 11; Mueller-Bieniek and Cywa 2022, 143), or in the loops of axes and phaleras, as in the hoard from Żelazo (Krzysiak 2006, 202) and Kaliska (Przymorska-Sztuczka 2021, 406). Some of the artefacts also contain visible leather fragments, which are the remains of straps, belts or fastenings – such finds were discovered in the deposit from Kaliska (Kaczmarek and Szczurek 2022, 120, 121) and Sanok (Kotowicz 2022, 18, 28; Mueller-Bieniek and Cywa 2022, 142).

In this article, we focus on one category of organic finds: cords made of tree bast from the Late Bronze Age and Early Iron Age from Susz in northern Poland. We begin with a short overview of the history and processing of this raw material, highlighting its long and rich tradition in textile production. Bast undoubtedly ranks among the most important organic materials utilised by prehistoric communities (Hurcombe 2014, 29). Along with bark, grass stalks, reeds, and roots, it was one of the primary raw materials for producing everyday items, such as various mats, strands, and containers. The manufacture of tree bast cordage in Europe dates back to the Palaeolithic, and has an unbroken tradition to the present day (Myking *et al.* 2005, 67; Rast-Eicher 2005, 117). The craft was developed by nomadic hunter-gatherers and evolved to meet the growing need for cordage, likely associated with subsequent early farming cultures (Schjølberg 1988, 69). Bast can be obtained from many species of trees, including lime, birch, willow, hazel, beech, yew, pine, and spruce. However, analyses of bast product residues generally indicate that the material used came mainly from deciduous trees (Myking *et al.* 2005, 65, 66).

As a raw material for cordage making, lime bast fibres are excellent. Even a single strand is difficult to break and is resistant to decay. Bast fibre is collected from the inner bark surrounding the stems of certain plants. It must be extracted and prepared before such fibres can be worked into rope, cordage, or textiles. Usually, the bark is stripped off in the spring or early summer and submerged in water for retting. This causes a separation of the individual bast layers and releases the bast from the outer bark. Depending on the weather conditions, it can take between 2 and 8 weeks for the bark to transition from a solid structure to a soft, fibrous sheet of many layers (Myking *et al.* 2005, 68). These straps can be plied to form a strong cord or a rope, which is flexible and resistant to mould. Limited swelling and low weight made the lime bast cordage float well, making it ideal for use in fishing (Myking *et al.* 2005, 70). Making a sewing thread or cordage for netting from a millimetre-thick fine strand is possible. Thicker strands can be plied to make ropes (Leaf 2007, 24).

The archaeological finds provide a limited scope of evidence for the production and use of bast cordage during the Late Bronze and Early Iron Age in present-day Poland. Such finds are only evidenced from northern Poland and have been mainly preserved in association with metal objects. Fragments of cords from the hoard near Susz are an excellent example of this phenomenon and will be discussed in more detail. In the description that follows, cords are plied yarns more than 1 mm to 10 mm. An asterix (*) in front of the single strand is added to denote spliced yarn/cord structure (Rast-Eicher and Dietrich 2015, 36; Harris and Gleba 2024, 459). In this article, a cord composed of two spliced strands of s-twist, plied in a Z direction, is annotated Z2*s. If the twist in the singles is loose, it is placed in brackets Z2*(s). When strands/yarns have no discernible twist, they can be annotated by Z2*, or Z2*i (Gleba and Harris 2018, 2330; Harris and Gleba 2024, 459). All observations were made at macroscopic and microscopic levels, using a Dino-Lite Edge digital microscope (10-50× magnification) and an Axio Zeiss Scope A1 stereomicroscope.

BAST CORDS FROM SUSZ

In 2023, the Regional Museum in Susz received an anonymous package containing bronze objects: a phalera, a bracelet, and 21 sleeves made of sheet metal wrapped with cords. Unfortunately, the context of this discovery is unknown (Przymorska-Sztuczka *et al.* 2024, 2). Fragments of cords were preserved inside 11 of the sleeves. In contrast, a small fragment was found separately (Fig. 1). Since the cords were not removed from the sleeves to avoid damaging them, no direct diameter measurements could be taken. This was only made on a 'loose' fragment, which was then sent for radiocarbon testing. The date obtained was 900-790 cal. BC, which corresponds to the Ha B2 period according to Reinecke (Przymorska-Sztuczka *et al.* 2024, 4). A botanist also analysed the cord fragments, confirming archaeologists' assumptions about tree bast as the raw material used to produce it (Przymorska-Sztuczka *et al.* 2024, 7).

In seven objects, the cords were preserved along almost their entire length (from 30 to 90 mm), while in four, they were preserved only in a small fragment. The cords filled the inside of the sleeves tightly. Therefore, the original thickness of the cords was quite close to the diameter of the bronze objects, which was approximately 10 mm. The loosely preserved fragment was about 8.4 mm in diameter. These cords were probably plied from two strands of bast. Some of the fragments were made with a right twist (Z), and some with a left twist (S) (Fig. 2). Based on this, it was concluded that there were probably two types of cords in the bronze sleeves – Z2* and S2* (Przymorska-Sztuczka *et al.* 2024, table 1).

Consequently, the hypothesis that these sleeves were threaded onto a single long cord for transport can be ruled out. The preserved residues have a form typical of cords made from tree bast. As a rule, these are two- or three-strand cords, *i.e.* they are made of two or three strands twisted together (Fig. 3).

It is difficult to determine the function of the cordage in the Susz ensemble. They were not simple ropes intended to secure or transport the bronze sleeves. The edges of the sleeves were additionally bent inwards to prevent them from sliding along the cordage. Perhaps bast cords were a structural element of a larger whole, consisting of a set of sleeves and phalera, *e.g.*, a horse harness, or maybe they were related to the construction of a female outfit, such as a skirt made of cordage or a belt (Przymorska-Sztuczka *et al.* 2024, 10, fig. 9). Although strong, a bast cordage with a diameter of approximately 10 mm is not a suitable raw material for use in horse harnesses. Analyses of organic remains indicate the use of leather straps for this purpose, as seen in the cases of Kaliska, Sanok, or the Danish Bćkkedal (Sarauw 2015, 6; Korupka 2022, 149; Szczurek and Kaczmarek 2022, 120).

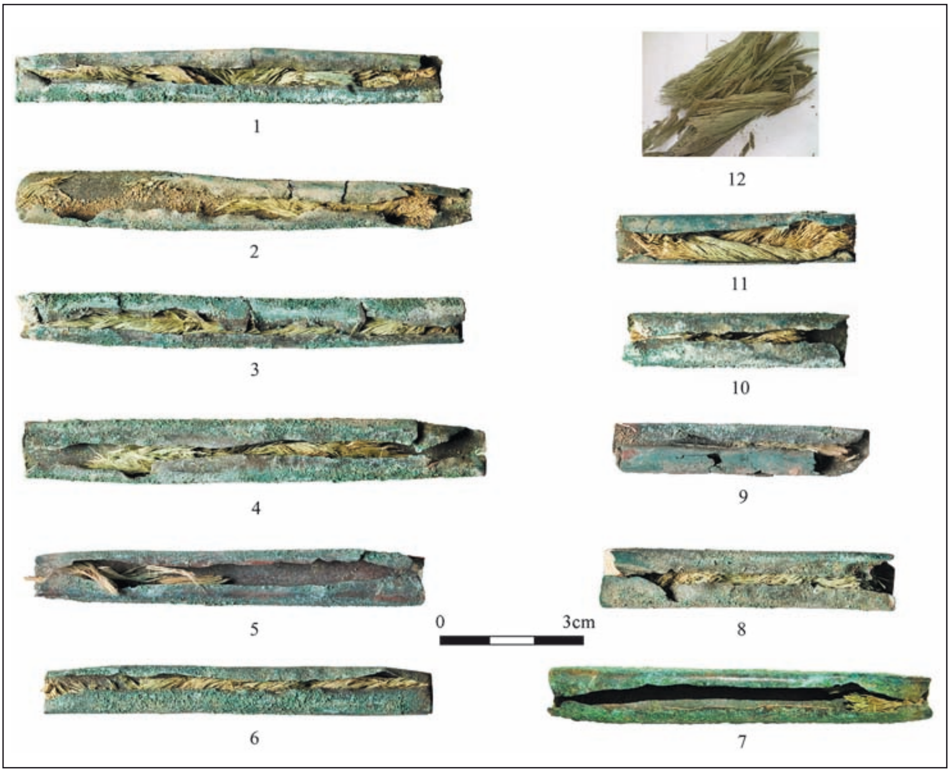

Fig. 1. Bronze sleeves from the Susz hoard with preserved fragments of a bast cord: 1-11 – sleeves; 12 – fragment of a bast cord under a Dino-Lite microscope, magnification ×20 (photo: M. Przymorska-Sztuczka)

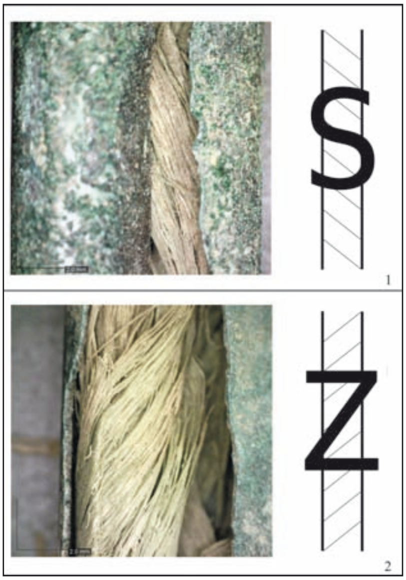

Fig. 2. Direction of a twist: 1 – left (S); 2 – right (Z) (photo: M. Przymorska-Sztuczka)

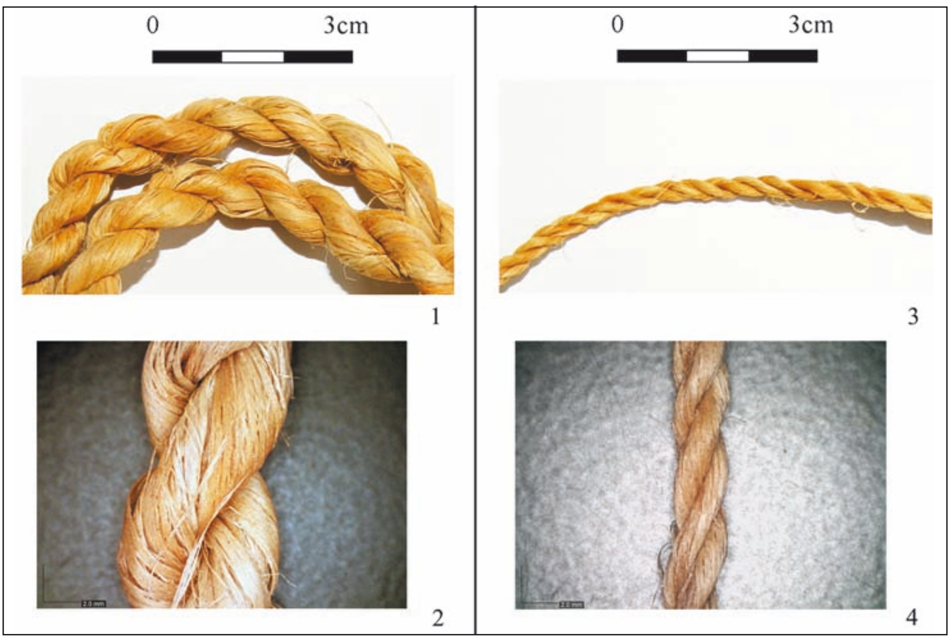

Fig. 3. Modern bast cords: 1 – thick cord made of two strands of bast; 2 – cord under a Dino-Lite microscope, magnification ×20; 3 – cord made of three strands of bast; 4 – cord under a Dino-Lite microscope, magnification ×20 (photo: M. Przymorska-Sztuczka)

Bronze sleeves and phaleras are also elements of women's attire associated with the Nordic cultural circle. Such examples come from Danish female burials and deposits dating primarily to the Early and Middle Bronze Age. There are over 20 known examples of the use of sleeves as parts of skirts made of cords. An example of the co-occurrence of bronze sleeves, phalerae and bracelets as elements of women's clothing are burials from Ølby and Gjedsted Sogn (Broholm and Hald 1940, 150, 151). In several Danish burials, larger fragments of skirts made of cords with metal sleeves have also been preserved, *e.g.*, Bustrup, Nellikehøj, and Hagendtrup (Broholm and Hald 1940, 147-152; Fossøy 2012, 39-41; Przymorska-Sztuczka *et al.* 2024, 10). However, it should be noted that analyses of these residues indicate wool as the raw material used to make them. The only example considered by M. Hald to be a cordage skirt made of bast is the find from Vester Doense (Broholm and Hald 1940, 104, 152).

Unfortunately, the lack of information regarding the arrangement of the artefacts from the Susz find and their relationship effectively hinders the interpretation of the purpose for which these objects were deposited and their original purpose. The fragments of bast cords from Susz are Poland's most extensive and well-preserved set of this type of cord. This find significantly expands the available source base and is a valuable example of an artefact made of tree bast.

OTHER FINDS OF BAST CORDS

Artefacts made of tree bast from the Late Bronze Age and the Early Iron Age in Poland are scarce. This is due to various causes such as the state of research, the state of publication, the methodology implemented during excavations and the fact that organic artefacts are rarely preserved except under exceptional conditions. Only a few artefacts made of tree bast have been published so far. These are fragments of cords from Jodłowno, Kaliska and Żelazo. Remains of cords come from deposits of bronze objects and other archaeological contexts, such as those found in the defensive settlements of the Lusatian culture in Mirakowo-Grodno and Słupca.

1. Jodłowno, Gdańsk district

Several fragments of cords, probably made of bast, were discovered in a deposit of bronze objects, dated to the Early Iron Age. They were found on necklaces, blades and bronze bars (Nowak *et al.* 2023, 98; Nowak and Gan 2023b, 106-110). The hoard from Jodłowno was presented at the exhibition accompanying the 8th Meeting of the Research Team on the Phenomenon of Mass Deposition of Goods, which took place on 17.05.2024 at the Institute of Archaeology of the Nicolaus Copernicus University in Toruń. The author of this article had the opportunity to look at the mentioned remains, although only through the glass of a display case. Based on available photographs and observations, it can be assumed that these are remnants of at least two types of cords. The first one is an untwisted strand of bast (Nowak and Gan 2023b, fig. 4: 16, fig. 5). The remnants adhering to the blades were about 5-8 mm wide. Perhaps a small fragment of a strip, also an untwisted strand, is a small fragment (approximately 2-3 mm wide) found at the end of the necklace (Nowak and Gan 2023b, fig. 9: 8). The second type is a thin cord, with which fragments of two bronze objects were tied together (Nowak and Gan 2023b, fig. 6: 1). It is made of two strands – Z2* ply. Its thickness is approximately 5 mm, and the width of individual strands is approximately 2 mm – the given measurements are approximate, based on the scale attached to the photographs in the publication Nowak and Gan (2023b).

2. Kaliska, Szczecinek district

Fragments of thin cord were discovered on the phalera. These artefacts were part of a hoard of bronze objects, dated to the Late Bronze Age. The cord is preserved in five small fragments (Fig. 4: 1). It was made of bast, probably from deciduous trees, in a Z2*(s). Its average thickness was about 1.66 mm, while the thickness of individual strands was about 1.05 mm (Przymorska-Sztuczka 2021, 407). The raw material was determined on the basis of microscopic analyses conducted under the supervision of M. Grupa from the Institute of Archaeology at Nicolaus Copernicus University in Toruń.

3. Mirakowo-Grodno, Toruń district

A fragment of a bast cord discovered at a defensive settlement of the Lusatian culture in Mirakowo-Grodno, dated to the Late Bronze and Early Iron Age. The cord was 55 mm

Fig. 4. Bast cords and cord imprint from Poland:
1 – Mirakowo-Grodno; 2 – cord imprint on the top of a loom-weight from Słupca; 3, 4 – bronze axes with residues of cords from Żelazo (without a scale); 5 – bast cord from Żelazo under a Dino-Lite microscope, magnification ×23 (photo 1: Ł. Gackowski, photo 2-5: M. Przymorska-Sztuczka)

long and 10 mm in diameter, ply Z3*S (Fig. 4: 2). Each strand is about 4 mm in diameter (Przymorska-Sztuczka 2022, 109). It was probably made of bast obtained from a lime tree. M. Grupa performed microscopic analyses from the Institute of Archaeology, Nicolaus Copernicus University in Toruń.

4. Słupca, Słupca district

An imprint of a cord was located on a fragment of a fired clay loom-weight. It was found during archaeological excavation in a defensive settlement of the Lusatian culture, dated to the Early Iron Age. The imprint measures 30 mm in length and 8 mm in diameter, exhibiting a left twist. That means that the cord that left it was made in the opposite direction, most likely made of three strands Z3*(s) (Fig. 4: 3), of a diameter of about 4 mm each (Przymorska-Sztuczka 2022, 111). It is difficult to identify the raw material from which the cord was made. However, it seems that it was indeed bast. This is indicated by the similarity of the imprint to the fragment of the cord from Mirakowo-Grodno, as well as experimental work carried out (Przymorska-Sztuczka 2022, 191).

5. Żelazo, Słupsk district

Fragments of cords were preserved in the loops of a few bronze axes. These artefacts were part of a deposit of objects dated to the Early Iron Age (Krzysiak 2006, 202). Analyses were carried out on a cord fragment found separately (Fig. 4: 4). The remaining fragments were covered with a substance that preserves the metal objects. The raw material was determined based on microscopic analyses carried out at the Conservation Department of the Archaeological Museum in Biskupin. The cord was made of two strands of bast (Z2*s). Its average thickness was about 4.5 mm, individual strands about 2.1 mm, while the preserved length was about 15 mm.

The hoards from Beston Regis I and II in Great Britain also provide an example of using bast cords to tie several axes together (Lawson 2013, 28, 38).

DISCUSSION

The Susz cords must be interpreted within the broader context of organic remains associated with metal deposits. Across northern and central Europe, such assemblages include birch bark baskets, leather or textile sacks, and vegetal packing material such as moss, bark, leaves, grasses or straw. These served both as containers and as protective linings for hoards, as seen at Papowo Biskupie, Cierpice, Jodłowno and Sanok. Individual artefacts were sometimes wrapped or tied with organic fibres, while others contained residues preserved in hollows, loops or fittings. Leather straps and fragments are also attested, often associated with belts, fastenings, or harnesses. The Susz cords thus join a broader category of perishable items deliberately related to the deposition and use of bronze artefacts.

The comparative background underscores the deep antiquity of bast use. Finds from Palaeolithic and Mesolithic sites such as Lascaux, Noyen-sur-Seine, Gönnersdorf, Friesack, Tybrind Vig, and Ærø demonstrate the early exploitation of bast fibres (Rast-Eicher 2005, 117). Neolithic and Bronze Age lake dwellings in Switzerland (Auvernier-Port, Egolzwil, Wetzikon-Robenhausen, Zürich-Mythenquai), Germany (Degersee) and Britain (Must Farm) have yielded nets, ropes and woven textiles of bast (Messikommer 1913; Vogt 1937; Médard 2012; Banck-Burgess 2015; Rast-Eicher and Dietrich 2015; Grömer 2016; Harris and Gleba 2024). These finds highlight both the durability of bast and its role in technological traditions spanning millennia. The Susz cords, therefore, continue a well-established European trajectory of bast utilisation, though their context within a bronze sleeve assemblage appears regionally distinctive. From a functional perspective, the evidence suggests that bast cords served multiple roles: both practical (tying, binding, and securing) and as elements of dress or composite artefacts. The rarity of preserved specimens reflects depositional and taphonomic biases rather than actual scarcity in the past. In all likelihood, prehistoric households made extensive use of many bast products such as baskets, ropes and mats, of which only a minute fraction has survived.

CONCLUSIONS AND PERSPECTIVES

The Susz assemblage represents the most substantial corpus of bast cords preserved from prehistoric Poland, significantly enhancing our understanding of organic technologies in the Late Bronze Age and Early Iron Age. Although their precise function remains unresolved, the cords demonstrate advanced knowledge of fibre properties and cord-making techniques. When combined with comparative evidence, the finds point to a long-standing European tradition of bast utilisation for both practical and decorative purposes. Future research should systematically document even the smallest organic remains, undertake experimental replication of cord-making, and further integrate archaeological, botanical, and microscopic analyses. Such approaches will situate bast cordage within broader technological and social frameworks, reassessing the role of perishable organic materials in the daily practices and symbolic expressions of Bronze and Iron Age communities.

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QUANTITY MATTERS. STUDIES ON DEFENSIVE SETTLEMENTS OF THE HALLSTATT PERIOD IN GREATER POLAND

ABSTRACT

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The issue of defensive settlement during the Hallstatt period (HaC-HaD) in the area of Greater Poland constitutes an important, although still insufficiently recognised, research topic. Given current research, 21 well-documented defensive sites are believed to have operated in the region at the beginning of the Iron Age. The article's findings indicate that there has been a significant underestimation of the phenomenon's scale. Pilot studies limited to three neighbouring districts have identified at least three new probable fortified settlements. The research was preliminary and requires continuation to confirm its chronological attribution to the Hallstatt period reliably. In the authors' opinion, applying analogous methodological assumptions in other areas of the region may yield comparable findings and thus significantly shape the catalogue of defensive settlements from the beginnings of the Iron Age in Greater Poland. Considerable progress in these studies could indeed be achieved through systematic and reliable remote sensing prospection, as well as through a re-analysis of sites previously assessed negatively.

Keywords: Early Iron Age, Wielkopolska (Greater Poland), Hallstatt period, defensive structures, fortified settlements, Lusatian culture

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INTRODUCTION

It has now been seventy years since Tadeusz Malinowski published the first summary and discussion of thirty-one fortified settlements of the Lusatian culture in Greater Poland in 1955 (Malinowski 1955). More than half of the sites included in that study, associated initially with settlement from the beginning of the Iron Age (HaC-HaD; 800/750-450 BCE), have since been shown to be defensive structures dating from the early medieval period (Śmigielski 1991; 1993). It should be noted, however, that the chronological classification of several of these sites remains subject to debate. Verification research, particularly in the 1970s, conducted by the teams of Dobromir Durczewski and Wojciech Śmigielski (Śmigielski 1993) and Zofia Kurnatowska and Alina Łosińska (Kurnatowska and Łosińska 1981), has significantly narrowed this list. Its later modifications (for example, Niesiołowska-Hoffmann 1963; Niesiołowska-Wędzka 1966) ultimately established a catalogue of eighteen confirmed fortified settlements dated to the Hallstatt period (Śmigielski 1993; Kaczmarek and Szczurek 2015). Despite uncertainties regarding its chronological position, this list should also include the site at Pudliszki in Gostyń County (Durczewski 1977; Lasak 1995; Jaeger 2010). In the years that followed, only two new fortified sites were added to this group. One is located in Jurków in Kościan County (Nowakowski and Rączkowski 2000; Wyrwińska 2001), and the other in Bieganin in Ostrów County (Splitt 1986; Janiak 2003, 52; Szczurek 2024, 89) (Fig. 1). It is also possible that the phenomenon of defensive settlement associated with the Lusatian Urnfields should be extended to include the extensive 14-hectare site at Wielowieś on the Prosna River in Ostrów County (Szczurek 2018). With a high degree of probability, this site complements the catalogue of large fortified settlements from the end of the Bronze Age in central Poland described over two decades ago by R. Janiak (2003).

The actual number of defensive sites in operation during the Hallstatt period in Greater Poland remains an open question, one that demands careful attention in any research efforts. Undoubtedly, in addition to exercising caution before drawing firm conclusions without comprehensive excavation-based verification of new discoveries, a careful review of the literature is recommended. This can help avoid the introduction of flawed information into academic discourse, especially information that was already discredited decades ago (see Góralczyk 2024).

Greater Poland is undoubtedly one of the most thoroughly studied archaeological regions in the Polish lands. Many generations of archaeologists have worked hard to bring us to what may seem a satisfactory level of understanding. Thanks to access to remote sensing data, our knowledge of immovable heritage sources is expanding at an unprecedented rate (*e.g.*, Mackiewicz 2023). In recent years, the so-called LiDAR revolution has led to a fundamental reshaping of inventories of early medieval strongholds and later knightly residences (*e.g.*, Krzepkowski *et al.* 2018). Why should this progress in available research tools not be reflected in studies on the scale of settlement at the beginning of the Iron Age in Greater Poland? As we will attempt to show, this phenomenon is also evident in the issue under discussion here. However, it is not only terrain model analyses that are leading to the expansion of the catalogue of fortified settlements from the early Iron Age. Traditional academic tools, such as diligence and the ability to critically assess sources, remain valuable.

In this text, the term defensive settlement refers to the remains of a settlement originally surrounded by a defensive perimeter, now visible as an embankment representing the collapse of former fortification structures with highly varied layouts (Puziuk 2010). The function of these entire complexes, conventionally referred to here as 'defensive settlements,' was also most probably diverse and multidimensional (Dzięgielewski 2017).

We will present several examples from the last two years, which may alter our current understanding of Hallstatt-period defensive settlements in Greater Poland quite drastically. This concerns, in particular, the southern part of the region, where pilot studies were concentrated. Nevertheless, the application of analogous methodological approaches (LiDAR analysis, aerial photography, trial excavations, geophysical surveys, earth science dating methods, and re-analysis of materials and documentation from earlier research – *cf.*, Niedziółka 2017) in other parts of Greater Poland will undoubtedly lead to comparable findings and thus significantly influence the current shape of the catalogue of fortified sites from the beginnings of the Iron Age.

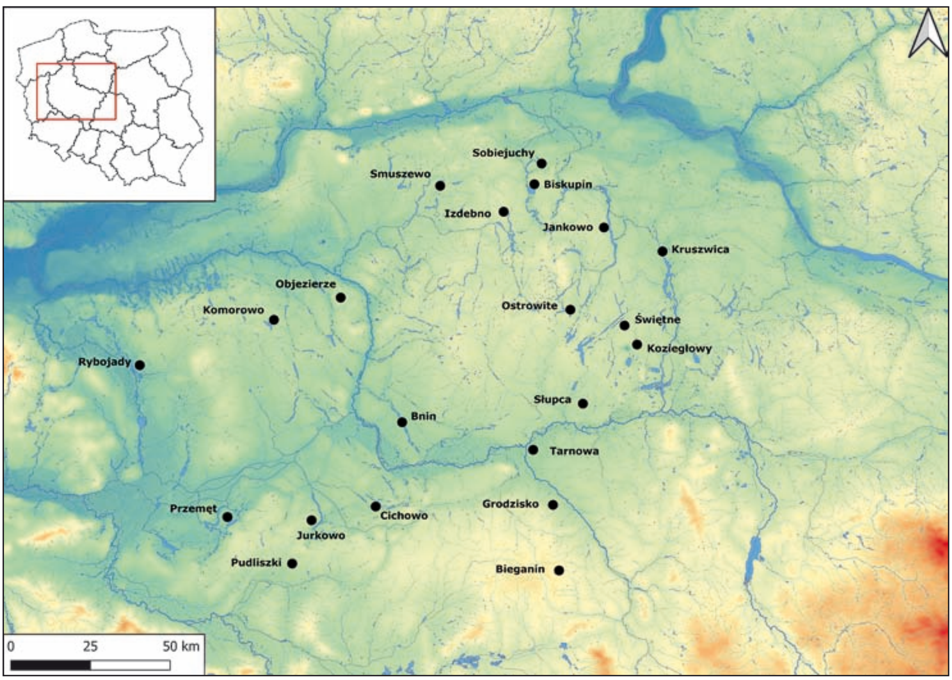

Fig. 1. Defensive settlements from the beginning of the Iron Age in Greater Poland in light of the current state of research (compiled by G. Szczurek after Śmigielski 1993; Kaczmarek and Szczurek 2015, with additions)

OVERVIEW OF RECENT DISCOVERIES OF PRESUMED DEFENSIVE SETTLEMENTS FROM THE HALLSTATT PERIOD IN GREATER POLAND

This section presents the results of the most recent research carried out within the Krzywiń Lakeland and the southern part of the Poznań Lakeland. First, we will refer to the findings concerning the site at Rogaczewo Wielkie in Kościan County (Krzepkowski *et al.* 2024). This will be followed by as yet unpublished results from fieldwork in Dolsk in Śrem County, remote sensing observations conducted in Mórka also in Śrem County, and very preliminary results from ongoing investigations related to an infrastructure project in Zaniemyśl in Środa County.

Rogaczewo Wielkie, Krzywiń Commune, Kościan County

The site is located in the Krzywiń Lakeland, approximately a quarter of a kilometre north of the village buildings. It lies in the floor of a marshy valley through which a now canalised stream flows, referred to as the Racocki Ditch or Wyskoć Ditch. Just 0.7 kilometres to the west lies the site at Turew, dated to the early phases of the early medieval period. It has been the subject of multiple surface and trial investigations and has been frequently mentioned in both older and more recent literature (*e.g.*, Kowalenko 1938, 312; Hensel *et al.* 1995, 101-104). Notably, the site under discussion here in Rogaczewo Wielkie, which is considerably more extensive than Turew and located nearby, has not been marked on any known maps of the area. No archival records or local accounts related to it have been preserved either. It is also surprising that the site was not recorded during two rounds of surface surveys conducted in the 1980s, especially since the area was not yet forested at the time and therefore would have been accessible for this type of prospection. Analysis of historical maps and aerial imagery indicates that, at least since the late nineteenth century, the site has been cultivated as meadows. A selection of aerial photographs from the years 1944 to 2021 clearly illustrates the change in land use and the gradual disappearance of the site's visibility in the vegetation cover (Fig. 2). During the surface surveys conducted over forty years ago on both sides of the valley, several extensive flat sites were identified in the immediate vicinity of the rampart remains. Many of these are associated with settlement from the Late Bronze Age and the early Iron Age. However, the nearby clearly visible scatter of ramparts was not recorded during those investigations.

The landform discussed here consists of an oval earthen rampart, heavily levelled, especially in its northern part. The base reaches a width of up to 14 metres, and its relative height does not exceed 1 metre. The total site area is 1.22 hectares. In the central part of the interior, a distinctive trapezoidal elevation draws attention. Its longer edges are oriented along the north-south axis (Fig. 3).

Preliminary verification of the newly discovered site at Rogaczewo Wielkie has so far been carried out in only two ways: the excavation of a single trial trench and a metal detector survey.

The first stage of the work involved the excavation of a trench with an area of 6 square metres (it measured 4 by 1.5 metres). It aimed to examine the rampart's structure, recover movable archaeological material, and collect samples for absolute dating of the site.

The stratigraphy within the trench was explored using a combined method of mechanical and natural layers. After removing the top layer of greyish-beige humic soil to a depth of approximately 35 centimetres, a cluster of partially burnt cobblestones was uncovered. Between the stones, there was a lens of coarse rust-yellow sand with crushed stone fragments. In the central and northern part of the trench, at a depth of around 40 centimetres, a layer of dark brown humus up to 25 centimetres thick was recorded, containing a high amount of charred material and fragments of carbonised wooden beams. Layers of light grey sand cut this structure with a small admixture of humic soil (Fig. 4).

At the next level of excavation, below the cluster of stones, a second layer of erratic boulders was found. These were slightly smaller in diameter and more loosely arranged. Beneath the layer containing the burnt material lay a stratum of grey humus. The level of

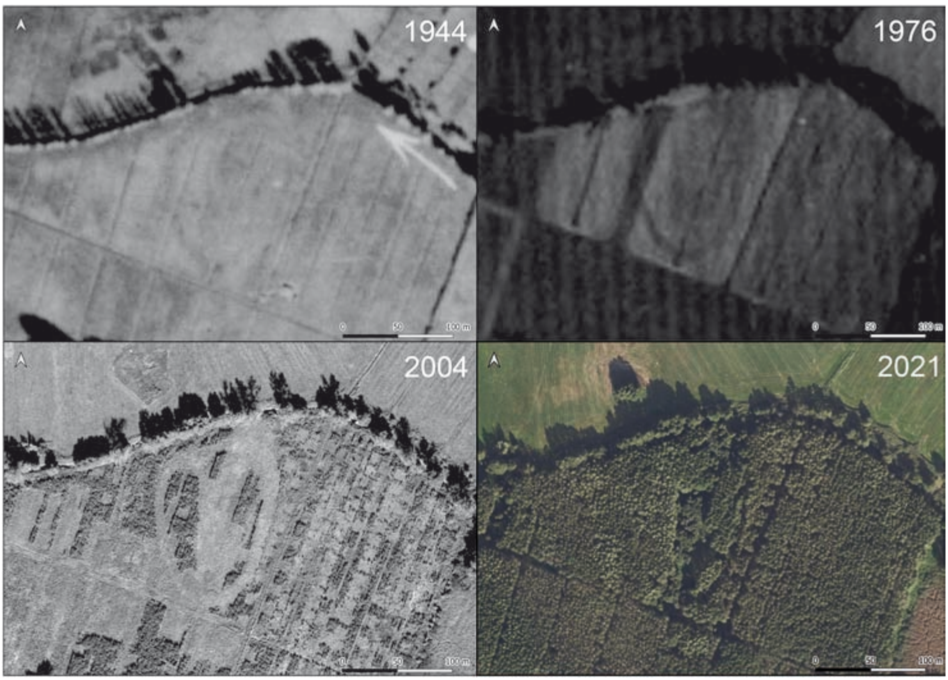

Fig. 2. Rogaczewo Wielkie, Kościan County, Site 22. Changes in land use and vegetation of the stronghold on selected photomaps from 1944-2021 (compiled by M. Krzepkowski after: igrek.amzp.pl – 1944; PAN Research Station archive in Turew – 1976; geoportal.gov.pl – 2004, 2021)

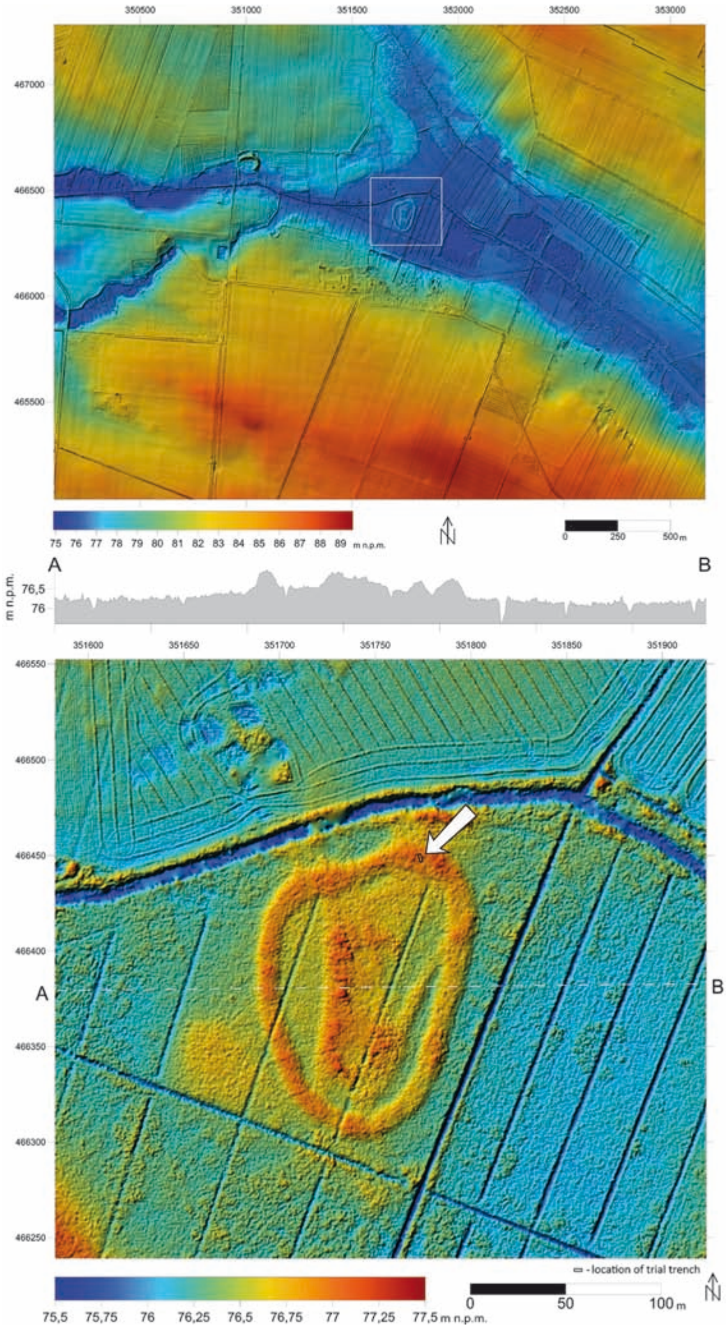

Fig. 3. Rogaczewo Wielkie, Krzywiń Commune, Kościan County, Site 22. Hypsometric visualisation based on processed ALS/LiDAR point cloud, source: GUGIK geoportal.gov.pl (compiled by W. Małkowski)

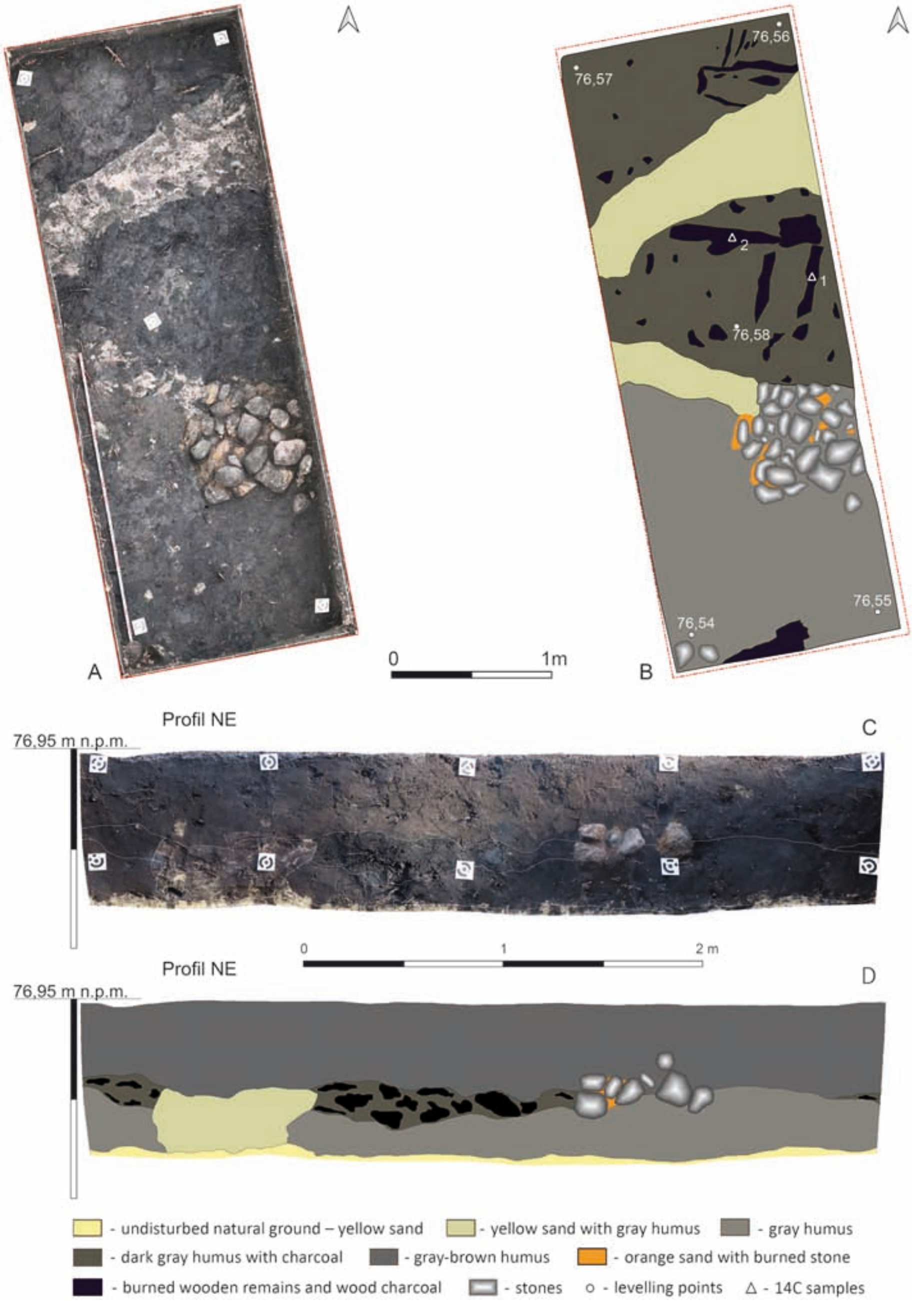

Fig. 4. Rogaczewo Wielkie, Krzywiń Commune, Kościan County, Site 22. Photogrammetric projections and NE profile drawings from Trench I: A, B – base of the first mechanical layer (level of wooden rampart construction); C, D vertical projections of NE profile (based on Krzepkowski *et al*. 2024)

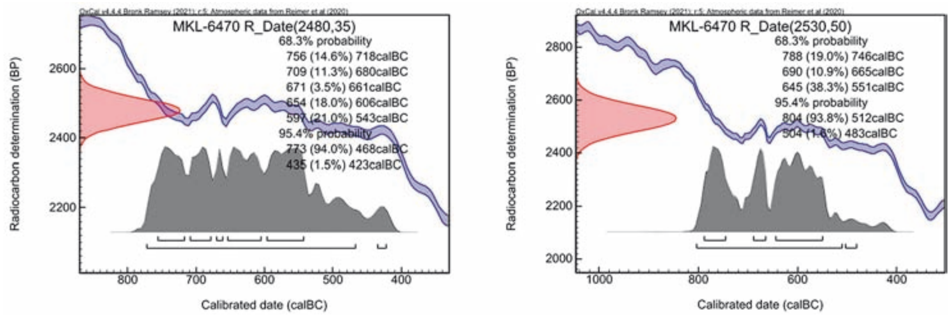

Fig. 5. Rogaczewo Wielkie, Krzywiń Commune, Kościan County, Site 22. Calibration graphs of radiocarbon dating results from burnt wooden elements of the rampart (compiled by M. Krąpiec)

compact sandy subsoil was reached at a depth of about 80 centimetres below the present ground surface. At this level, the outlines of two possible postholes were observed (Fig. 4). Although it was possible to distinguish individual horizontal construction elements, the small size of the trench limited broader observations of the rampart-construction method. Interestingly, despite very careful exploration, no movable archaeological material was recovered from the stratigraphy within the trial trench.

Similarly, a thorough surface survey of the site conducted with a metal detector did not yield any finds associated with prehistoric settlement. From the burnt layer revealed during the trial excavation, two charcoal samples were collected and submitted to the Laboratory for Absolute Dating in Kraków. The dating results indicate that the rampart was constructed at the beginning of the Iron Age. Both dates yielded very similar results, falling within the Hallstatt plateau: 804 to 483 BCE and 773 to 423 BCE (two sigma) (Fig. 5).

Dolsk, Dolsk Commune, Śrem County

The following site discussed here is located just under 20 kilometres southeast of Rogaczewo Wielkie, in the village of Dolsk, situated in the eastern part of the Krzywiń Lakeland. The site occupies a peninsula that projects into the gradually overgrowing Małe Dolskie Lake. The peninsula has an area of about 2 hectares (approximately 260 by 120 metres) and lies about 0.5 kilometres east of the medieval urban layout of Dolsk. It is separated from the mainland by an artificial ditch (which is visible on a map from the year 1853). Slightly farther to the west, a transverse earthen embankment runs across the peninsula along a north-to-south axis, with a base width reaching up to 50 metres (Figs 6 and 7).

The site at Dolsk's research history may be considered representative of a particular group of defensive sites in Greater Poland that have never received broader scholarly attention. Although the Dolsk feature has long been known, it has never been investigated through excavation. Previous activity was limited to occasional visits to the peninsula and surface surveys conducted as part of the Archaeological Record of Poland (Polish

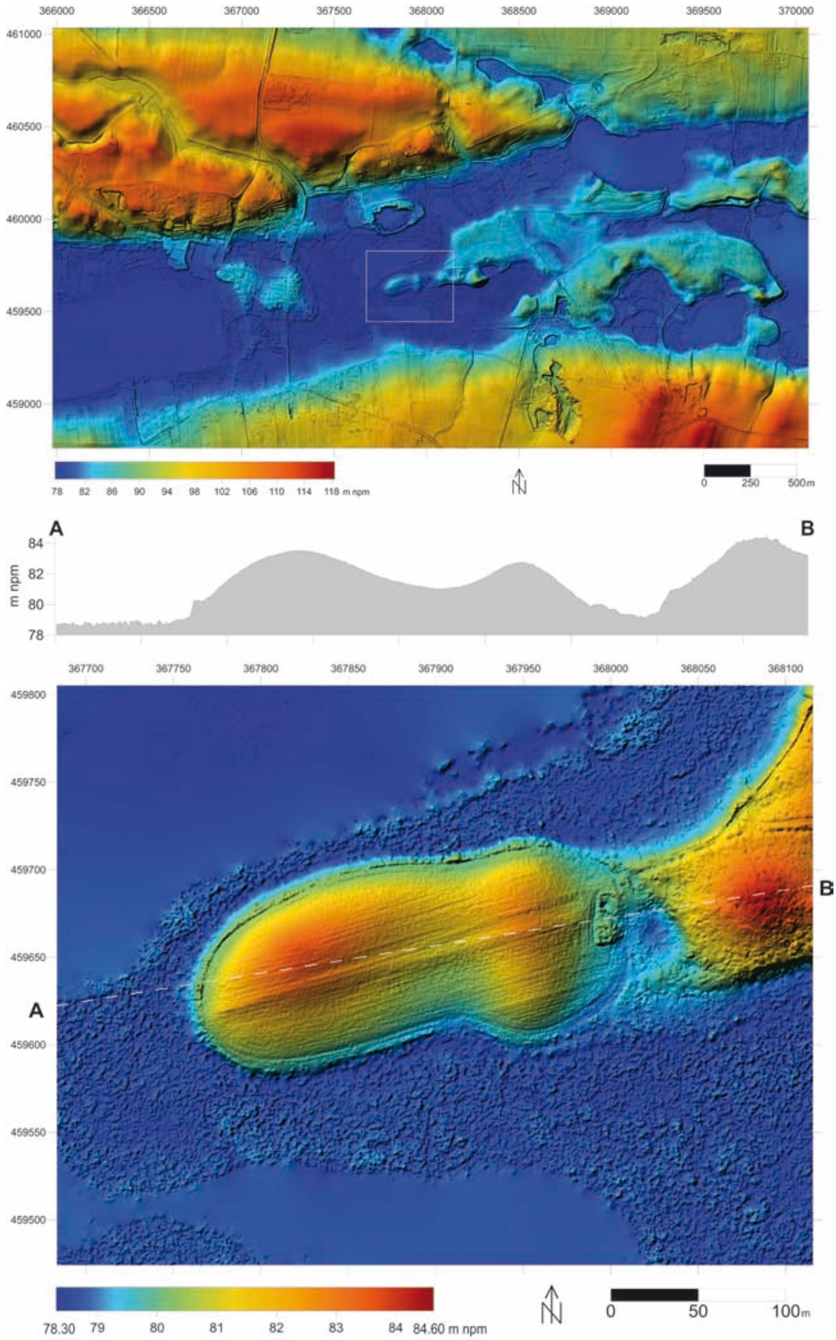

Fig. 6. Dolsk, Dolsk Commune, Śrem County (Kotowo, Site 68). Hypsometric visualisation based on processed ALS/LiDAR point cloud, source: GUGIK geoportal.gov.pl (compiled by W. Małkowski)

abbreviation: AZP) program. The existence of a defensive structure on the headland of Małe Dolskie Lake has often been questioned, and most of the information about the site dates from the interwar period or the first years after the Second World War (Kozierowski 1935, 79; Kowalenko 1938, 197, 198; Münch 1946, 107). The scarcity of information led Witold Hensel (1950, 180, 181) to classify the fortified settlement, or possibly fortified settlements, at Dolsk among the 'sites of undetermined type'. He stated that 'on the peninsula one might suspect the former presence of a concave stronghold,' adding, however, that 'the report of a stronghold in Dolsk should be verified once again, since two people have noted the complete absence of early historical artefacts from this location.'

A new chapter in the study of this site began with a surface survey conducted as part of the AZP program under the direction of A. Prinke. This time, a substantial amount of archaeological material was identified on the surface, allowing researchers to distinguish several settlement phases. These include a settlement of the Lusatian culture population, a settlement of the Przeworsk culture population, and an early medieval stronghold dated to phases B and C of the local dating scheme for that period.

The most recent phase of work conducted between 2022 and 2024 was part of a joint project by the Śrem Museum and the Relicta Foundation titled 'Inventory of Defensive Sites in Śrem County.' The research conducted so far has focused on remote sensing analysis, the creation of a topographic and contour map of the peninsula, multiple aerial

Fig. 7. Dolsk, Dolsk Commune, Śrem County (Kotowo, Site 68). Aerial photograph of the stronghold with visible remains of a transverse rampart (11.06.2022) (photo M. Krzepkowski)

surveys, and magnetic investigations. In the acquired imagery, the most clearly visible feature is the rampart of the defensive settlement located in the eastern part of the peninsula, extending along a north-to-south axis. However, in the southwestern section of the peninsula, a slight curved depression and an embankment can also be seen, which most probably correspond to the remains of a defensive perimeter such as a ditch and rampart. These observations have been confirmed by non-invasive investigations that covered the entire non-forested portion of the peninsula, which spans approximately 2 hectares (Wroniecki 2024). Based on the magnetic survey results, several significant features can be distinguished, providing valuable information about former defensive and settlement structures. The results indicate the presence of a complex, multi-layered system of anomalies, dominated by linear and curvilinear structures that often intersect and overlap one another (Figs 8 and 9). These complex patterns suggest that, despite considerable erosion of the terrain, deposits associated with defensive constructions are still preserved, albeit

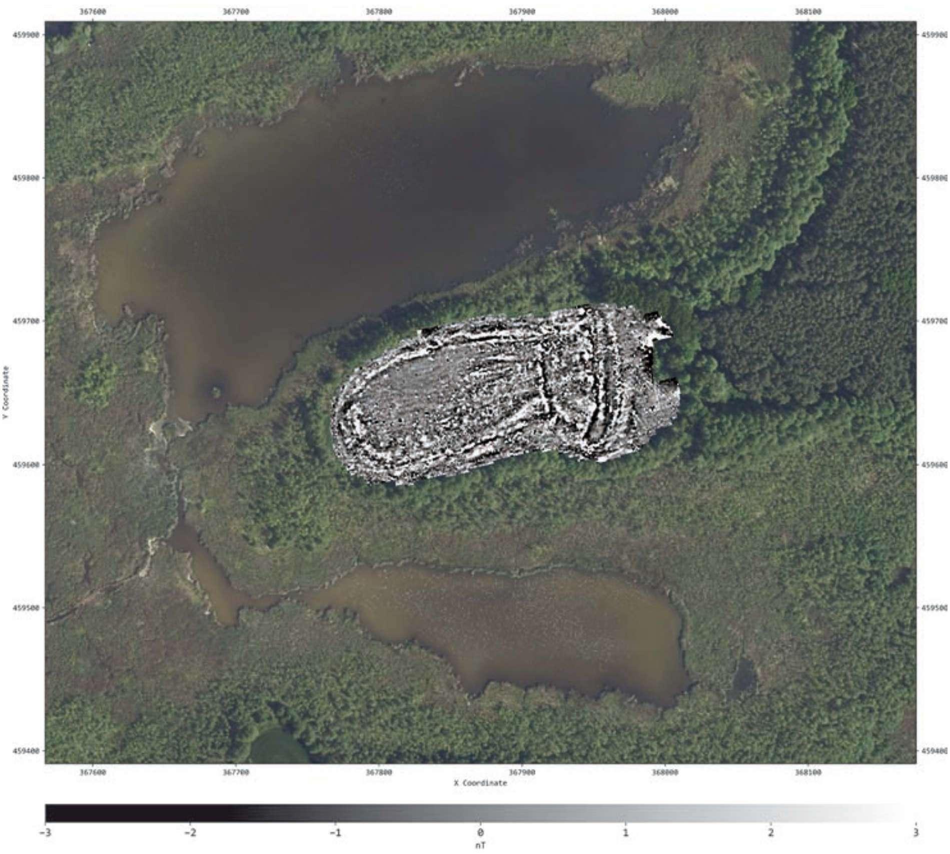

Fig. 8. Dolsk, Dolsk Commune, Śrem County (Kotowo, Site 68). Orthophotomap of the site with superimposed geophysical survey results (compiled by P. Wroniecki)

in a heavily disturbed form. The richness of the recorded anomalies, in both quantity and quality, is highly impressive. The identified structures can be divided into two main groups. The first is a system encircling the entire headland, probably connected to former defensive features such as ramparts and ditches. The second group is an oval structure in the eastern part of the site, encompassing only that section. This difference in layout suggests a possible chronological relationship between the two configurations. It can be hypothesised that the circular structure in the eastern zone may be later than the fortifications surrounding the entire headland. However, due to the overlapping and interwoven nature of these structures, a clear interpretation of their temporal relationship is not possible at this stage of the research. Data obtained by the magnetic method provides a flattened horizontal view of underground structures. More complex stratigraphic sequences may lie beneath the surface, and understanding them will require further investigation.

Importantly, these numerous and complex anomalies indicate that the peninsula was once occupied by defensive structures such as ramparts and ditches, which were constructed and modified multiple times over different periods. In the centre of the interior area, within the site's central part, numerous point-like magnetic anomalies were recorded. These may indicate settlement remains such as post-built structural elements, hearths, or pits.

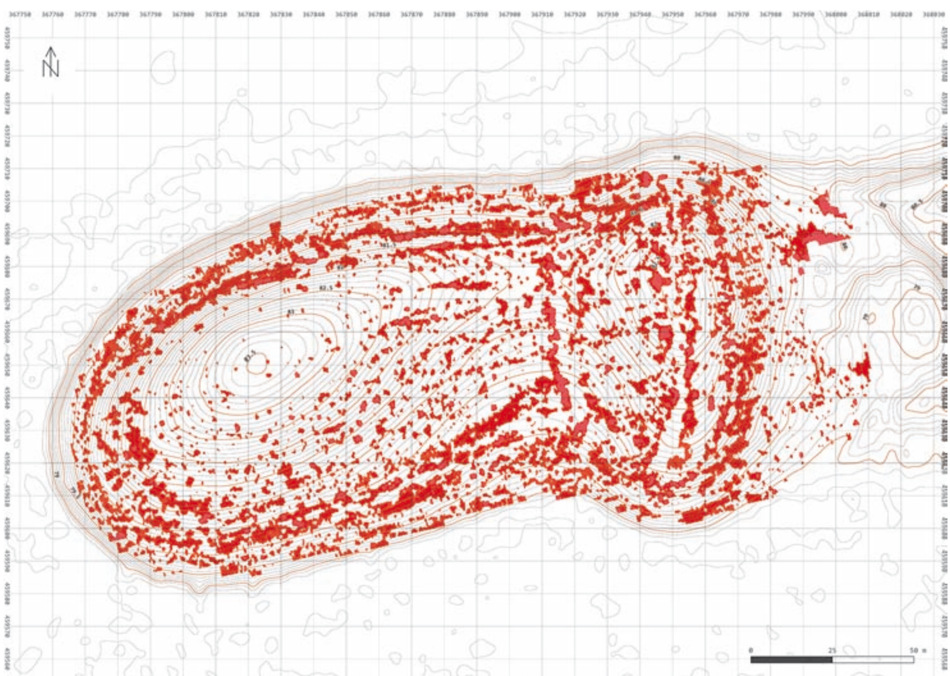

Fig. 9. Dolsk, Dolsk Commune, Śrem County (Kotowo, Site 68). Topographic-height plan of the site with magnetic survey results (compiled by P. Wroniecki)

Fig. 10. Dolsk, Dolsk Commune, Śrem County (Kotowo, Site 68). Aerial photograph of the stronghold showing rampart damage and charcoal sampling spot for radiocarbon dating (01.03.2022) (photo M. Krzepkowski)

During field inspection of the site, attention was drawn to the heavily damaged crest of the eastern rampart, oriented north to south, which had been significantly disturbed by ploughing. After ploughing, the field surface was covered with large quantities of charcoal, burnt wood, daub, and stones, all clearly originating from the fortification structures (Fig. 10). Across nearly the entire agriculturally used peninsula, large amounts of pottery fragments and animal bones were observed. Particularly noteworthy is the apparent predominance of relatively large, poorly fragmented sherds typical of ceramic production by Greater Poland communities in the early Iron Age, with only a minimal presence of early medieval pottery (Fig. 11). Naturally, we are not proposing here to establish the chronology of the fortified settlement based on surface ceramic analysis and frequency. Archaeology has fortunately moved beyond that stage. Considering the preliminary nature of the research efforts in Dolsk, it was decided to submit the material recovered by the plough from the rampart crest for radiocarbon dating. Samples were taken from two burnt wood fragments, which the Laboratory analysed for Absolute Dating in Kraków (Fig. 12).

In this case as well, although the results leave much to be desired in terms of precision, they are undeniably important in the research history of this site. At the 95 per cent confidence level, both results fall within the Hallstatt plateau: 778 to 520 BCE and 761 to 441 BCE. Although the samples did not originate from a homogeneous layer, the results provide a basis for hypothesising that the defensive site at Dolsk may have a significantly

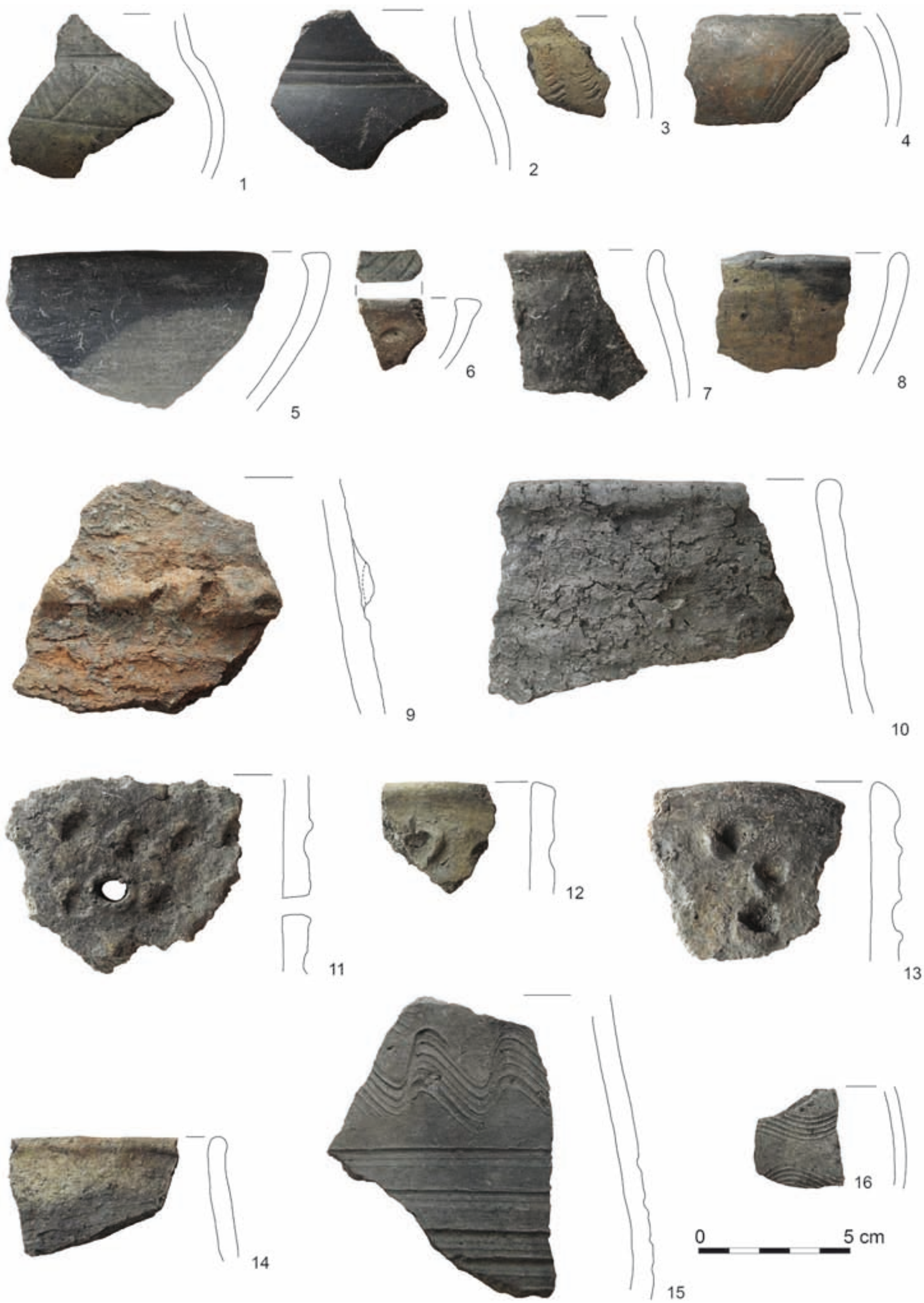

Fig. 11. Dolsk, Dolsk Commune, Śrem County, Site 68 (Kotowo, Site 68). Pottery fragments observed on the surface of the stronghold in Dolsk (03.04.2022) 1-14 – early Iron Age, 15, 16 – early Middle Ages (later phases) (photo M. Krzepkowski)

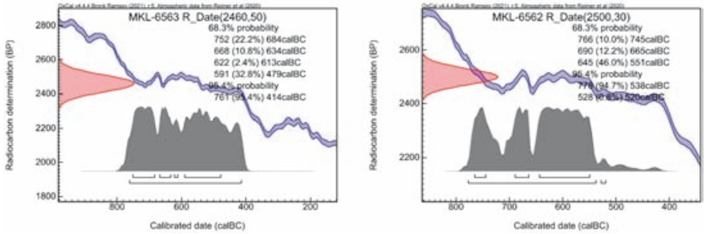

Fig. 12. Dolsk, Dolsk Commune, Śrem County, Site 68 (Kotowo, Site 68).
Calibration graphs of radiocarbon dating results from burnt wooden rampart elements (compiled by M. Krąpiec)

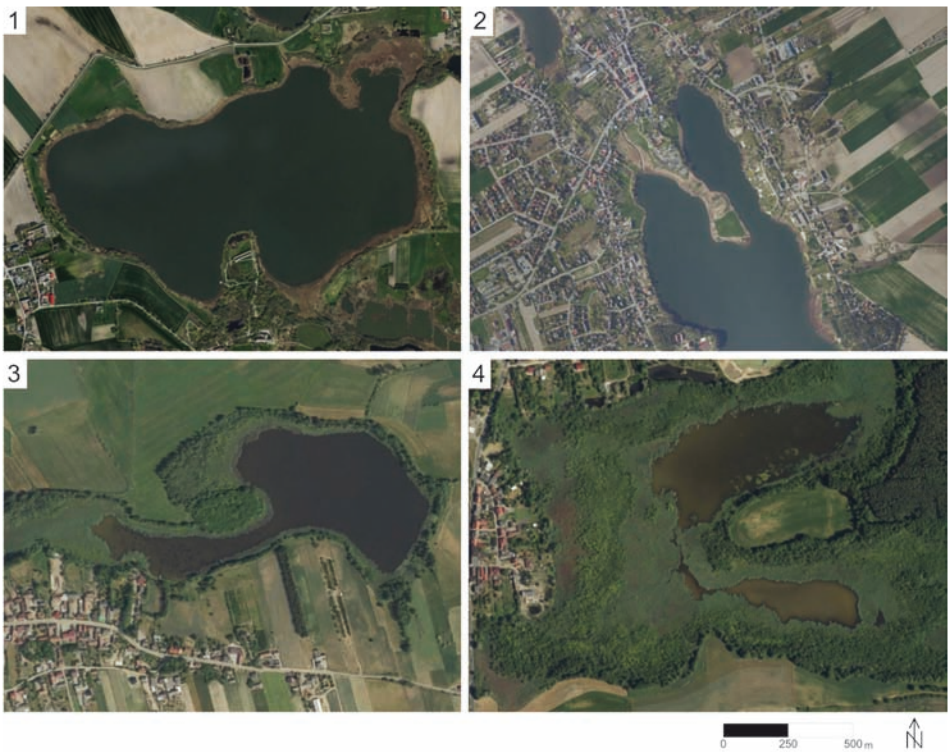

Fig. 13. Comparison of shape and location (peninsulas) of selected defensive structures from the early Iron Age in Greater Poland: 1 – Biskupin, Żnin County; 2 – Bnin, Poznań County; 3 – Cichowo, Kościan County; 4 – Dolsk, Śrem County (compiled by G. Szczurek after geoportal.gov.pl)

earlier origin than previously suggested. Support for this interpretation is also provided by analyses of the geomorphological conditions at the location, the site's size and shape, and the previously mentioned ceramic materials found on the surface. The location of fortified settlements on peninsulas is characteristic of at least one-quarter of the Hallstatt-period sites in Greater Poland. Examples include Biskupin in Żnin County, Bnin in Poznań County, and the relatively nearby site at Cichowo in Kościan County (Fig. 13). The surface area of approximately 2 hectares for the presumed early Iron Age fortified settlement in Dolsk also corresponds well with the dimensions of other similar features in the region. For example, Biskupin in Żnin County measures about 2 hectares, Smuszewo in Wągrowiec County about 2.7 hectares, Grodzisko in Pleszew County about 2.4 hectares, and Rybojady in Międzyrzecz County about 1.9 hectares (Szamałek 2009; Śmigielski and Szczurek 2013). The movable material lying on the peninsula consists of high-quality ceramics with excellent aesthetic and technological characteristics, identical to those known from other well-documented Hallstatt defensive sites in Greater Poland.

Mórka, Śrem Commune, Śrem County

Less than 10 kilometres west of Dolsk, in the village of Mórka in Śrem County, analysis of aerial imagery has produced interesting observations. On the shore of the lake that bears the village's name, an Iron Age settlement was identified in the 1980s as part of the AZP project. The area is now occupied by recreational development. Recent observations based

Fig. 14. Mórka, Śrem Commune, Śrem County, Site 68. Aerial photograph of the presumed defensive settlements (after Google Earth)

on remote sensing data have made it possible to identify an intriguing oval-shaped area of approximately 2 hectares, enclosed by a fully levelled rampart and ditch with a combined width of about 13 to 15 metres (Fig. 14). This is by far the least thoroughly documented site in the context of the settlement issues discussed here. In our opinion, however, there are reasons based on micro-location conditions, site parameters, and the chronological position of the artefactual material that conditionally warrant including this site among those requiring more extensive research.

Zaniemyśl, Zaniemyśl Commune, Środa County

To conclude, we briefly signal the preliminary results of research conducted on Edward's Island in Zaniemyśl in Środa County. Until now, the island was known mainly as the scene of the elaborate suicide of Count Edward Raczyński in 1845, who famously fired a cannon directly at his own head. Since the beginning of 2025, rescue archaeological excavations have been carried out around the foundations of a nineteenth-century larchwood Swiss-style cottage once belonging to this distinguished Polish patriot. These investigations have led to important findings that point to a much earlier phase of habitation on the island than previously recognised (Fig. 15). Beneath layers associated with nineteenth century settlement and the early medieval period, a stratigraphic layout characteristic of rampart collapse was recorded (Fig. 16). The ceramic material found in this layer is, without exception, linked to pottery traditions from the end of the Bronze Age and the beginning of the Iron Age (Żychlińska 2013; Kaczmarek 2017; Szczurek 2021). The assemblage is dominated by fragments of discoid plates and coarse-surfaced pot forms, as well as so-called tableware, carefully finished with blackened and polished surfaces (Fig. 17). The presence of ceramic material within the collapsed rampart cannot, of course, be taken as conclusive evidence for dating the entire site. The context of the finds in the relevant layers suggests secondary deposition, most probably associated with slightly earlier settlement activity that preceded the construction of the fortifications. It is important to reiterate that no later artefactual material was found in the rampart layers. This absence supports the hypothesis that the newly identified rampart remains are associated with settlement from the beginning of the Iron Age. Charred wooden construction fragments were collected during the excavations for radiocarbon dating. However, at the time this text was submitted for publication, the samples had not yet been analysed, and rescue work at the site was still ongoing.

DISCUSSION

The preliminary research results presented here warrant consideration in challenging the existing estimates of the number of defensive settlements from the Hallstatt period in Greater Poland, which are based on previously accepted findings. The observations

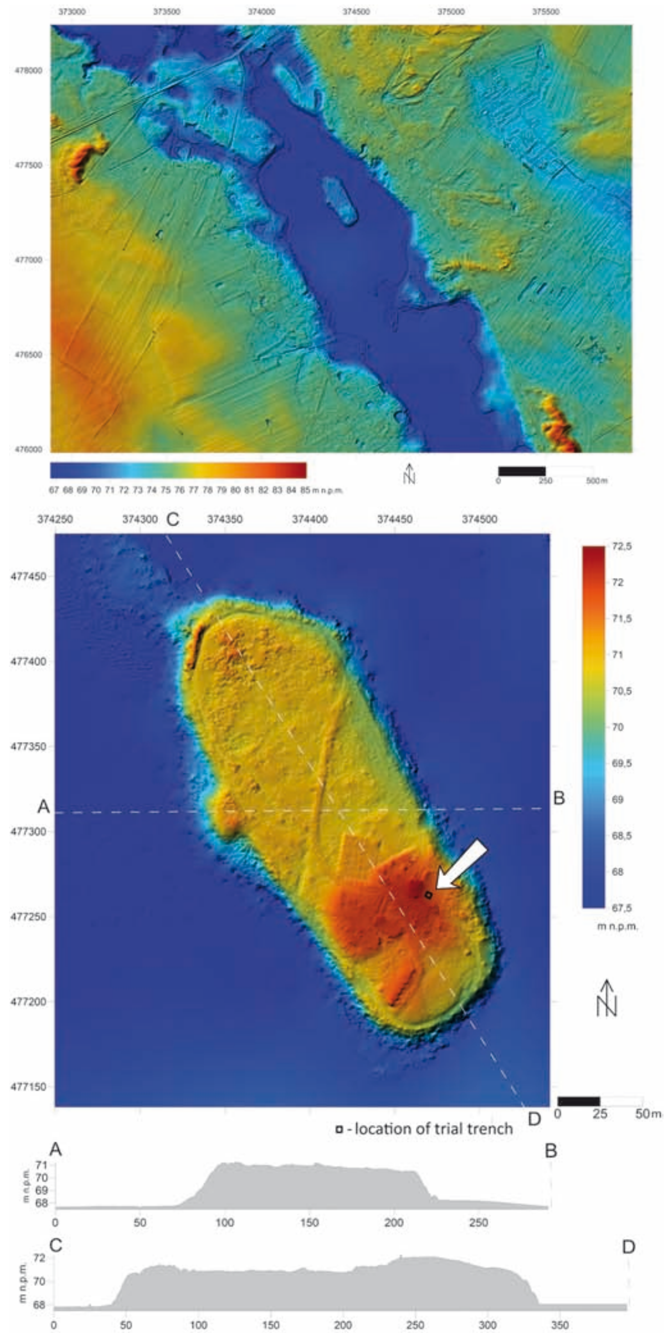

Fig. 15. Zaniemyśl, Zaniemyśl Commune, Środa County. Hypsometric visualization based on processed ALS LiDAR point cloud, source: GUGIK geoportal.gov.pl (compiled by W. Małkowski)

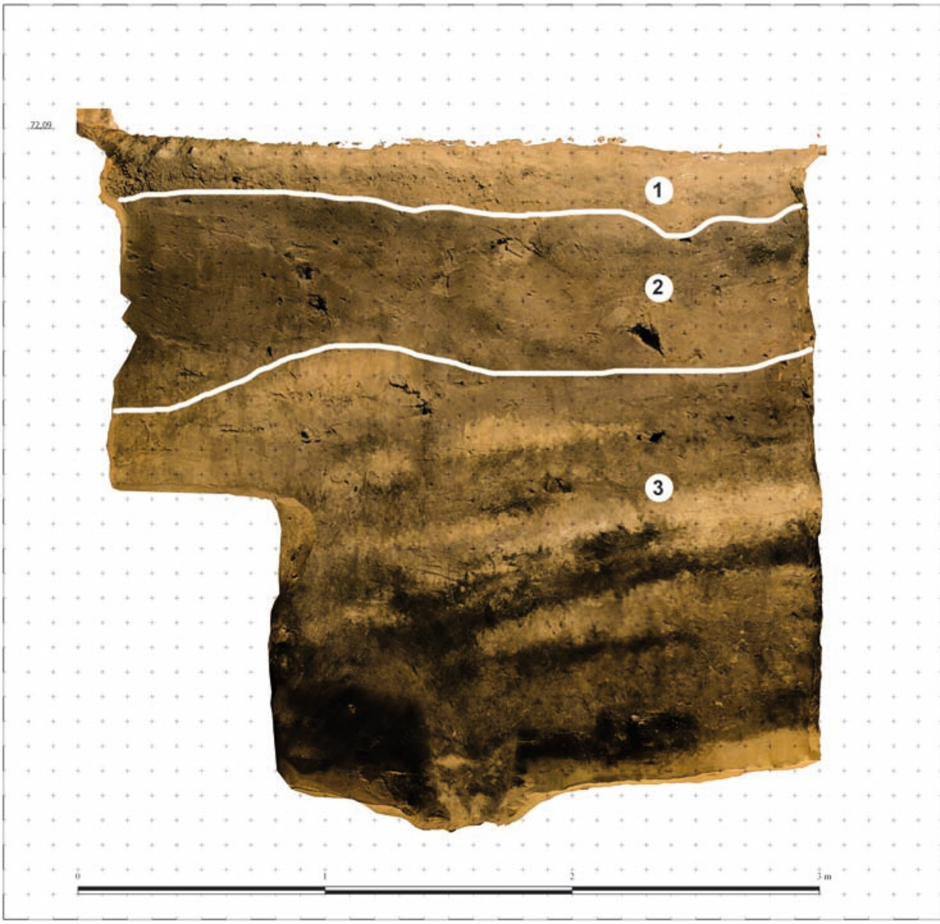

Fig. 16. Zaniemyśl, Zaniemyśl Commune, Środa County. Projection of the northern trench profile in the area of the Swiss House (compiled by A. Dębski and A. Różański)

discussed were preliminary, and while the possibility of negative verification for some of them cannot be ruled out, it appears unlikely. Even at this early stage, we already possess information that, to some extent, permits a more confident interpretation.

Definitive certainty regarding the chronological position and function of the sites briefly described here can only be achieved through excavation research that includes the entire sequence of defensive enclosures and the stratified deposits adjacent to them on the interior side, to investigate their interrelationships. This approach follows the model applied in the 1970s during the program to verify Lusatian culture defensive settlements, carried out by the Department of Greater Poland Archaeology at the Institute of the History of Material Culture of the Polish Academy of Sciences (Śmigielski 1993).

Fig. 17. Zaniemyśl, Zaniemyśl Commune, Środa County. Fragments of early Iron Age pottery recorded in the test trench within the rampart layers (photo G. Szczurek)

The preliminary nature of the work discussed and the resulting lack of adequate financial support did not allow for a research scope broad enough to determine the chronological position of individual sites with certainty. The extent of the undertaken activities was determined by the budget available to our team. Nevertheless, despite these evident limitations, the results should be considered satisfactory and provide a hopeful outlook for the future outcomes of the research efforts that have just been initiated.

The sites at Rogaczewo Wielkie and Dolsk are the most promising for a Hallstatt-period attribution of their defensive layouts, as we already have initial radiocarbon dating results for both locations.

The first two dates obtained for the wooden rampart at Rogaczewo Wielkie generally align with previous observations on the absolute chronology of Lusatian defensive settlements. However, their low precision is, of course, far from satisfactory. We are dealing exclusively with radiocarbon dating results, specifically from the clearly defined Hallstatt plateau (Walanus and Goslar 2004). The results become more acceptable if we assume that the actual age falls in the earlier part of the probability range, although this is only partially supported by modelling.

Only future planned investigations will allow a more precise determination of the site's chronological position at Rogaczewo Wielkie. It is possible that exploring stratified deposits in better-preserved, elevated parts of the rampart may yield valuable samples suitable for dendrochronological analysis. A broader excavation scope will also allow examination of the constructional and material layout of the rampart, as well as the internal architecture, including the nature of the enigmatic trapezoidal feature occupying the central zone of the enclosure. The absence of ceramic material within the rampart may indicate a lack of earlier settlement activity at this location. Despite the wooded condition of the defensive site, attempts were made to identify ceramic material in exposed areas such as animal burrows, uprooted trees, and molehills. Unfortunately, these efforts did not result in the recovery of a single pottery fragment, nor any metal artefacts.

This situation requires us to adopt a perspective somewhat different from the traditional interpretation of a Lusatian Urnfields defensive settlement. It is clearly too early to determine the role of this site within local settlement structures. Other, less conventional interpretations must also be considered, including ones not directly related to a settlement function in the strict sense. This is particularly relevant in light of the mysterious trapezoidal outline within the enclosure. On the other hand, if geophysical prospection confirms the absence of anomalies that could be correlated with domestic or utility structures, then it is worth considering the possibility that this may be an abandoned construction, left unfinished or used only briefly. Such cases are well documented in later historical periods (Wroniecki *et al.* 2021), and there is every reason to believe that similar instances occurred during the Hallstatt period as well. After all, ill-considered and unsuccessful decisions have always been a part of the human journey.

In the case of the defensive site at Dolsk, although the samples used for radiocarbon dating did not originate from a homogeneous layer, when combined with other data such as location, shape, surface area, and surface artefacts, we have a solid basis for formulating the hypothesis that this site expands the catalogue of early Iron Age defensive settlements in Greater Poland. The information obtained thus far through the research process clearly demonstrates that the site situated on the peninsula of Małe Dolskie Lake holds significant cultural value as an archaeological site, along with a previously underappreciated scientific and cognitive potential (Krzepkowski 2024). This is only one site among a long list of locations forgotten or overlooked by both academic research and heritage protection services, yet 'valued' by amateur metal detectorists, whose destructive activity is evidenced by countless pits scattered across the field.

As in the case of Rogaczewo Wielkie, the dating results align more closely with our current understanding of the absolute chronology of Hallstatt-period fortified settlements if we assume their age lies within the earlier portion of the probability range. Due to the significant flattening of the calibration curve, date modelling using OXcal software allows only for minor adjustments to individual intervals and the exclusion of the latest portion of the range, that is, after 500 BCE. The results obtained for both Dolsk and Rogaczewo Wielkie therefore fit only broadly within current observations concerning the chronology of fortification construction processes in Greater Poland during the Hallstatt period (Ważny 1994; 2009; Harding and Rączkowski 2009; 2010; Kaczmarek and Szczurek 2015). However, the possibility of later dating for the discussed sites should remain admissible, as is supported, among other evidence, by radiocarbon dates obtained for defensive settlements in the Chełmno Lake District (Gackowski 2012). It should be emphasised that the anomalies recorded during geophysical prospection form a complex system indicative of a multi-phase structure at Dolsk. Their precise dating and chronological differentiation will require extensive excavation, during which well-documented samples can be obtained for absolute dating, including radiocarbon analysis, but above all, dendrochronology. The physical characteristics of the timber fragments from the rampart structure brought to the surface by agricultural activity support the likelihood that future excavation will uncover preserved beam remains suitable for dendrochronological analysis, allowing the precise determination of the felling dates of the trees used in the construction of the fortifications.

There is much to suggest that future work will not yield definitive conclusions regarding the heavily damaged presumed site at Mórka in Śrem County. If we provisionally accept that the defensive perimeter enclosing part of the small headland is chronologically consistent with the ceramic material recovered during surface surveys, then, hypothetically, it would have had a form that departs from the known early Iron Age patterns. Fortifications from the Hallstatt period, not only in Greater Poland, were typically characterised by massive, structurally varied ramparts made of wood, stone, and earth, or by constructions combining multiple building materials (Puziuk 2010). When using the term 'defensive settlement' as a synonym for 'stronghold' or 'fortified site,' it is worth reflecting on the conceptual scope of this designation. Including such sites within the category of defensive settlements in the strict sense, as understood in the scholarly literature, would undoubtedly be an overstatement. The character and constructional solutions of the defensive perimeter at Mórka may, unfortunately, remain forever unclear due to the extensive destruction caused by gravel extraction.

Despite the initial stage of research on Edward's Island in Zaniemyśl, the character of settlement organisation within the Kórnik-Zaniemyśl lake channel is beginning to take shape intriguingly. Years ago, this issue was addressed by J. Fogel in the context of his studies on the Bnin microregion, with the fortified settlement on the Szyja Peninsula in Bnin serving as a key reference point (Fogel 1985). The highly probable identification of a fortified settlement in nearby Zaniemyśl, located just 10 kilometres away, undoubtedly opens a new chapter in studies of late Bronze Age and early Iron Age settlement in this part of Greater Poland (Fig. 15). The limited scope of excavation, restricted to a trench measuring 9 square metres, does not yet allow even a hypothetical reconstruction of the fortification layout on the three-hectare island. The analysis of the digital terrain model and the spatial distribution of artefactual material provides some provisional insights in this regard. It is possible that the defensive structure encompassed the southern, slightly elevated part of the island, where characteristic pottery fragments are most heavily concentrated. The enclosed site identified on Edward's Island most likely expands the catalogue of numerous early Iron Age sites located on islands, such as those at Komorowo in Szamotuły County, Słupca in Słupca County, and Ostrowie in Konin County (Szamałek 2009 and references therein).

The example of Zaniemyśl, much like the remains of the site at Przemęt in Wolsztyn County studied by R. Virchow (Malinowski 1955 and earlier references therein), clearly illustrates a category of stronghold-type sites that have become entirely unrecognisable, lacking any visible topographic form due to later settlement and urban development. The number of such sites may be pretty substantial, and their identification through remote sensing methods is, for obvious reasons, nearly impossible.

It is important to emphasise the limited spatial scope of the pilot study, which was restricted to the three counties of Kościan, Śrem, and Środa. This represents just under seven per cent of the region's total area, from which only two Hallstatt-period fortified settlements were previously known, both located in Kościan County, in the villages of Jurków and Cichowo, in the Krzywiń Commune. It would be a methodological flaw to apply simple mathematical proportions and extrapolate the observations from these three counties to the entire region. Nevertheless, such a concentration of sites with comparable chronological attribution inevitably sparks the imagination. From there, it is only a short step to proposing a model in which fortified settlements in the early Iron Age were a relatively common feature of the settlement landscape in Greater Poland.

The cluster that is beginning to emerge, comprising the defensive sites at Jurków, Rogaczewo Wielkie, and Cichowo (all located within Krzywiń Commune), as well as Dolsk

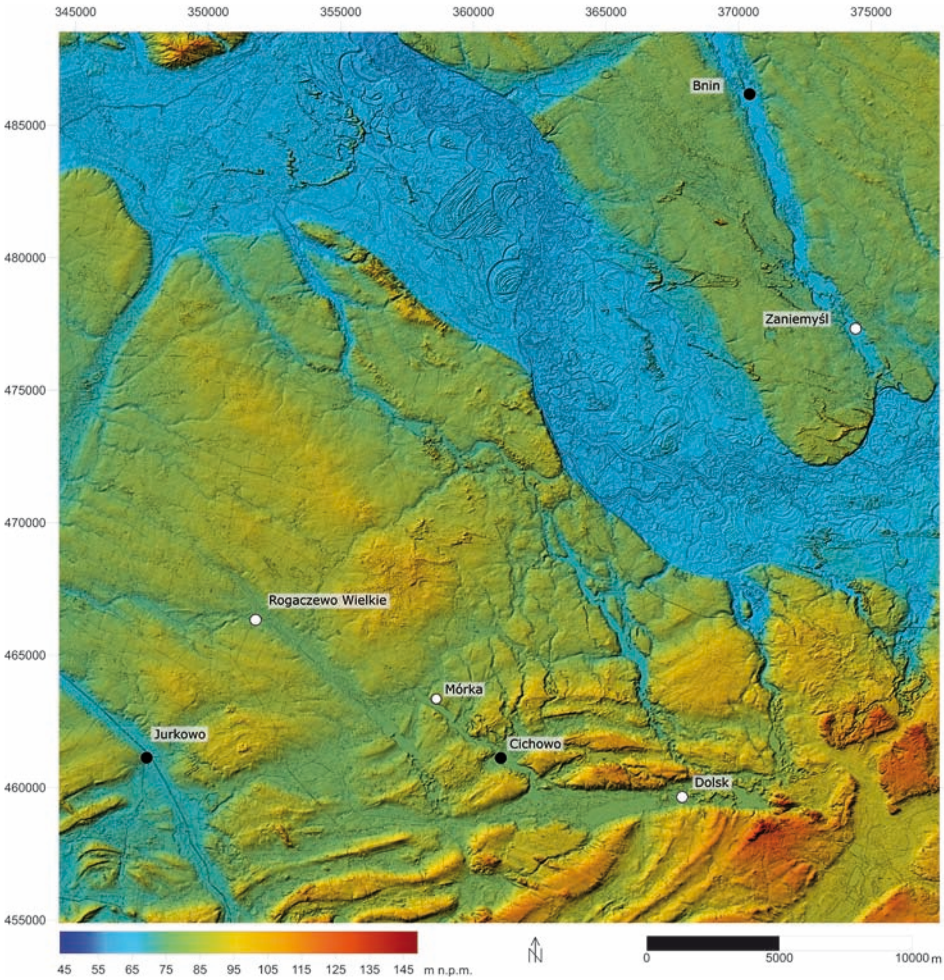

Fig. 18. Distribution of early Iron Age defensive sites in the Krzywiń Lake District and the Kórnik-Zaniemyśl lake valley. Black dots mark sites previously known in the literature, white ones mark those discussed in this article (compiled by G. Szczurek and M. Krzepkowski)

and, potentially, Mórka, is increasingly intriguing. Such a concentration of defensive settlements has not previously been observed in Poland. The frequency of fortified sites in this area may be higher than in the Pałuki region, which has held the lead in research on this phenomenon since its earliest stages (Figs 18 and 19). This area offers an excellent research ground for micro and mesoregional studies and for attempts to explain the place and function of early fortified enclosures within the settlement network of southern Greater Poland. Realising this fascinating objective will require long-term and interdisciplinary research, but there is no doubt that the effort should be made. It is at the most basic level

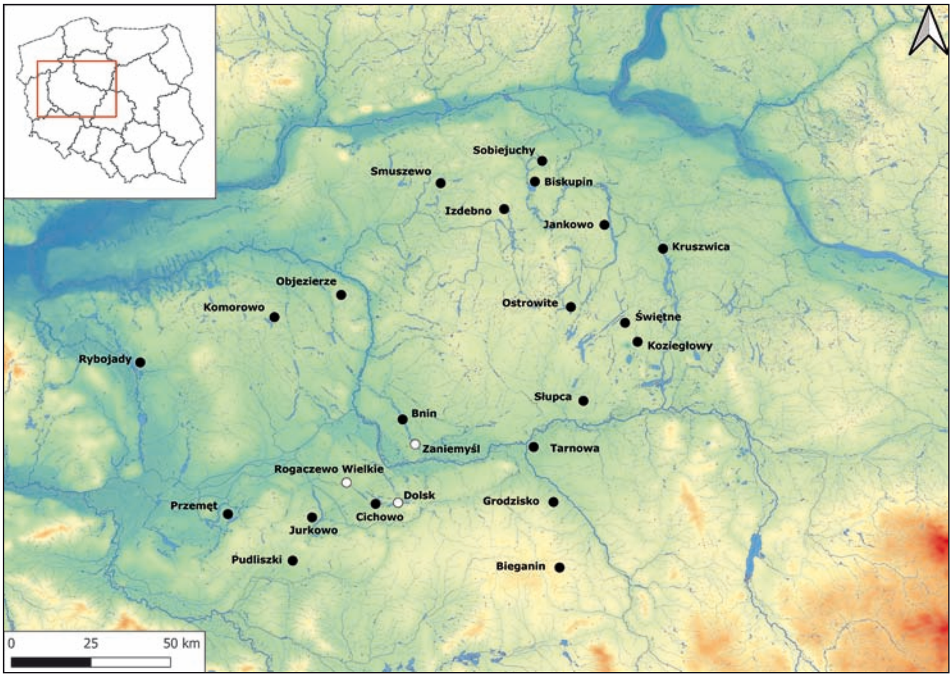

Fig. 19. Defensive settlements from the beginning of the Iron Age in Greater Poland in light of the current state of research – black dots (compiled by G. Szczurek after Śmigielski 1993; Kaczmarek and Szczurek 2015, with additions), including presumed new defensive sites discussed in this article – white dots

of organisational analysis — the microregional scale — that the most significant research potential lies, offering the possibility of identifying real past social and economic structures. The investigations within the Krzywiń Lakeland may mark the beginning of a new chapter in the study of fortified settlements in Greater Poland during the early Iron Age. They may help lift the field out of the stagnation it has undoubtedly endured for several decades.

FINAL REMARKS

More than one hundred years after J. Kostrzewski initiated research on defensive features from the beginning of the Iron Age, we still appear to be at a very early stage in understanding the nature and scale of this phenomenon. Throughout the past century, successive catalogues of Lusatian defensive settlements have shown considerable variation. Over time, they exhibited a clear tendency to expand. From thirteen sites identified at the outset of studies in the 1920s (Kostrzewski 1923), the number grew to 45 before the completion of verification work by W. Śmigielski and D. Durczewski (Śmigielski 1991 and earlier references therein), as well as research on early medieval strongholds by Z. Kurnatowska and A. Łosińska (Kurnatowska and Łosińska 1981). Until now, the catalogue of defensive sites in Greater Poland with a Hallstatt-period attribution confirmed through excavation included 21 entries. In light of the most recent research findings presented in this article, this number will likely increase soon. The level of documentation concerning the site at Rogaczewo Wielkie already provides substantial grounds for such an addition. Further research is mainly required for the sites at Dolsk and Zaniemyśl, but even in these cases, solid source-based evidence supports this chronological classification.

Observations from three adjacent counties in Greater Poland authorise the hypothesis of a decidedly greater intensity of defensive settlement in the Hallstatt period than is confirmed by the current results of excavation work. Decisive progress in these studies will undoubtedly be driven by systematic, reliable remote sensing surveys covering the entire region. The picture that is beginning to emerge is much more complex and dynamic than previously thought, and it can be expected that large-scale application of aerial photography, LiDAR data analysis, and geophysical research will continue to significantly expand the corpus of known sites and our understanding of their functions (*cf.*, Fernandez-Gotz 2018). Important progress should also be associated with the re-analysis of some sites previously verified negatively, but for which such elementary analytical work as dating by natural science methods was not carried out. The implementation of a broadly conceived work will inevitably lead to a significant increase in the number of known fortified settlements in Greater Poland from the beginning of the Iron Age. In our assessment, estimates at least 50% higher than the current compilation are not exaggerated. Accepting as at least somewhat representative the observations from an area of less than 2000 km^2 of the region, since that is what the three counties covered by preliminary research encompass in total, one should decidedly lean toward the need to modify the existing picture of defensive settlement in the Hallstatt period in Greater Poland.

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OLD AND NEW AT DĄBROWA. RICHLY FURNISHED EARLY IRON AGE GRAVES AT A LUSATIAN CULTURE CEMETERY IN WIELUŃ DISTRICT, CENTRAL POLAND

ABSTRACT

Janiak R. and Drozd-Lipińska A. 2025. Old and new at Dąbrowa. Richly furnished Early Iron Age graves at a Lusatian culture cemetery in Wieluń District, central Poland. *Sprawozdania Archeologiczne* 77/1, 347-368.

The Lusatian culture burial ground at Dąbrowa, Wieluń district, lies in the upper Warta River basin. Due to its location in the south-western part of central Poland, it accumulated imports from the Halstatt zone (bronze serpentine clasp, iron and bronze spearheads). This was evident in the inventories of two early Iron Age graves. Local artefacts were also discovered in the cemetery, which were imitations of imports (bronze clasps). This was demonstrated by the results of surveys conducted in 1927 and 1928. This makes it possible to identify representatives of the local elite among the buried. Research undertaken on the same cemetery in 2021 confirmed the presence of burials from the Halstadt period. However, their equipment was not as prestigious (swan-necked pins, iron sickles). It is worth noting that this cemetery was already established earlier, during the Younger Bronze Age.

Keywords: Central Poland, Lusatian Culture, Hallstatt period, cemetery, elite
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INTRODUCTION

The Lusatian culture cemetery at Site 2 in Dąbrowa, Wieluń District, has been known for almost a century. It is located south of the currently small River Pyszna, which is part of the upper Warta watershed (Figs 1 and 2). It is also notable that the cemetery is situated almost equidistant from the upper reaches of two rivers: the Prosna and the Warta. They played important roles during prehistory as contact routes, as well as in long-distance

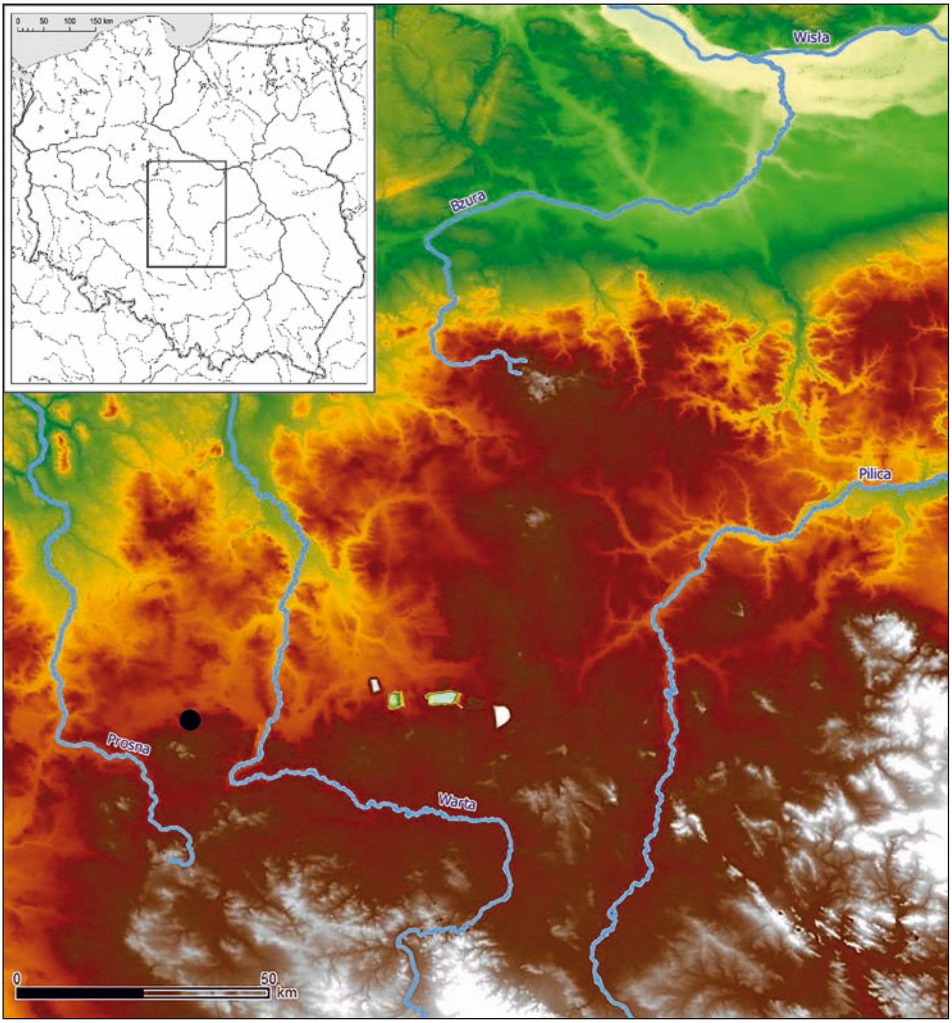

Fig. 1. Location of Dąbrowa, Wieluń District in central Poland marked with a black dot (drawing by R. Janiak)

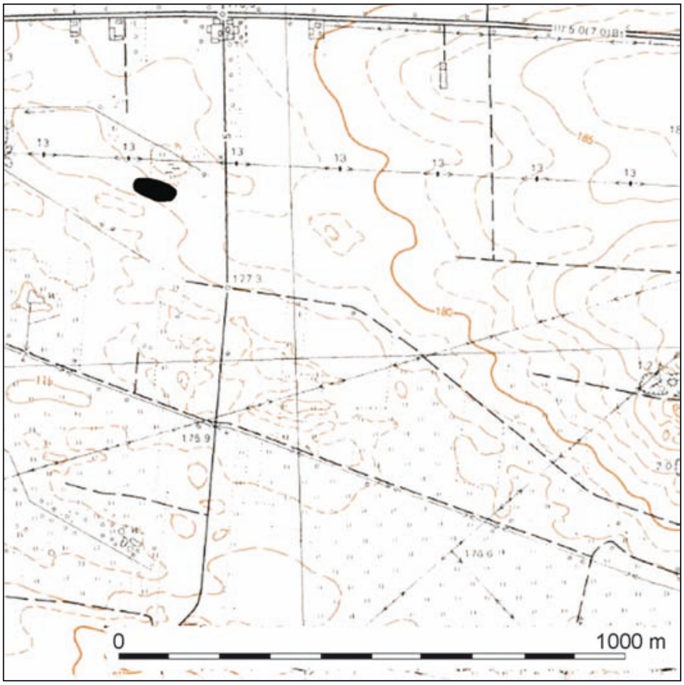

Fig. 2. Location of the Lusatian culture cemetery in Dąbrowa, Wieluń District, site 2 marked with a black oval (drawing by R. Janiak)

trade. Due to its location, this cemetery has frequently been included in discussions of the Early Iron Age in central Poland.

Coincidental discoveries made by local farmers prompted fieldwork. Thanks to their alert, Konrad Jażdżewski, then a prehistory student (and later in the mid-1940s the founder of the Archaeological Centre in Łódź), conducted the first excavations in 1927. He uncovered two burials, one of which dates back to the Early Iron Age and warrants special attention (Janiak 2010). This grave was labelled II/1927 (Jażdżewski 1929; Durczewski 1948, 218), and is distinguished by its size and rich pottery assemblage, as well as numerous iron and bronze objects. Jażdżewski continued fieldwork at this site the following year. At that time, 13 additional graves and a stone pavement were uncovered (Durczewski 1948, 218-226). Among the burials of 1928 is one labelled 10/1928. It differs from II/1927 in both form and its metal furnishings. This numerically more modest metal assemblage indicates a date in the Hallstatt Period. Excavations did not resume until the 1960s, when an additional 31 graves were discovered. Those finds are kept in the Wieluń District Museum in Wieluń and have not been published to date. They were ascribed a preliminary date in Hallstatt C. However, this now seems doubtful. More likely, they date from the Late or Final Bronze Age. No metalwork was found in them.

The third fieldwork campaign at Dąbrowa commenced in 2021, during which twelve features were investigated. Among them were four graves: one dating from the later phase of the Bronze Age (Ha A2), another (labelled 2/2021) from the Late Hallstatt Period. Two further features, being small clusters of burnt human bones, appear to be the remains of destroyed burials. The remaining features were not identifiable as burials. Due to the small scale of the fieldwork, it has not been possible to determine whether the non-funerary features were integral parts of the cemetery space or remains of settlement.

In the summer of 2022, a new trench was opened about 80 metres to the east of the burials discovered in 2021. The finds made at that time cannot be ascribed to any known funeral rituals of the Lusatian culture. They reflect a different type of activity. However, in view of how close they were to the cluster of graves, it would not be easy to see them as settlement remains.

GRAVE II/1927

Today's significantly expanded set of comparative material encourages a reassessment of the discoveries made in the 1920s at Dąbrowa. Grave II/1927 is exceptional in many respects (Durczewski 1948, 218, pl. 95: 9-12; 96). Firstly, it was big: 3.5 m by 2.5 m (Fig. 3).

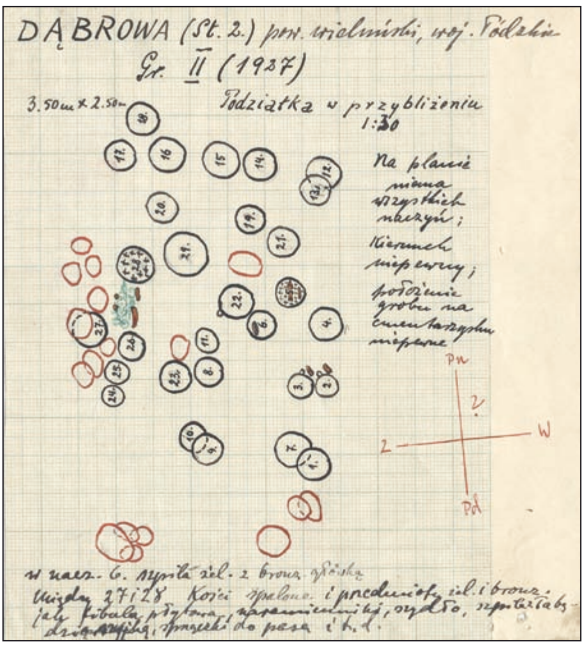

Fig. 3. Dąbrowa, Wieluń District, site 2. Grave plan II/1927:
vessels – black, bronze – green, iron – light brown, red – stones (based on the Archive of the Archaeological Museum in Poznań – made by R. Janiak)

Secondly, it had a stone cist. The pottery represented about 40 vessels, eight of which contained burnt human bones. The preserved archival plan, however, does not include all the vessels found in the grave. A cluster of burnt human bones, marked on the plan, raises doubts, among which were metal objects (Janiak 2010, 196, 197, fig. 1). Equally unusual are the furnishings, consisting of several dozen bronze and iron objects. Vessel #6 contained an iron pin with a bronze head. In vessel #5 were an iron spearhead and some unspecified bronze objects, along with burnt bones. Between vessels #27 and #28 was a concentration of burnt human bones without any trace of a container. Among the bone fragments were a bronze fibula with a richly decorated bow, known since that time as the Dąbrowa type, bracelets/armlets, an awl, a swan-neck pin, and iron belt hooks (Fig. 4).

Locating Grave II/1927 on the site is challenging. It is marked on a plan of uncovered features drawn only in 1928. As a result, its exact spatial relationship to the other graves is

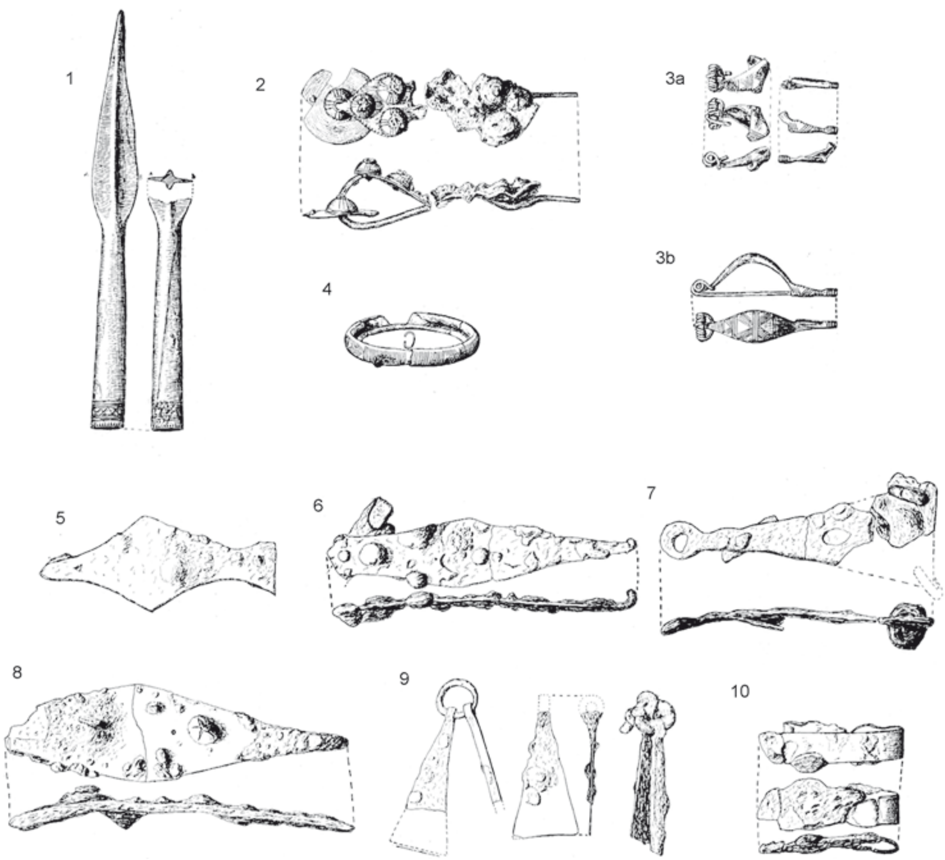

Fig. 4. Dąbrowa, Wieluń District, site 2. Selected artefacts from grave II/1927:
2, 3a, 3b, 4 – bronze; 1, 5-10 – iron (no scale, after Durczewski 1948 – made by R. Janiak)

unknown. Another important aspect to note is related to Grave II/1927's stone enclosure, which is discussed in more detail below. In the same cemetery in 1928, four more graves with similar stone surrounds were discovered. However, these were smaller structures. They were also not equipped with metal items. It is worth noting that similar stone grave structures were also discovered in the cemetery in Łubnice, located on the upper Prosna River. Seven such burials were discovered here (Kaszewski 1986, 136).

A popular publication of the first fieldwork season's results at Dąbrowa (Jażdżewski 1929) presents a relatively small selection of metalwork from this grave. Perhaps only representative pieces of the assemblage were illustrated, to avoid duplicating similar artefacts. In any case, it did not accurately reflect the actual value of the metal furnishings in Grave II/1927. The fieldwork documentation is currently kept in the archives of the Archaeological Museum in Poznań. It confirms the quality, quantity and significance of the metalwork. It has been estimated that the grave contained 1.5 kilos of bronze and iron (Janiak 2010, 196). Some of these artefacts were damaged, and most, sadly, were lost during World War II.

GRAVE X/1928

Few details survive about the grave numbered X/1928. It was covered by a round stone pavement with a diameter of 1.5 m (Durczewski 1948, 222, pl. 63: 9-12; 95: 8; 99: 9, 12). We also encounter this outline on the 1928 cemetery plan. However, there is no plan drawing of the grave. None was probably made due to the fast pace of the fieldwork. Under the stone pavement was a pit with burnt human bones, sherds of four pots and some metal objects. The published description of the grave does not provide precise details. The burnt human bones that were collected were treated as a single find unit. The vessels were reassembled, completely or to a large extent. Without sufficient evidence to clearly determine the type of burial, we may consider the destruction of these vessels, for instance, during the laying of the pavement over the burial pit. We can only assume this was an urn burial.

It seems that the burial container was a large vase-shaped vessel with a cylindrical neck and a slightly roughened belly surface (Fig. 5: 1). This vessel is carefully made. It has a regular shape and a carefully controlled symmetry. Its upper part is carefully smoothed. The rusticated belly surface should be seen as equally intentional. Our suggestion that this was the cremation urn is supported by similar vessels found in Grave 2/2021. Here, vase-like vessels with a distinct, cylindrical neck and a bulbous, slightly rusticated belly served as burial urns.

Next to the vase-like vessel in Grave X/1928 was a large cup or vase (Fig. 5: 2). It had initially had a single ribbon-like handle that seems to have been intentionally broken off before burial, so 'cup' may be more apt. It is decorated on the upper part of the belly with vertical and diagonal bands of engraved lines, separated by groups of holes. This vessel is also very carefully made, as evidenced by the regularity of its shape, the meticulous smoothing of its external surface, and the good firing. The two other vessels found in the fill of the grave pit are a small vase-shaped vessel with a cylindrical neck (Fig. 5: 3) and a bowl with conical rim (Fig. 5: 4). The metal inventory probably consisted of only three items: an iron spearhead (Fig. 5: 5; Durczewski 1948, 222, pl. 95: 8; Gedl 2009, 88, pl. 34: 434) and two bronze objects (Durczewski 1948, 222, pl. 99: 9, 12). One of the latter is a spiral-disc pin (Fig. 5: 7). The disc is made of a thin rod or thick wire with a quadrangular cross-section. The other bronze one should be reassessed (Fig. 5: 6, see below).

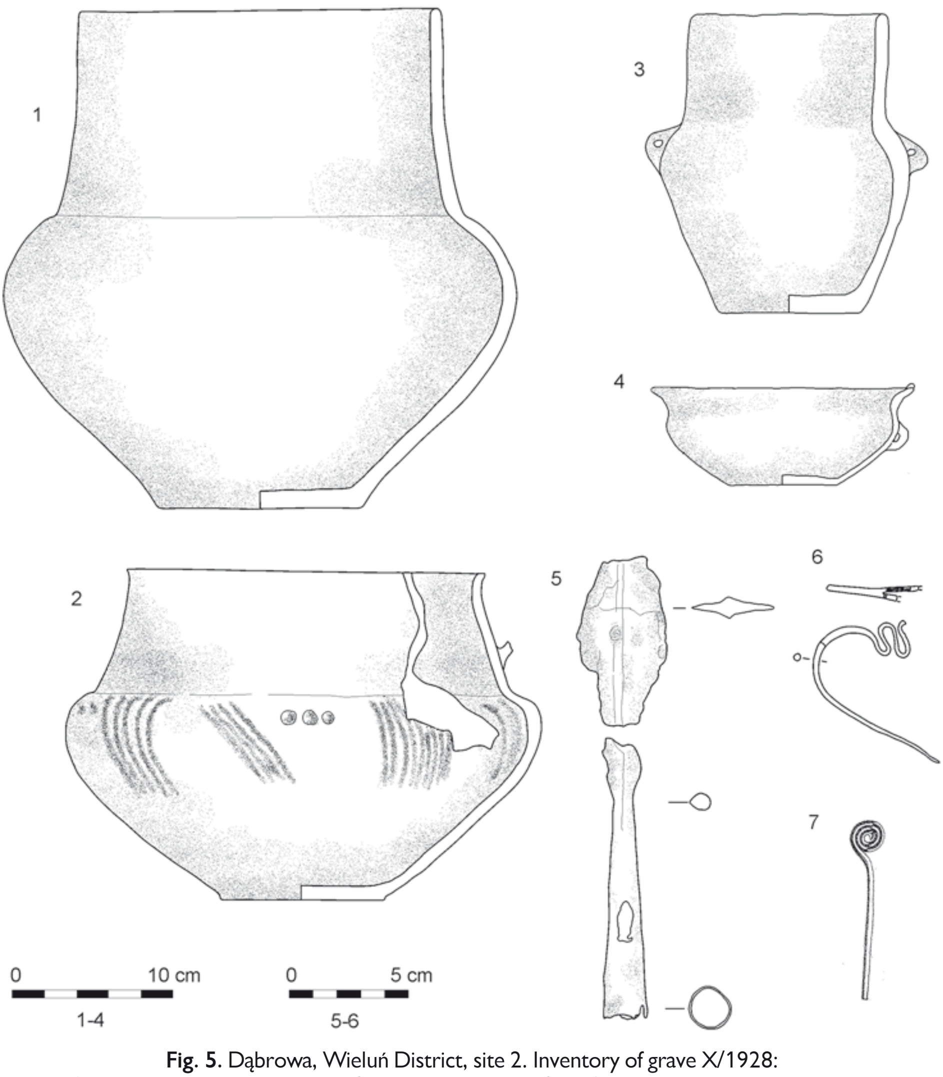

Fig. 5. Dąbrowa, Wieluń District, site 2. Inventory of grave X/1928:
1-6 – drawings based on originals from the collection of the Archaeological Museum in Poznań
(1-6 – drawing by R. Janiak; 7 – no scale, after Durczewski 1948)

GRAVE 2/2021

Grave 2/2021 was a multi-urn burial (Fig. 6). It did not yield as many prestigious objects as the graves discussed above. However, the size, set of vessels, and metal inventory also mark it as relatively wealthy. The oval burial pit measured c. 2.05 by 1.5 m. No traces of any stone enclosure were observed. In total, it has been possible to reconstruct 27 vessels from its pottery contents (Fig. 7). These vessels were placed on two or three levels, creating a compact layer. Only in the case of the lowest-deposited funerary vessels (Figs 6; 7: 1, 2) and the bowl covered with a disk (Figs 6; 7: 3, 4) was it possible to characterise them precisely. We cannot provide specific details about the location of the vast majority of the vessels, especially those situated slightly higher. This is because they had been largely crushed and displaced by later agricultural practices. Two burial urns were placed at the bottom of the burial pit. These are vase-shaped vessels with cylindrical necks. The lower parts of the bellies were slightly rusticated. On top of the layer of crushed pottery, a cluster of burnt bones was found, next to which there were fragments of two other vase-shaped vessels (Fig. 7: 5, 6). Their partial reconstruction shows that they also had a separate neck. In this way, they resemble the previously discussed urns, although they were slightly smaller in size. We assume that they also served as burial urns, originally placed on top, which were almost completely destroyed over time. One of them was decorated with a pseudo-cord ornament. Differences in deposition methods and levels above the bottom of the pit sug-

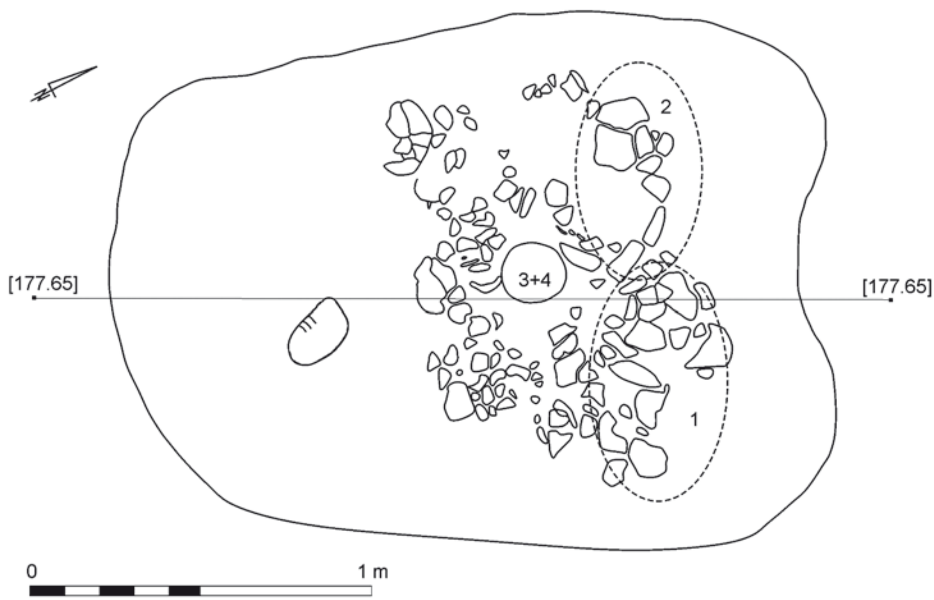

Fig. 6. Dąbrowa, Wieluń District, site 2. Grave plan 2/2021: 1-4 – location of identified vessels (drawing by R. Janiak)

gest that the burnt bones and vase-shaped vessels on top may have been deposited in two separate events.

Other vessels found in the grave are two small vase-shaped vessels, one larger one, a bowl originally covered with a plate, five egg-shaped pots, another fragmentarily preserved plate, seven ladles with ears, and five bowls of various sizes.

Among the burnt human bones in burial urn #1 at the bottom of the pit were several iron and bronze objects. The iron sickle (Fig. 8: 1) had been damaged on the pyre. It is curved and has a bent tang, which was probably intended to attach it to a wooden or bone handle. The tang is bent in a way that suggests a right-handed person used the sickle. On the edge of the blade, near the base, are some oblique cuts, which were probably intended to increase its effectiveness in use. The sickle is about 16.5 cm long. The tang is 1.7 cm long. The blade is no thicker than 4 mm. Weight 34.3 g.

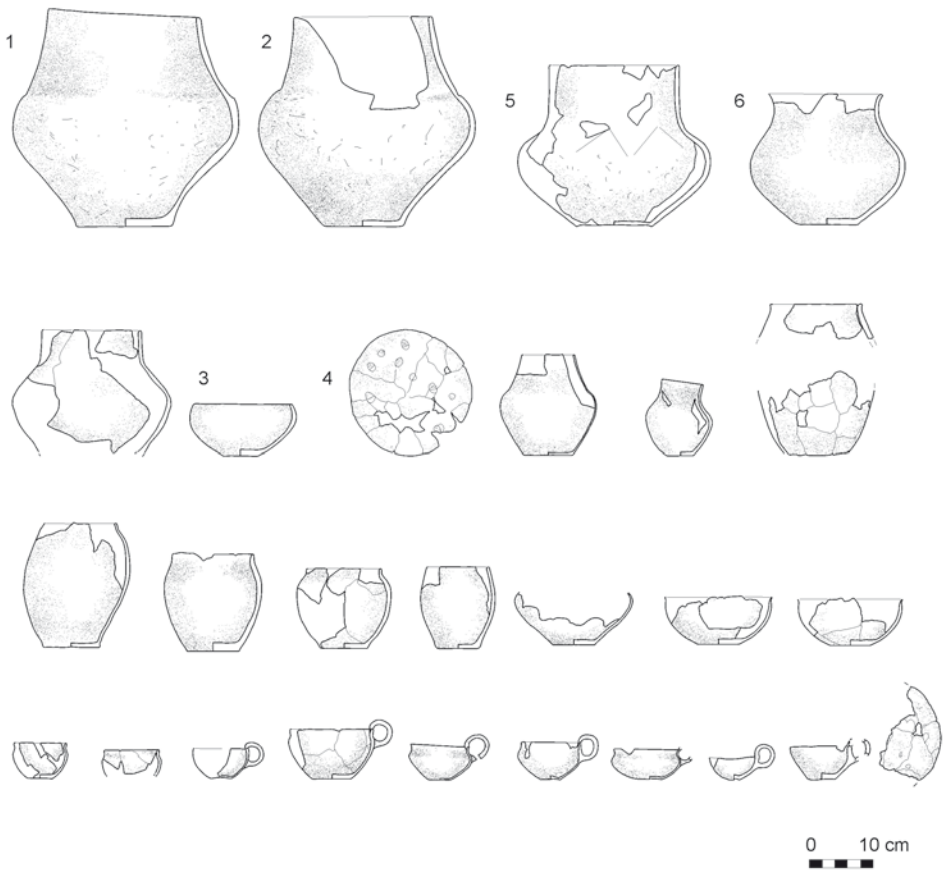

Fig. 7. Dąbrowa, Wieluń District, site 2. Vessels from grave 2/2021. Vessels of certain (1-4) or presumed (5-6) location within the grave (drawing by R. Janiak)

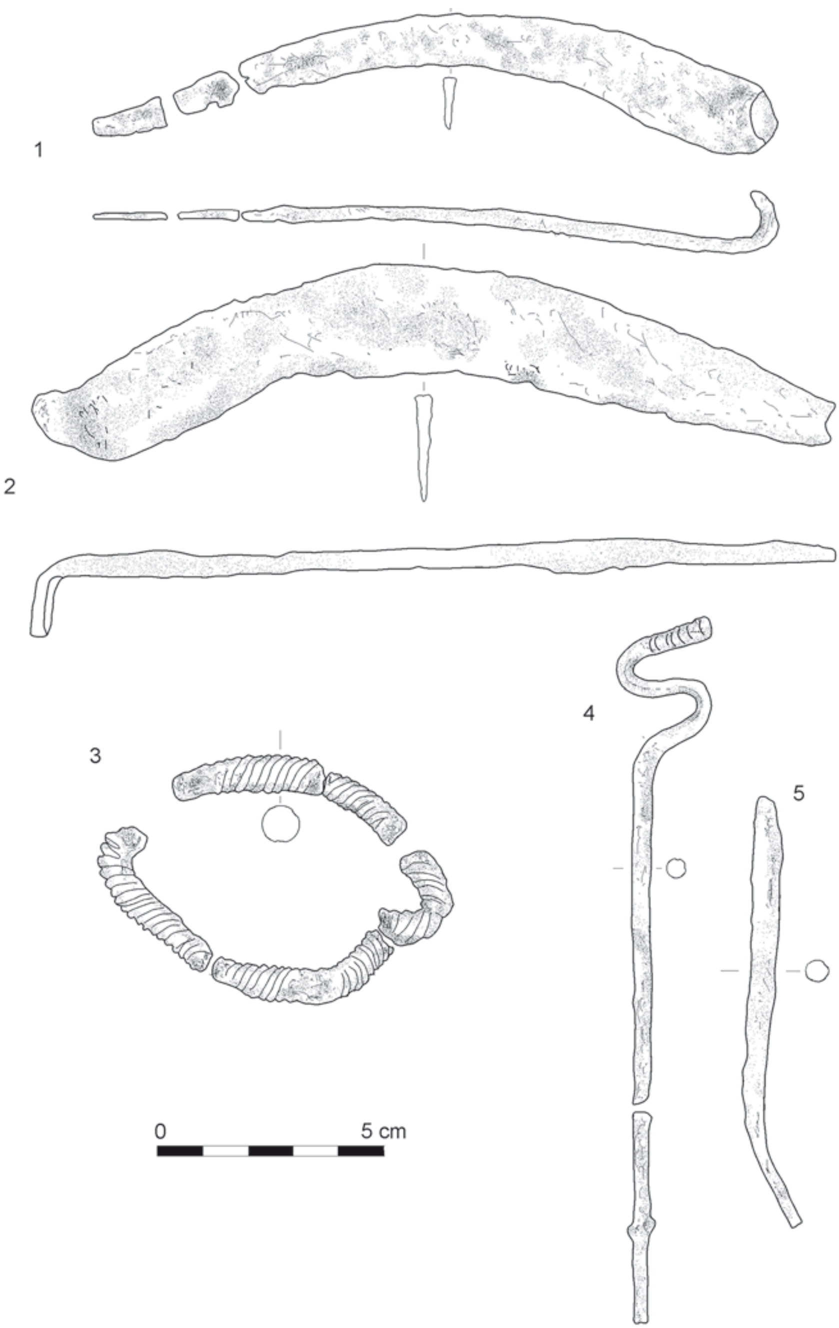

Fig. 8. Dąbrowa, Wieluń District, site 2. Metal inventory from grave 2/2021: 1, 3-5 – urn 1; 2 – urn 2 (3 – bronze; 1, 2, 4, 5 – iron) (drawing by R. Janiak)

The swan-neck iron pin with a corn cob-shaped head survives in three pieces (Fig. 8: 4). The neck's cross-section is quadrangular, while the pin shaft's is circular. The point is damaged. Total length 16.1 cm. Diameter of the head end: 0.5 cm. Diameter of the shaft at the bend: 0.45 cm. The width of the bent neck: 0.5 cm. Weight 8.1 g. This specimen was probably accompanied by a second pin (Fig. 8: 5), which has lost its head. The narrower end is slightly bent. Total length 10.1 cm. Diameter of the thicker end: c. 0.5 cm. Diameter of the narrower end: 0.3 cm. Weight: 5.1 g. Another object that survives in five fragments may have been a bracelet, probably made from a piece of a torc (Fig. 8: 3). The total weight of these fragments: 42.4 g. This piece of jewellery has carefully executed spiral-turning created by casting (*cf.,* Kłosińska *et al.* 2005, 226).

In the same cremation urn were also three bronze fragments, all likely from the same object that was cremated with the deceased. It may have been a toiletry accessory. Other small molten lumps may represent additional bronze objects. Iron staining on the burnt bones is further evidence for furnishings placed on the pyre. Traces of what seems to be molten glass on the bones suggest glass beads as well. On the other hand, in cremation urn #2, only an iron sickle (Fig. 8: 2) was found among the bones. This one survives in three pieces and also shows traces of having been on the pyre. This sickle is curved, too. The tip of the blade is slightly bent upwards. Here, the blade has oblique cuts. They are pretty deep, so the blade is almost serrated. This sickle appears to be intended for use with the left hand. Length: c. 15.2 cm. Tang length: 1.2 cm. Max blade thickness: 0.35 cm. Blade width: 1.9 cm. Weight: 9.5 g.

OSTEOLOGICAL REMAINS

The burnt bones from Grave X/1928, preserved at the Archaeological Museum in Poznań, have been analysed (Drozd-Lipińska 2023). They represent two human individuals. One is an adult, probably male, the other an infant who died during the age bracket late *infans* I or *infans* II. Note that the analysed bones include a few fragments of the two individuals' skulls.

Grave 2/2021 contained several separate sets of burnt human bones (Drozd-Lipińska 2022). Two such were deposited in vase-shaped vessels (urns #1 and #2) in the northern part of the burial pit. These urns were relatively easily distinguished in the lowest layer of crushed vessels. Urn #1, with the richer metal furnishings, yielded 691.5 grams of burnt human bones. Urn #2, with only a sickle, yielded 941.3 grams.

In the immediate vicinity of both urns, there were burnt human bones in the sand. The small quantities do not suggest that the remains of each pyre were divided, with some placed in an urn and some next to it. These bones must have spilt from the cremation urns when they were broken. If we add the weight of the bones found around the cremation urns to the above values, we obtain the following sums: 731.7 g and 968.7 g, respectively.

Both are less than the expected weight of a cremated adult. Therefore, one may conclude that only part of the cremated bones of a given individual were placed in each urn. The shafts of long bones predominate here. Thus, it seems that only selected parts of the skeleton were placed in the urns. As noted, skull fragments are not represented in large numbers. Only in the case of urn #1 is there a greater proportion. This selection of skeletal elements hampers sexing and ageing. In fact, we can say very little about these subjects at all. We can only assume, tentatively, that each urn represents one person.

The burnt human bones found lying on top of the layer of crushed pottery can be assessed similarly. They constitute a third separate set of bones weighing 754 g. These too are mainly from the shafts of long bones, along with a few fragments of flat skull bones, tooth roots, and the mandible. Neither sexing nor ageing of this individual, or individuals, has been possible. The two slightly smaller vases deposited here might suggest that two individuals were involved, but the issue is unclear.

The above indicates that at least three, possibly four, people were buried in Grave 2/2021. Two vessels identified as successive burial urns were found in the upper part of the grave. This may suggest that two individuals were buried this way. This interpretation is, however, not supported by the relatively small number of skull fragments retrieved. With a view to the stratigraphy of the vessels deposited in the grave, it does not seem to be a result of agricultural damage. It should therefore be the result of a procedure that excluded or limited the placement of skull bones in the grave. Such a procedure would not be unique to Grave 2/2021. The same has been seen with Grave 1/2021. In this grave from the later Bronze Age (Ha A2), in addition to burnt fragments of long bones from one individual (age and sex unknown), a small number of skull fragments were also found.

Numerous burnt fragments of human bones were also found separately from the artefacts, in layers of sand. These are generally well cremated, similarly to the fragments found in the graves. We wish to suggest that the vast majority of the bone material was intentionally scattered across the cemetery as part of the funeral rite. However, in this case too, skull fragments are relatively rare. This suggests that a special role was assigned to the head or skull, which excluded it from being incorporated into the graves themselves.

In the case of Grave II/1927, unfortunately, we do not know the age or sex of the buried individuals. The human remains have not been preserved, having probably been lost during World War II. There is only scant information that among the 40 vessels found, eight contained burnt human bones. In only two cases are we sure which ones served as burial urns. Looking at the preserved plan, we can also see an urnless cluster of burnt bones accompanied by metal objects. It is impossible to tell whether this was a destroyed urn burial or – perhaps more likely – an urnless cremation burial.

METALS

We can tell the social gender of the urnless bone cluster in Grave II/1927 in a general way, but not without reservations, based on the furnishings. The spearhead and belt hook indicate the male gender. The question is, however, whether each belt hook corresponds to a single individual. The presence of a hollow bracelet decorated with cross-hatching is suggestive in this context. It belongs to variant V5 as distinguished among finds from the Magdalenska gora cemetery in Slovenia (Tecco-Hvala 2012, 314, fig. 116: 5, 117). This bracelet variant has overwhelmingly been found in the graves of women and children, but also sporadically in men´s graves.

When judging how far into the Early Iron Age use of the Dąbrowa cemetery stretched, attention should be paid to a sabre-shaped bronze object (Durczewski 1939-1946, 92-93; 1948, 222, pl. 99: 9) found in Grave X/1928. This should be interpreted not as a dress pin, as previously thought, but as part of a serpentine fibula (Fig. 5: 6). Its preserved length is about 13 cm, while the diameter of the bronze pin is 1.5 mm. One of the ends of the pin, corresponding to the fibula bow, is flattened and then bent into an S-shape. From the second bend, the rod is cut lengthwise, creating two parallel arms. This object was destroyed prior to deposition and lost its supporting plate and pin catch.

On the exterior surface, the serpentine part is decorated with two parallel grooves. In the opinion of Durczewski (1939-1946, 93), this specimen would date to Hallstatt C. This find also appears in later literature. It was published by Gedl (1991, fig. 38: 4), who considered it a dress pin, although it was actually illustrated among brooches from the Hallstatt Period. At this point, it is worthwhile to take a closer look at serpentine fibulae of type IIb, which are known from present-day Slovenia.

One of the specimens so assigned comes from the inhumation burial 29 in Barrow VII at Magdalenska gora (Hencken 1978, 56, fig. 249; Tecco-Hvala 2014, 126, fig. 2: 3). In Grave 2340-1 at the cemetery of Most na Soči, serpentine fibulae of type IIb were also found together with a situla, which allows us to place the assemblage in the Sv. Lucija IIa phase, falling in Ha D1 (Teržan *et al.* 1984, fig. 247: B; 1985, 368; Tecco-Hvala 2014, 142, fig. 9: C, pl. 1: C). The characteristic feature of the fibulae from Grave 2340-1 is a fourfold bending of the bow, which is formed from a flattened rod (Diagram S4). This bend was probably intended to lend spring to the fibula. The bow is separated from the pin by a disc, the function of which was to protect or separate the bow and the pin, as well as to create resistance against the fastened garment. On this type of fibula, the foot or pin catch is cut straight and has no decoration. These comparisons allow us to recognise the find from Grave X/1928 as part of an imported serpentine fibula.

This reclassification of the artefact previously referred to as a dress pin is important for the assessment of the brooch (Fig. 4:2) from Grave II/1927 (Jażdżewski 1929, fig. 5; Gedl 2004, 91, Taf. 55: 262). The serpentine fibulae that have bows decorated in scheme S4 and hat-like shields separating the bow from the pin, found in cemeteries at Este and Padua in Veneto, should be kept in mind. The shields are decorated with concentric circles. On the brooch from Padua, there are additionally small circles arranged in a circle. When viewed from above, the bow of these brooches takes the form of two lenses, one end of which narrows into a fourfold bend (Eles Masi 1986, 229, pl. 177: 2386, 2388). The brooch from Dąbrowa Grave II/1927 is one of three specimens of this type known from Polish territory. The other two are from cemeteries at Bogumiłów and Pyszków on the upper Warta (Gedl 2004, 91, pl. 55: 261, 263). All have a wide flat bow with profiled edges. The bow is additionally decorated with studs, probably riveted. The hat-shaped shield of the Dąbrowa brooch has no additional decoration. However, the shields of the two other specimens carry a motif of small ring and dots arranged in circles around the curvature. A further element is the presence of small holes at the edge of the brim.

At this point, it is worth mentioning the shape of a serpentine fibula, found in Grave 2/1939 at the eponymous cemetery of Hallstatt itself (Kromer 1959, 196, Taf. 209: 24). A characteristic element of this brooch is the cap-shaped shield. It has a motif of a ring and dots arranged in a circle. The same motif is found on the dome of the shield. The Dąbrowa type brooches discussed here constitute a small but distinct group that occurs in a reasonably small area concentrated on the upper Warta. Their characteristic trait is the cap-shaped shield. This, according to Gedl (2004, 91), suggests that the type is a local design inspired by imported serpentine fibulae. We endorse this interpretation. The bronze craftsman, likely responding to a regional order, creatively developed an imitation of the imported pieces, giving them a unique shape while maintaining the hat-shaped shield, which was important from a functional perspective.

Thus, two richly furnished graves at Dąbrowa have yielded stylistically related metals: an imported serpentine fibula in Grave X/1928 and its imitation in Grave II/1927. We believe that these graves are effectively coeval and date from Ha D1. Another fibula was also found in Grave II/1927 (Fig. 4: 3a, 3b). It was a two-part boat-like fibula with crossbow winding and carved decoration on the rhomboid bow (Jażdżewski 1929, fig. 7: 1, 2; Gedl 2004, 98, 99, Taf. 57: 283, 283a). This jewellery is considered a product of local workshops influenced by Italian prototypes. Boat-like fibulae, characterised by a single-part structure, are found in northern Italy from the 7th to the early 6th centuries BC. This two-part fibula type is known from Polish territory and Moravia. Their dating should be within the Ha D2 phase (Woźniak 2010, 42; Golec and Fojtik 2020, 106-109).

The second dress pin found in Grave X/1928 (Durczewski 1939-1946, 92; 1948, 222, pl. 99: 12) had a head in the form of a spiral disc made of rod or wire with a quadrangular cross-section (Fig. 5: 7). Unfortunately, it has not survived in a museum collection. Similar pins are also known, for example, from Grave 2051 at the cemetery of Kietrz (Gedl 1985, 30, pl. 5: 4, 5). This being the only non-ceramic furnishing of the grave, it received a general Hallstatt Period date in the publication. On the other hand, a study of documentation from the cemetery in Świbie (Michnik and Dzięgielewski 2022, 90) places this type of dress pin in the early and middle phases of the cemetery's use, equivalent to phases Ha C1 and Ha C2.

The iron spearhead from Grave II/1927 (Fig. 4: 1), approximately 22.5 cm long (Jażdżewski 1929, fig. 4; Durczewski 1939-1946, 121; 1948, pl. 95: 9) has a long socket and a long, narrow, almond-shaped blade (Gedl 2009, 90, pl. 35: 444). A characteristic feature is the engraved ornament at the socket's opening. The motif is intersecting diagonal lines framed from above and below by a double line, which probably goes all the way round. Of three assemblages of iron spearheads found in cemeteries at Magdalenska gora (Tecco-Hvala 2012, 123, fig. 48, 49), two include specimens with decorated sockets. These are spearheads with a) a short socket and a long blade, b) a long socket and a short blade. The spearhead from Dąbrowa is similar in shape to the finds in the first group of Slovenian finds mentioned above. A 27 cm long spearhead found in Grave X/1928 (Durczewski 1939-1946, 121; 1948, 222, pl. 95: 8; Gedl 2009, 88, pl. 34: 434) has been assigned to the type 'iron spearheads with a wide blade' (Fig. 5: 5). Note that in the light of Gedl's research (2009, 88), this type includes only six items. Among them, a specimen similar to the find from Dąbrowa was discovered in a stronghold of the Lusatian culture at Czarnowo (formerly Kamieniec; Zielonka 1955, 164, pl. 25: 11; Gedl 2009, 88, pl. 34: 436). During excavations here, layers associated with fire and destruction were found. The spearhead is 20 cm long, and the width of the blade is 4 cm. Unfortunately, we do not know the exact spot where it was found. In the past decade, an eastern origin has been suggested for this type of weaponry (Andrzejowska 2016, 301; Gackowski *et al.* 2018, 332). The presence of other militaria, such as arrowheads of eastern provenance, at the stronghold in Czarnowo suggests that it fell to a Scythian attack. However, the use of these weapons by the local community, or even their local production, is not out of the question (Zielonka 1955, 164, pl. 25: 1-6; Gackowski 2020, 47, 48; Gackowski *et al.* 2018, 333, 334).

Grave II/1927 also yielded iron belt hooks (Jażdżewski 1929, figs 8 and 9; Durczewski 1948, fig. 96: 1, 3, 6). Three of them have a characteristic rhombic and oval shape (Fig. 4: 5, 6, 8). They were accompanied by rings, probably also iron, that formed the other half of the belt closure. In the cemetery at Hallstatt, this type of belt hook is known from both male and female graves and belongs to phase Ha D1. On the other hand, in Slovenia, in the Doljenska group, among the assemblages from the cemetery at Magdalenska gora, the type occurs in phases distinguished by serpentine fibulae as well as in the Certosa phase, which can be attributed to the Ha D1 and Ha D2-D3, respectively (Tecco-Hvala 2012, 169). Artefacts similar in form to belt buckles are also known from the Moravian territory. They occurred there after the Ha D1b phase (Golec and Fojtik 2020, 132).

One of the belt hooks differs in its shape (Fig. 4: 7), being an isosceles triangle topped by a ring (Jażdżewski 1929, fig. 8 at the bottom; Durczewski 1948, fig. 96: 2). At the other end, at one side of the base, perpendicular to the fastening plate, is a separate ring. Since part of the base of the triangle is missing, we may assume that the original belt hook had two such rings. On the other hand, it might be appropriate to consider this artefact as a pendant, similar to another specimen from this grave (Fig. 4: 9). In Moravia, pendants of a similar form were one of the elements of multi-part belts, which are attributed to people of higher social status (Golec and Fojtik 2020, 125, 129, 130, fig. 42: 1, 5).

The hollow bronze bracelet/armlet from Grave II/1927 (Fig. 4: 4; Jażdżewski 1929, fig. 3; Durczewski 1939-1946, 104; 1948, fig. 96: 4) has a fairly broad date. In burials from modern Slovenia, the type first appears in Ha C2 and persists into LT A, when it remains fairly common (Tecco-Hvala 2012, 320). In Ha D1, the phase of Grave II/1927, such bracelets/armlets are relatively rare.

The last item from Grave II/1927 – probably a folded iron strip (Fig. 4: 9) – is difficult to identify with certainty.

Another distinctive group of artefacts are the two iron sickles from Grave 2/2021. In the western zone of the Lusatian culture, two other graves with sickles are noteworthy here (Kołodziejski 1974, pl. 11: 3; Madera 2002, 167, fig. 11: c). Both are richly furnished barrow burials, each equipped with a bronze sword and iron axes (both flat axes with side protrusions and socketed axes). The first of them is from a barrow at Żukowice in Głogów district, dating from Hallstatt C. The location of this burial in the central part of the cemetery seems significant (Kołodziejski 1974, 85, pls 9-12; Gedl 1991, 26-28, Abb. 8). As Gedl (1991, 27, 28) emphasised, due to its rich furnishings and form, this grave represents a high-status individual. Moreover, in the Silesian group of the Lusatian culture, it would be an exceptional burial. The second sickle grave is number 4/95 at Łazy in Wołów District – a chamber grave. This find is also dated to the Hallstatt C (Madera 2002, 163-167, 170, figs 9-11). The presence of sickles in such richly furnished burials is suggestive. These sickles co-occur with weaponry, that is, male-gendered assemblages.

A monograph on the Lusatian culture cemetery at Świbie in Upper Silesia also provides information on iron sickles in burials. Although there are not many sickles from this cemetery, one was found in Grave 6, along with an iron flat axe with side protrusions and an iron knife (Michnik 2022, 14, 15, pl. 3: 8, 4: 1; Michnik and Dzięgielewski 2022, 107, 116). The combination of a tool and a weapon indicates a higher status. Other finds from Silesia also demonstrate the presence of big iron sickles in graves of the Lusatian culture during Ha C (*e.g.*, Cieszków in Milicz District; Domańska and Gołubkow 1976, 114, 116, fig. 26d; 1978, 77, 79, fig. 20: o). They are more common, though, in Ha D and the Early La Tène Period (Dzięgielewski *et al.* 2011, 329). Ten graves in the cemetery at Domasław yielded sickles (Gediga *et al.* 2020, 78). Here, however, the assemblages do not support any interpretation of a higher status. The status of the deceased buried with a sickle cannot be read from the presence of a wooden chamber either.

The latest literature on sickles draws attention to two metalwork assemblages from southern Bohemia. Here again, sickles are found along with iron flat axes with side protrusions at Třebanice and Vráž/Zlivice (Michálek 2017a, 506-5-7; 2017b, pl. 401; Michálek *et al.* 2015, 125, fig. 7: 4, 8: 4, Půlpán *et al.* 2022, 46). At Vráž, it is suggested that the metalwork was found in Barrow 1. Some finds from the fortified settlement at Smolenice-Molpír are also illuminating. There are sickles in four out of six hoards (#1, 2, 3, 5) from the acropolis, the most important, upper part of the settlement (Čambal and Makarová 2020, 208, 218, fig. 2; 3: 11; 4: 1-6; 5: 1, 3, 8; 8: 1a, 1b) – all the hoards from Smolenice-Molpír date from Ha D1.

Sickles in themselves can hardly be considered high-status attributes. However, the above examples demonstrate that they were deposited in diverse contexts: in graves at Łazy, Żukowice, Świbie, Domasław and Vráž/Zlivice (?); in hoards at Smolenice-Molpír and Třebanice. They are associated with special places, such as the aristocratic precinct at Smolenice-Molpír, or are part of rich barrow inventories, co-occurring with tools or weaponry. As for Grave 2/2021 at Dąbrowa, sickles were included, although not many other metal objects were found. It is difficult, in comparison with the furnishings of Graves II/1927 and X/1928 with their weaponry and imports, to talk about the social status of the people buried in Grave 2/2021.

CONCLUSION

The site at Dąbrowa belongs to a small group of Lusatian culture cemeteries in the southern part of central Poland that have yielded prestigious grave furnishings, including imported fibulae or their local imitations (Fig. 9). An instructive example is the Dąbrowa fibula type (Fig. 4: 2) – Gedl 2004, 91, fig. 55: 262). Two other such fibulae have been found in the Lusatian cemeteries of Pyszków and Bogumiłów, both in Sieradz District on the upper Warta (Antoniewicz 1939–1945, 14, 34, fig. I: 13, II: 10; Łuka 1957-1959, 31, 32, fig. 18; Gedl 2004, 91, fig. 55: 261, 263). We believe that this fibula type is an imitation of imported serpentine fibulae that underwent additional redesign. These few finds of the type in a fairly small area suggest a local metalworking workshop (Gedl 1991, 66; 2004, 92). Furthermore, the boat-like fibula from Grave II/1927 recalls the two pairs of such fibulae (with a rhomboid bow and a narrow bow respectively) in Grave 15 in the Lusatian cemetery at Chojne in Sieradz District (Ząbkiewicz-Koszańska 1972, 182, 183, fig. 12: 1, 2, 6, 7; Gedl 2004, 94, 98, 148, fig. 56: 268, 269, fig. 57: 281, 282). All of these finds date back to Phase Ha D2 (Woźniak 2010, 42). Therefore, the chronology of Grave II/1927 should fall within the Ha D2 phase.

The location of these cemeteries in the Prosna and Warta River basins is significant for the broader context. Dąbrowa is the westernmost of them, located almost halfway between the upper reaches of the Prosna and the Warta. Chojne, Pyszków, and Bogumiłów are located slightly to the northeast, above the southern course of the Warta. The prestigious objects found here reflect trade and other communication along these two major rivers (Janiak 2003, 81-83). This connected the Lusatian culture communities of north-east Silesia with groups controlling areas along the Warta, above the confluence with the Oleśnica River.

This route had been established earlier, as evidenced by a group of Lusatian culture strongholds that we refer to as the 'Silesian type'. They flourished already during Ha B3 (Janiak 2003, 69-72). The finds from Dąbrowa, Pyszków, Bogumiłów and Chojne show that Ha D1-Ha D2 saw a re-activation of this route. Prestigious objects reached the southern part of central Poland. They found recipients and imitators here. Not only elements of

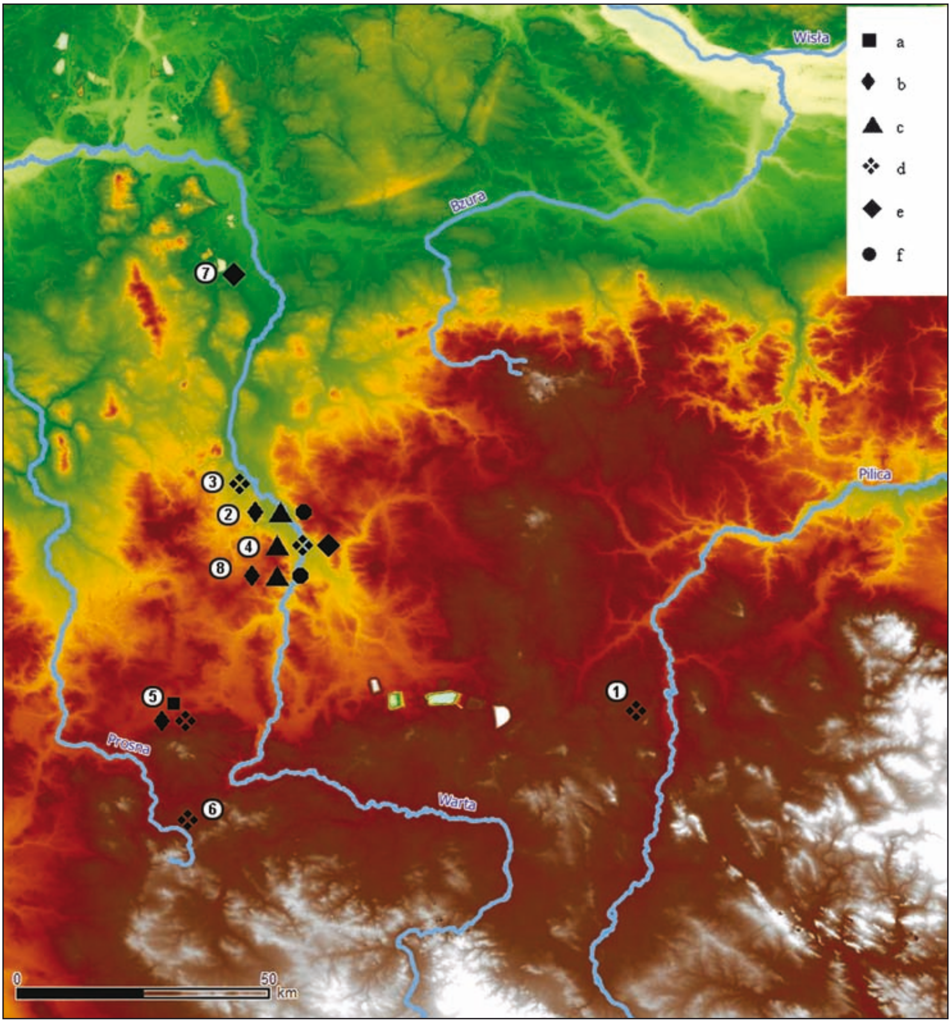

Fig. 9. Distribution of fibulae in the Upper Warta and Prosna Basin zone in the Halstatt D stage (after Gedl 2004, drawing by R. Janiak): a – serpentine fibula; b – Dąbrowa-type fibula; c – arched fibula of crossbow design with a long sheath; d – boat-like fibula with a rhomboidal bail; e – Wojszyce-type fibula; f – fibula with a decorative foot – Wicina variant; 1 – Bęczkowice, Piotrków County; 2 – Bogumiłów, Sieradz County; 3 – Charłupia Mała, Sieradz County; 4 – Chojne, Sieradz County; 5 – Dąbrowa, Wieluń County; 6 – Dzietrzkowice, Wieruszów County; 7 – Przykona, Turek County; 8 – Pyszków, Sieradz County

costume, but also weapons indicate the presence of persons of higher social status in the area (*cf.,* Schumann 2015, 25-27; Trefný 2017, 121, 123). These individuals likely exercised political control within their local settlement structure, while also engaging in long-distance trade and exchange. Their presence in the area stimulated such exchange as well as the activities of local metallurgical workshops.

Discovered in 2021, the multi-urn burial, dated 2/2021, was equipped with, among other things, iron sickles. It differs in character from the two burials equipped with weapons and imports or their local imitations. At the same time, it is an example of another burial from the early Iron Age discovered at the cemetery in Dąbrowa. The differences, apart from the type of metal objects, also lie in the different 'architecture' of the grave.

The verification of previous findings presented in this text concerns discoveries made at the necropolis in Dąbrowa almost 100 years ago. The authors intended to reinterpret the metal objects found in two graves. In addition, the results of anthropological research have been made available, which, albeit to a small extent, provide insight into the structure of the community that used the necropolis in question. These more precise data refer only to Grave X/1928. To a lesser extent, they refer to the people buried in Grave 2/2021. In the future, they may provide material for studying the age and gender structure of people buried in Lusatian culture cemeteries in central Poland. The results of archaeological research conducted at the cemetery in Dąbrowa in 2023 and 2024 may, to some extent, verify views on the social and economic roles of the cemetery's users.

Based on the discovery of graves from the Hallstatt period, the cemetery in Dąbrowa can be added to several other necropolises in the southern settlement area of the Lusatian culture in central Poland. In addition to the previously mentioned cemeteries in Bogumiłów, Pyszków, Łubnice, and Chojne, the necropolis in Charłupia Mała, Sieradz District, located on the Warta River (Kurowicz 2002), should also be mentioned here. The artefacts discovered here are still awaiting more comprehensive publication. All these cemeteries offer fascinating insights into the cultural changes that occurred in the early Iron Age in the aforementioned region.

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THREE LINES OF DITCHES AND EMBANKMENTS, AND INSIDE A VOID: RESULTS OF ARCHAEOLOGICAL RESEARCH AT THE EARLY IRON AGE SITE IN KOŚCIUKI (PODLASKIE VOIVODESHIP, NORTH-EASTERN POLAND)

ABSTRACT

Żurek K. and Wawrusiewicz A. 2025. Three lines of ditches and embankments, and inside a void: Results of archaeological research at the Early Iron Age Site in Kościuki (Podlaskie Voivodeship, North-Eastern Poland). *Sprawozdania Archeologiczne* 77/1, 369-388.

Airborne LiDAR surveys have identified 27 Late Bronze and Early Iron Age fortified sites in the valleys of the Biebrza and Narew rivers in northern Podlasie, sharing similar locations, forms, and dimensions. In 2019, interdisciplinary geomagnetic and ground-penetrating radar (GPR) surveys, followed by excavations, were carried out on the site in Kościuki (Białystok district).

The site lies on a sandy elevation near a peat bog and consists of three concentric embankments and ditches about 100 m in diameter, enclosing a central area of only 20 m. Excavations revealed traces of palisade-topped ramparts and well-preserved wooden elements between the ramparts. Radiocarbon dates of the timbers indicate construction between the 7th and late 5th centuries BC.

No structural remains or artefacts indicating habitation were found within the enclosure, only a few ceramic sherds in the ditch fills. The monumental scale and inward-sloping palisades suggest a non-defensive role, perhaps as a permanent ritual or ceremonial centre rather than a military fortification.

Keywords: North-Eastern Poland, Podlaskie voivodeship, Kościuki site, fortified site, Early Iron Age
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INTRODUCTION

One of the current issues in the prehistory of north-eastern Poland is the functioning of defensive structures dating to the Late Bronze and Early Iron Ages. In Warmia, Masuria, and the East Baltic Lakeland, the earliest defensive structures dating to the Early Iron Age are relatively well understood and conform to the general models of local cultural development (Okulicz 1981; Łapo 1998; Kobyliński 2017; Welc *et al.* 2018). In contrast, the defensive structures of a slightly different construction, located at the bottoms of the Narew and Biebrza valleys, the main watercourses of the North Masovian and North Podlasie Lowlands, remain a new and widely discussed subject.

These structures have become the subject of separate studies – for example, the sites at Podosie (Miastkowo commune, Łomża district, Podlaskie voivodeship) and Jednaczewo (Łomża commune, Łomża district, Podlaskie voivodeship), located in the Narew River valley (Ościłowski 2015a; 2015b; Grabowski and Muzolf 2016), or the comprehensively recognised site at Jatwieź Duża (Suchowola commune, Mońki district, Podlaskie voivodeship) already located in the Biebrza River basin (Żurek *et al.* 2022a; 2022b), the state of our knowledge of them is far from sufficient. This is evidenced by the multiplicity of theses and interpretations indicated in the synthetic study entitled 'Settlement pattern of Lusatian culture in Podlasie (NE Poland) and man-environment interaction' (Żurek *et al.* 2022b).

While the first research results were difficult to interpret unambiguously (Ościłowski 2015a; 2015b; Grabowski and Muzolf 2016), the interdisciplinary study of the site at Jatwieź Duża provided complementary and reliable data. The chronology, cultural attribution and structural features of the site were identified. However, the study's results did not provide a clear answer about the function of this type of site (Żurek *et al.* 2022b, 220-222). At this stage of the research, the actual defensive value of the ring-shaped system of embankments and ditches surrounding the central square was called into question. Among the more convincing interpretations is the identification of these sites as specific ceremonial or administrative-social centres (Żurek *et al.* 2022b, 222) – analogous to Neolithic rondels (*cf.*, Řídký *et al.* 2019). This assumption, which is extremely attractive for its broad interpretation of the socio-economic transformations of Podlasie's Late Bronze Age and Early Iron Age communities, needed to be verified against data from other sites of this type.

Taking the above into account, one of the largest and most complex sites, located near the village of Kościuki (Białystok district, Podlaskie voivodeship), was selected for detailed archaeological investigation (Fig. 1: A, B, C). The choice of this site was selected based on the analysis of airborne laser scanning (ALS) data and the resulting digital elevation models (DEM) (Banaszek 2014) that allow for the identification of faint anthropogenic structures in the landscape, both in forested areas (Devereux *et al.* 2005; Crow *et al.* 2008; Stereńczak *et al.* 2020) and in difficult-to-access river valleys.

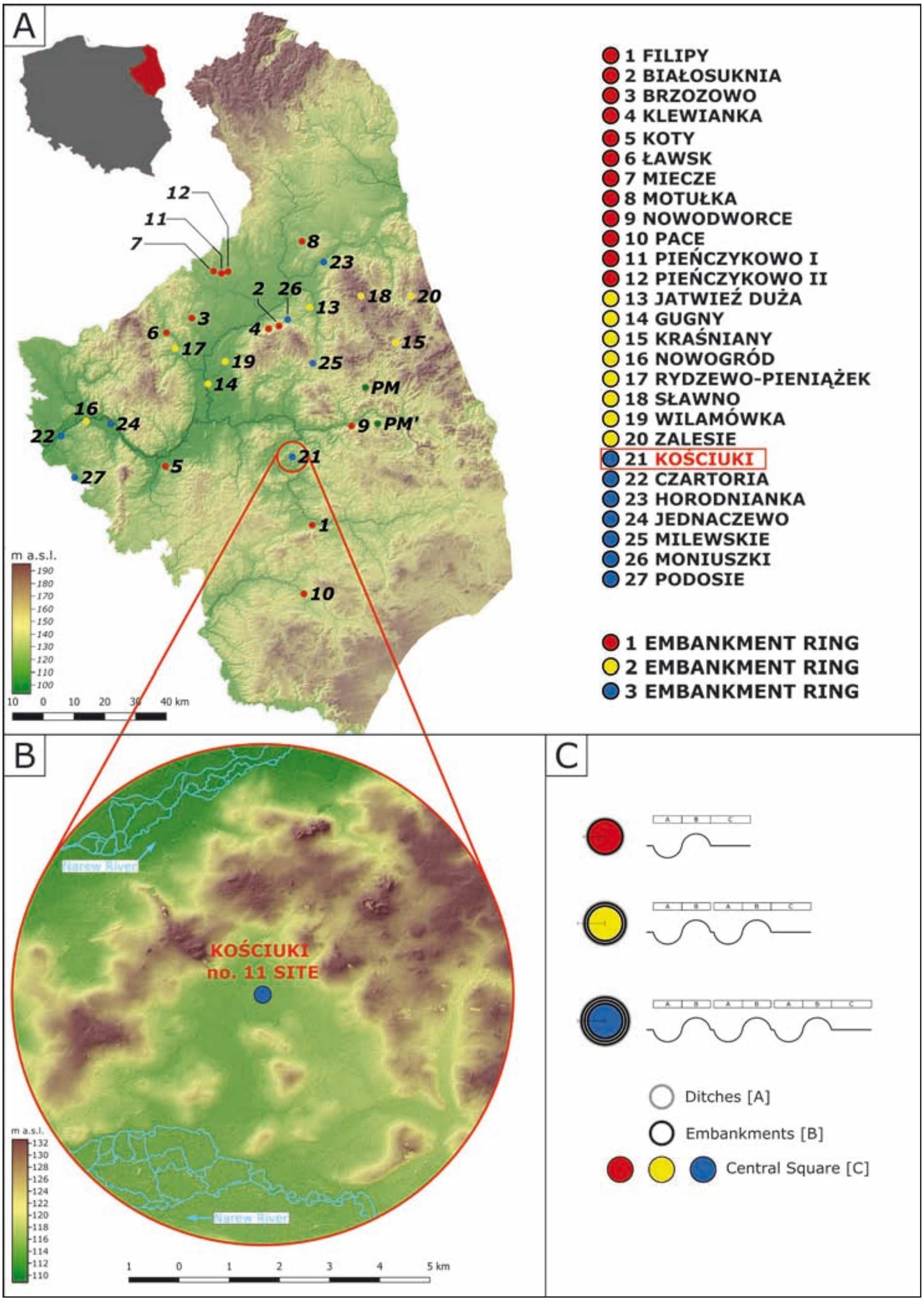

Fig. 1. Location of Late Bronze Age/Early Iron Age (NE Poland) ring enclosures inventoried in Podlaskie Voivodeship (A); location of Kościuki Site 11 (B); schematic plan of ring enclosure. GUGiK data

MATERIALS AND METHODS

Archaeological Site No. 11 in Kościuki (φ = 53°06'19.6" N, λ = 22°54'48.4" E) is located in the Upper Narew Valley, a part of the North Podlasie Lowland, which belongs to the Masovian-Podlasie Lowland macroregion (Kondracki 2002). The site is situated (Fig. 1: B) in a kettlehole filled with peat (Butrymowicz 2013), surrounded on three sides (north, east, and west) by moraine uplands of the Białystok Upland (Kondracki 2002). To the south, this area borders the Narew River valley, whose sinuous, S-shaped course also encloses the upland from the west and north (Banaszuk and Banaszuk 2010; Banaszuk *et al.* 2015).

Geologically, the area surrounding the site is characterised by a complex mosaic of Pleistocene and Holocene deposits. The area is dominated by glaciofluvial gravels and sands, which in some places have been transformed by wind into aeolian and cover sands. Among them, in the form of 'islands', there are glacial tills and kame deposits. A characteristic feature of this area is the kettlehole, which is currently filled with Holocene organic sediments. In the central part of such, the largest of the depressions, the investigated site in Kościuki is located.

At present, the site's morphological structure is barely visible (Fig. 2: A). It was only by correlating field observations with publicly available relief imagery that it was possible to delineate a circular structure about 100 metres in diameter consisting of three concentric rings of potential embankments and moats (Fig. 2: B).

To limit interference with the site's structure, a set of complementary non-invasive methods was used. The extent of the excavations was reduced to the minimum necessary to identify the site's structural elements and determine its chronology and function.

The first step was to develop a digital terrain model (DEM) of the site and its closest surroundings within a 5 km radius (Fig. 1: B; 2: B). LIDAR data in ASCII format, obtained from the resources of the Main Office of Geodesy and Cartography, were used for this purpose. The elevation points were distributed in a regular grid with a 1 m resolution and a maximum measurement error of 0.2 m. The data analysis was carried out using Global Mapper, QGIS, and RVT software. In addition, a series of aerial photographs were taken in 2019 that documented the site's appearance at different times of the year and under varying hydrological conditions (Fig. 3). Based on the results obtained in this phase of work, further field investigations were planned, focusing on the acquisition of geophysical data that would enable the identification of possible structures hidden beneath the ground surface.

A geomagnetic survey was carried out over an area of approximately 0.5 hectares, covering as much of the site and its surroundings as possible (Fig. 4: A). A significant part of the site was excluded from the works, including the centre of the site, where contemporary infrastructure elements, such as the paved causeway of a modern dirt road, a drainage ditch, and its accompanying culvert, are located. Measurements were made using a Bartington Grad 601 transducer magnetometer, recording the vertical magnetic field gradient to the nearest 0.1 nT (nanoTesla), in a 0.25 m mesh grid along parallel traverses of 20 m length spaced north-south at 0.5 m intervals. The data were processed in GeoPlot 3.0, creating maps of magnetic anomalies with raster visualisation ranging from -100/100 nT to -1/1 nT. To analyse the distribution of anomalies, the generated images were converted into shapefile polygons, which were then verified and categorised according to magnetic parameters, shape, and spatial distribution (Niebieszczański and Bahyrycz 2019).

To verify the geomagnetic imaging, a series of GPR surveys was conducted (Fig. 4: B). The 40 × 20 m survey polygon was located in the south-eastern part of the site, where

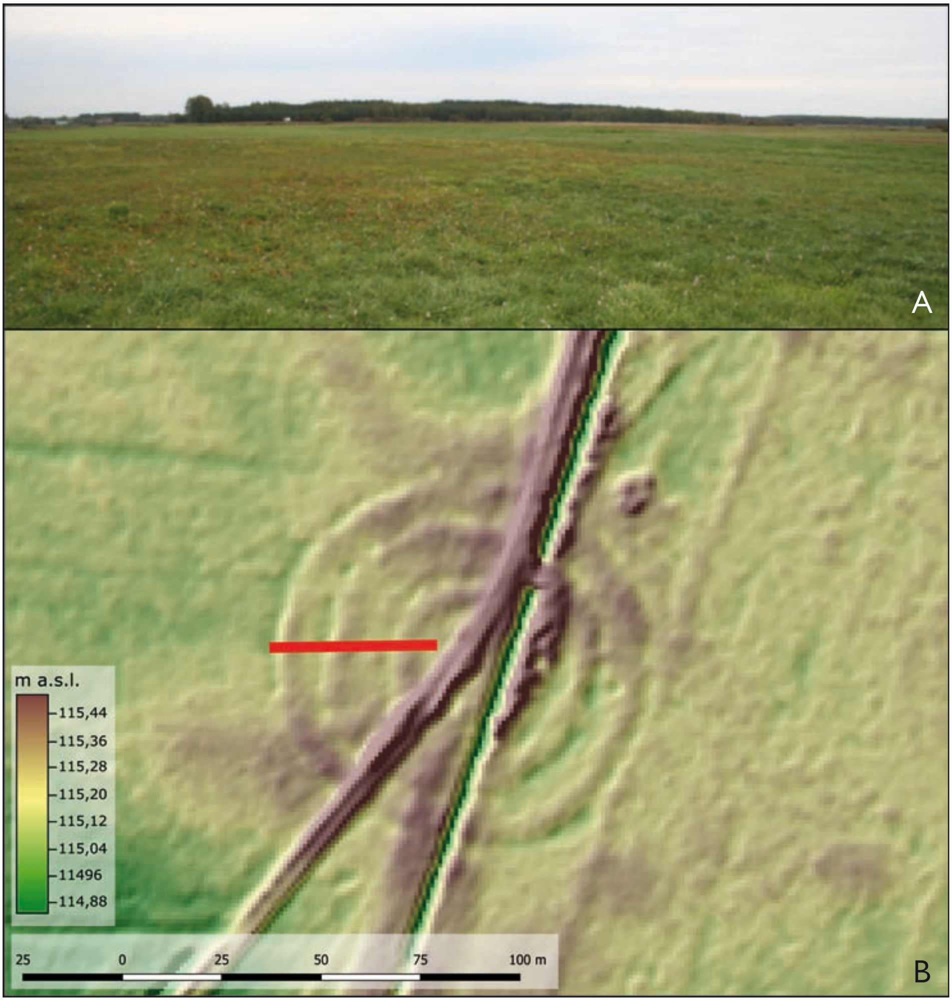

Fig. 2. Kościuki, Site 11, Białystok district, Podlaskie voivodeship. Photo of modern ground surface (A) and digital elevation model with location of archaeological excavation (B)

relatively prominent structures had been recorded during the geomagnetic survey. Within it, radar profiles were made at 0.3 m intervals. For the GPR survey, the Mala GeoScience ProEx (Professional Explorer) system was used – a two-channel radar with a 200 kHz pulse rate and a shielded 500 MHz antenna. The geophysical results were compared with excavation data, allowing them to be cross-checked and the structure of the investigated site to be identified (Kalicki *et al.* 2019).

An archaeological excavation verified the inconclusive data obtained by non-invasive methods. An archaeological excavation measuring 42 × 1.3 m was located in the western part of the site, along the E-W axis. It crossed all visible elements of the site's structure in the relief, from the flat central space to the edge of the outer ditch. Cultural and geological layers were examined manually, in 10-centimetre-thick increments. Drawn and photographic documentation of each level was prepared. The artefacts found were documented using the microlithographic method by recording their location on the plans of each exploration level. Macroscopic analyses of the artefacts were carried out to determine their relative chronology and cultural attribution.

Fig. 3. Kościuki, Site 11, Białystok district, Podlaskie voivodeship. Aerial photos with a positive vegetation index. Summer 2019. Photo by A. Nikonowicz

Radiocarbon dating was carried out on selected samples of organic matter. Dating was done at the Laboratory of Absolute Dating in Kraków. The results were calibrated using the OxCal v4.4.2 programme (Walanus and Goslar 2009).

RESULTS

Based on the DEM analyses, the site at Kościuki has a circular form with a diameter of approximately 98 m (Fig. 2: B). The site's structure consists of three concentric rings of depressions, with the ground level reaching approximately 114.9 m a.s.l., and gently outlined rings of elevations reaching approximately 115.3 m a.s.l. on the inner side. At the centre of the site is a flat elevation with a diameter of approximately 30 metres, whose surface reaches 115.2 m a.s.l. Today, the site has been cut along an axis running from NNE to SSW by a drainage ditch and a parallel road on an embankment, which, in the area of the site's centre, changes direction from NNE to SW (Fig. 2: B).

Similar results were obtained from the analysed aerial photographs (Fig. 3). During the late summer 2019 drought, vegetation markers became visible. Composed of greener grass, these formed three concentric circles which overlap with the depressions identified on the DEM. On their inside was the drier outline of rings – probable embankments. Apart from the indicated elements, the vegetation features did not identify any other potential archaeological features.

The results of the geomagnetic surveys conducted in Kościuki reveal a complex picture of the recorded anomalies. Interpretation difficulties are particularly posed by the proximity of the road, which interferes with the magnetic field. The magnetically strong bipolar anomalies located in its vicinity probably document the presence of modern anthropogenic waste deposited on the ground surface and just below it (Fig. 4: A). Accordingly, only those anomalies that form coherent, linear sequences capable of being a true reflection of prehistoric structures were considered significant. Their characteristic feature is a relatively low disturbance gradient – the signals are exclusively positive. In the northern and south-eastern parts of the site, a series of linear structures, showing a curved course corresponding to the profile of the embankments visible on the DEM (Fig. 2: B; 4: A). A similar relationship was observed in the western part, where a series of anomalies indicates the presence of an internal embankment line. The genesis of these anomalies remains incompletely elucidated. It is the lack of clear continuity in these systems that suggests they are unrelated to the clear ditches in the area's morphology (see Kittel *et al.* 2018; Niebieszczański *et al.* 2018; 2019). Their association with the presence of erratic boulders – elements of embankment construction, and/or the remains of burnt wooden structures, *e.g.*, palisades – should be considered the most probable. The second type, polygon-shaped anomalies, occurs both outside the main site area and in various parts of the site located between the embankment system. This distribution suggests the possibility of pits, but could equally well be due to lithological differences in the sediments or indicate the natural presence of erratic boulders lying beneath the ground surface (Niebieszczański and Bahyrycz 2019).

The GPR surveys enabled detailed imaging of dielectric field disturbances in horizontal and vertical cross-sections (Fig. 4: B). The GPR survey grid revealed a linear arrangement of anomalies characterised by a uniform medium density across all surveyed depths. This arrangement is clearly visible at depths of approximately 1.0 m. Within the linear anomaly system, there is a set of parallel, arc-shaped disturbances of comparable density at a given depth – these disturbances mainly occur at levels of 1.0 to 1.5 m and most probably correspond to structural embankment reinforcements. Parallel anomaly lines were recorded in the southern part of the grid, facing towards the central part of the site; their interpretation remains unclear (Kalicki *et al.* 2019).

The excavations not only verified the geophysical data but also accurately determined the site's stratigraphy, chronology, and construction. Several segments of the site were documented during the work (Fig. 5).

In the central part of the site, over a length of 4 m, beneath a modern layer approximately 0.2 m thick, a humus horizon composed of fine-grained sands containing a significant amount of mineralised organic matter was identified. Below this, only sandy geological

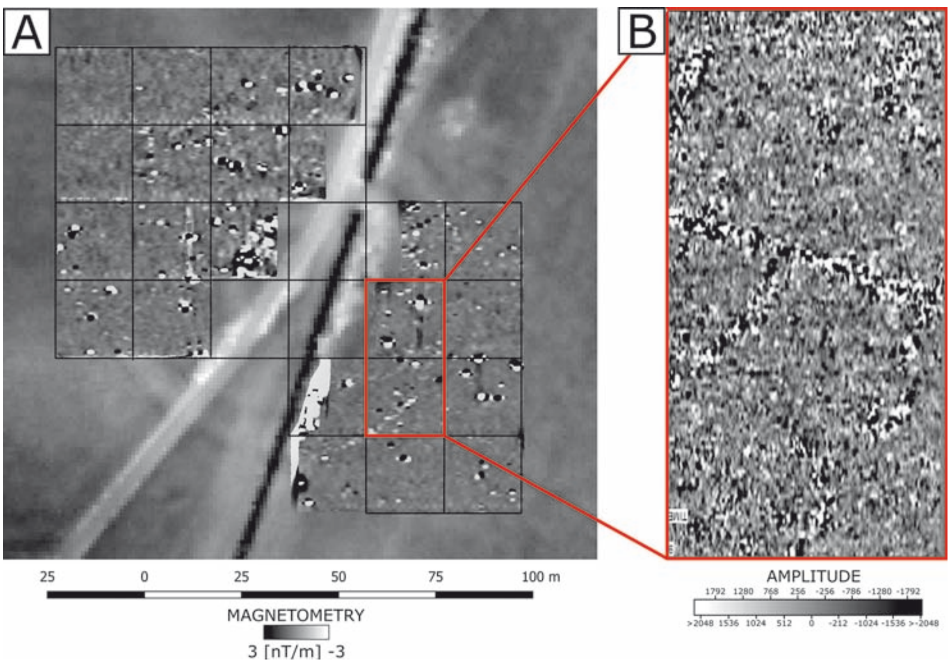

Fig. 4. Kosciuki, Site 11, Białystok district, Podlaskie voivodeship. Results of magnetometric (A) and GPR survey (B). Based on: Kalicki *et al.* 2019; Niebieszczański and Bahyrycz 2019

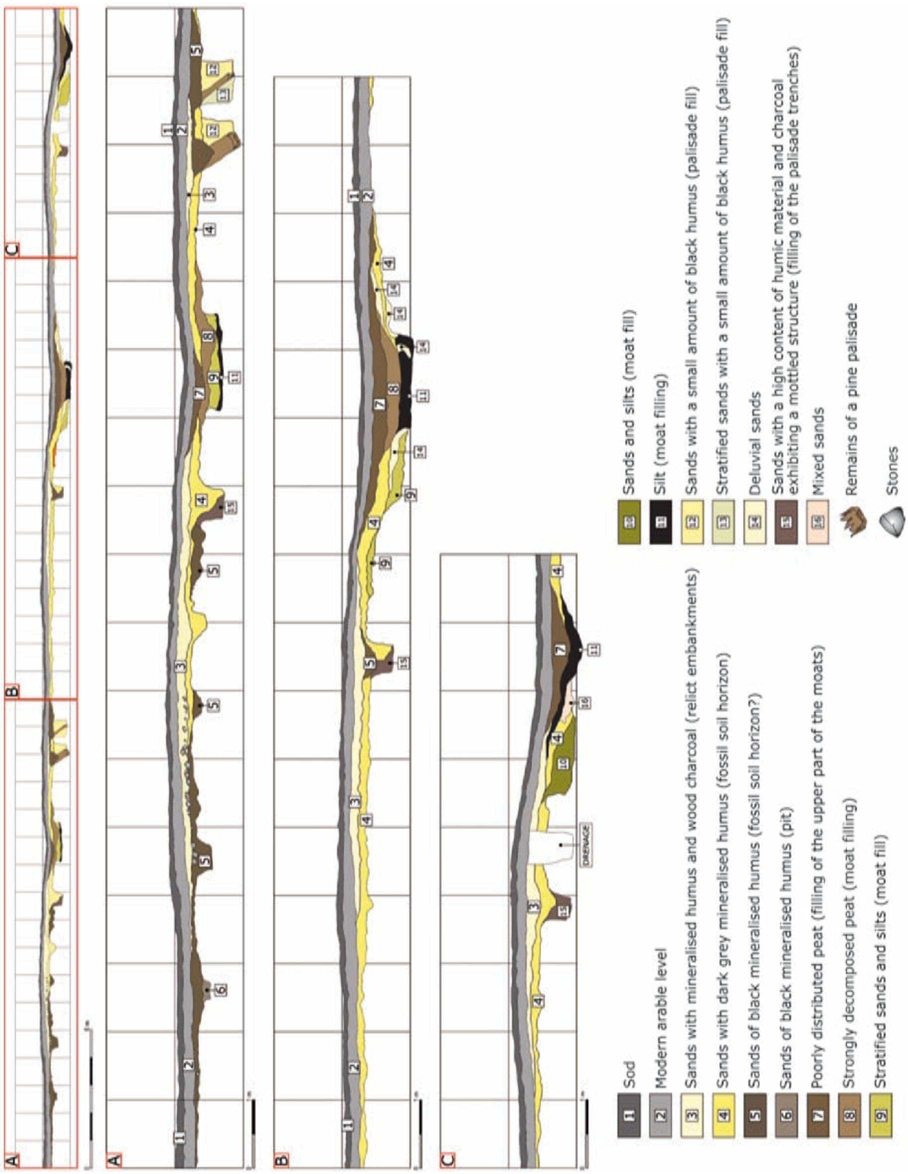

Fig. 5. Kościuki, Site 11, Białystok district, Podlaskie voivodeship. Southern cross-section through the archaeological excavation area

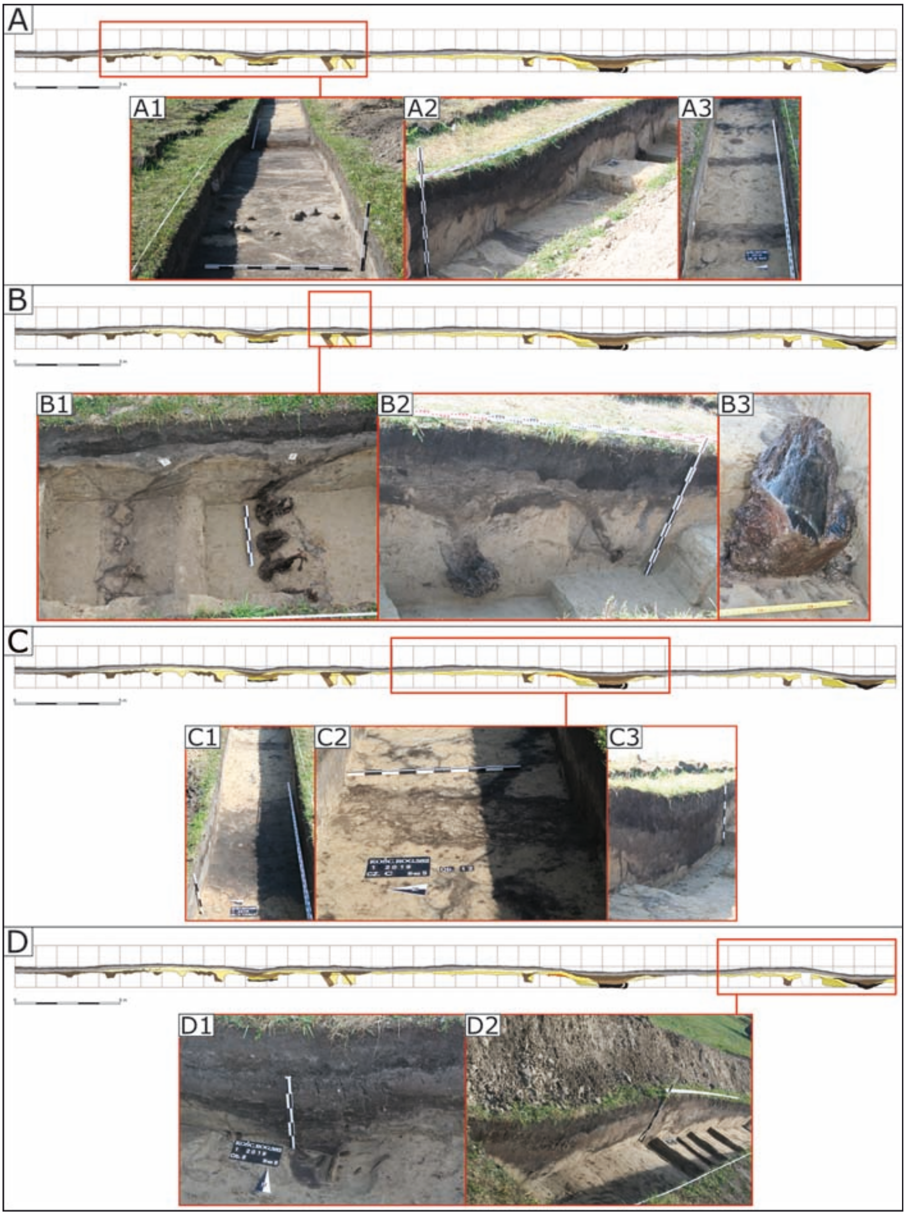

Fig. 6. Kościuki, Site 11, Białystok district, Podlaskie voivodeship. Southern cross-section through the archaeological excavation area with inner ring of fortifications (A) – remains of the stone structure of the embankment (A1); outline of the inner ditch (A2); outline of palisade slots (A3); inner diagonal palisadę (B) – outline of palisade slots (B1); wooden elements of the palisade (B2); traces of cuts on one of the palisade elements (B3); middle ring of fortifications (C) – outline of the middle ditch (C1); outline of the palisade slot (C2); profile of the middle ditch (C3); outer ring of fortifications (D) – wooden fragments at the bottom of the ditch (D1); outline of the outer ditch (D2)

subsoil was encountered, with no traces of human activity (Fig. 5: A). Spot disturbances within it were interpreted as the result of natural factors, such as animal burrows or the remains of tree root systems. No artefacts were recorded in this part of the site.

The central area was surrounded by a first ring of fortifications about 10 m wide, consisting of a stone-and-earth embankment and an accompanying ditch (Fig. 5: A; 6: A). The heavily denuded embankment was about 6 m wide at the time of the survey. In the central part, the upper face of the embankments was most probably reinforced with a stone pavement composed of erratic stones with a diameter not exceeding 0.3 m (Fig. 6: A1). The presence of this structural element was revealed at a depth of approximately 0.1 m below the modern turf. Below the earth embankment, with a preserved maximum thickness of about 0.3 m, two parallel trenches, about 0.4 m wide, were discovered, spaced 1.5 m apart (Fig. 6: A3). At deeper levels of exploration, the outlines of fully mineralised posts with a diameter of about 0.3 m were revealed. On the outside of the embankments, a clearly visible depression of the ditch surrounding it was distinguished – most likely a moat with a reverse trapezoidal profile, a flat bottom and a depth of only 0.5 m (Fig. 6: A2). Its width measured at the upper edge was 2.1 m, and the flattened bottom was 1.6 m (Fig. 6: A3). The depression was filled with organic sediments (peat) and, in the eastern part, adjacent to the earth embankment structure, with mineral material probably originating from the eroded embankment structure. No artefacts were recorded within this segment of the site.

The central segment of the fortifications was approximately 17 m wide. It consisted of three main elements separated by empty spaces (Fig. 5). Approximately 3 m to the west of the edge of the inner moat, within the flattening of the space between the inner and middle segments of the embankment, two parallel palisade trenches were revealed (Fig. 6: B). Their width at the upper edge level was approximately 0.6 m. The distance between them was approximately 0.5 m. During their exploration, well-preserved pine logs measuring about 0.35 m in diameter were discovered. Their upper parts underwent partial mineralisation – only the more decay-resistant inner portions and resinous knots have been preserved (Fig. 6: B1). Lower down, in the damp sands, they were preserved in their full circumference, and at their ends, one could see the negative impressions of cuts made with a sharp, probably metal tool (Fig. 6: B3). The wooden logs, a remains of a double palisade, were set pointing diagonally towards the interior of the structure at approximately 45 degrees (Fig. 6: B1, B2). Radiocarbon dating of a sample of the outer ring of rings of one of the preserved logs gave a result of 2440 ± 35BP (MKL-4709), which, after calibration taking into account the probability level of 68.2% is determined in the ranges of 733-690, 661-650, 545-428, 423-416 BC. In the bottom part of one of the palisade slots, two small fragments of a small vessel decorated with holes were noted, which were located under the rim of the spout (Fig. 7, Table 1).

The image of the central segment of the fortifications is completed by a low earth embankment with a preserved height of about 0.3 m and a width of 7 m (Fig. 6: C). Also, in

Table 1. Kościuki, Site 11, Białystok district, Podlaskie voivodeship. ^{14}C dating table

Kościuki no. 11 Site						
No	Age	Cal. BC/AD (1σ) 68.3%	Cal. BC/AD (1σ) 95.4%	Lab number	Material	Context
1	2360 ±50 BP	515-385 BC (68.2%)	750-684 BC (26.8%) 668-639 BC (10.5%) 590-577 BC (0.6%) 570-358 BC (28.0%) 277-258 BC (1.0%)	MKL-4710	Wood	The bottom of the filling of the outer moat
2	2440±35 BP	733-690 BC (16.7%) 661-650 BC (4.3%) 545-428 BC (45.1%) 423-416 BC (2.2%)	754-681 BC (23.0%) 670-610 BC (12.8%) 594-407 BC (59.6%)	MKL-4709	Wood	Diagonal palisade between the embankments

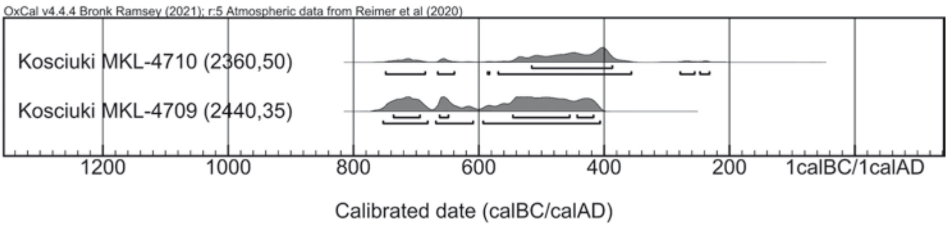

Fig. 7. Kościuki, Site 11, Białystok district, Podlaskie voivodeship. ^{14}C dating calibration

this case, below the now-eroded and transformed embankment, a single palisade slot, this time about 0.4 m wide, was revealed (Fig. 6: C1, C2). At its bottom, mineralised traces of posts have been preserved, most likely remains of a palisade. The entire ring of the middle segment of the fortifications was closed by a ditch with an inverted trapezoidal cross-section and a width of approximately 3 m (Fig. 6: C3). The original depth of the ditch can be estimated at 0.7 m. The filling also consisted of organic sediments and mineral layers derived from embankment erosion. In the bottom part of the ditch, two small fragments of pottery were noted.

The outer segment of the Kościuki fortifications has a structure similar to that of the inner segment, consisting of an earth embankment and a ditch adjacent to its inner edge (Fig. 6: D). The probable axis of the now-eroded earth embankment was approximately 16 m from the edge of the central moat. Its width, recorded in the archaeological excavation profiles, was about 6 m, undoubtedly the result of slope erosion and not reflecting its original state (Fig. 6: D2). Below the eroded embankment, as in other cases, a single palisade slot was observed, with preserved negative impressions of the mineralised palisade structure. The outer edge of the facility was marked by a relatively shallow ditch adjacent to the embankment. Its form and dimensions were similar to those observed in previous cases. The preserved depth was about 0.5 m with a width of 3 m. Characteristic flattening of the ditch

Fig. 8. Kościuki, Site 11, Białystok district, Podlaskie voivodeship. Selection of pottery finds

bottom was also noted, which is currently filled with organic sediments and mineral matter originating from the erosion of the adjacent embankment. Several small sticks were discovered at the bottom of the ditch, which probably found their way there by accident when the structure was in use (Fig. 6: D1). One of them was subjected to radiocarbon analysis, yielding a result of 2360 ± 50 BP (MKL-4710), which, after calibration with a 68.2% probability, falls within 515-385 years BC (Fig. 7; Table 1).

During archaeological research, a highly modest collection of artefacts was obtained. It consists of seven small pottery fragments, most of which lack stylistic features. The exceptions are three rim fragments from two small, thin, and medium-walled vessels with a barrel-shaped profile and a non-separated neck. Beneath the rim, they feature a single row of perforations. The outer surfaces of the pottery were coated with a clay slip containing a coarse mineral temper. No finger impressions were recorded. All ceramic fragments are consistent in terms of technological characteristics and can be dated to the Early Iron Age (Fig. 8: 1, 2).

DISCUSSION

The correlation of terrain morphology analysis, aerial imagery, and geophysical prospection with observations made during excavations provides a coherent picture of the site. It enables the reconstruction of the general layout of the original settlement at Kościuki. The feature is a circular structure with an overall diameter of 98 m. At its centre lies a circular, flat, open area approximately 20 m in diameter. No material traces of structures or economic use were identified within this space. These observations are further supported by the absence of any movable artefacts – such as pottery fragments, flint objects, or osteological remains – that would typically indicate settlement activity.

This relatively small central area was surrounded by an exceptionally complex system of timber-and-earth fortifications, composed of three concentric rings of embankments accompanied by ditches. The innermost ring, initially the most developed, consisted of a shallow ditch and an earthen embankment built from soil extracted during ditch excavation. The ditch was no more than 0.5 m deep and slightly over 2 m wide. The rampart itself was likely somewhat higher and appears to have been constructed within a space defined by two concentric palisade lines. This is suggested by the stratigraphically lowest position of the palisade trenches, whose outlines were entirely covered by the eroded rampart deposits. Probably, the top of the embankment was further reinforced with small pebbles, possibly to protect it against erosion or to stabilise a walkway.

Between the inner and middle lines of embankments and ditches, a double palisade ring was constructed. It was formed by setting pine trunks, approximately 0.3-0.4 m in diameter, into previously excavated parallel trenches. The palisade itself was arranged at an angle of about 45 degrees, leaning inward toward the centre of the structure. Its original height is currently difficult to estimate.

Both the middle and outer segments of the fortifications featured a very similar construction. On their outer side, relatively shallow ditches were excavated, approximately 3 m wide and no more than 0.5 m deep. The soil obtained from these excavations was used to build low ramparts, which were probably supported by a previously installed wooden palisade. Currently, there is no evidence that these structural elements were reinforced in any other way, such as with stone paving.

There is considerable evidence that during the construction and use of the site at Kościuki, the ditches were filled with stagnant water. This is indicated both by the composition of their fill, peaty silt deposits accumulated through decantation, and by the presence of well-preserved organic matter still visible at the bottom of the ditches. There is, however, no evidence of water flow, such as erosional channels, that would suggest running water.

A natural question arises about the possible locations of entrances or gateways into the site's interior. No such features were observed in the terrain's microtopography or in aerial imagery. Nor did the results of geophysical surveys provide a definitive answer, as they revealed only part of the site's complex construction. Magnetometric surveys only partially registered circular structural elements (Fig. 4: A). This is likely because the magnetic characteristics of the ditch fill closely resemble those of the surrounding geological background, despite the clearly observable differentiation, documented in the excavations, between the mineral base and the organic fill of the ditches.

It also remains unclear whether the detected concentric-ring segments represent the remains of stone constructions or burned remnants of wooden structures, such as palisades. In the former case, small stones were confirmed only in the construction of the inner embankments, while anomalies were observed in the middle and outer rings. Excavations did not confirm the burning of wooden structural elements, though localised burning, limited to small sections of the fortifications, detected in the geomagnetic imagery, cannot be ruled out. GPR results likewise fail to provide clear answers. The ditches were visible as curving linear anomalies. However, gaps in these anomalies were also recorded, which are currently difficult to interpret. Although they could hypothetically represent entrances or gateways, this interpretation is contradicted by the site's microtopographic layout (Fig. 2: B; 4: B). Another unclear feature is a linear GPR anomaly running perpendicular to the site's layout. It most probably represents a modern drainage system, parts of which were also uncovered during archaeological excavation.

The chronological relationship between the uncovered structural elements also warrants comment. Current evidence suggests that these features were constructed during a single, coherent building phase, and that the site was intended from the outset to assume a deliberately monumental form, a central area enclosed by three rings of ditches and ramparts, along with six concentric palisade lines. This interpretation is supported by the mutual consistency of the structural elements and the absence of any signs of rebuilding or repair. No evidence of fire or other catastrophic events was identified to explain the need for repairs or expansion of the structure.

The chronology of the material recovered from Kościuki is internally consistent. The homogeneous collection of artefacts can be dated to the beginning of the Iron Age, corresponding in absolute terms to the mid-1st millennium BC. This is consistent with the radiocarbon dating results (Fig. 7). A wood sample from one of the posts of the inward-leaning inner palisade yielded a date of 2440 ± 35 BP, which falls within the plateau phase of the calibration curve (Walanus and Goslar 2009), covering a broad range from the mid-8th to the late 5th century BC. A slightly later date was obtained from a wood sample deposited at the bottom of the outer ditch. Its age is between the 6th and early 4th centuries BC (2360 ± 50 BP). This is not surprising: the first date marks the actual construction phase of the site, while the second sample is associated with its use. Nevertheless, considering the likely contemporaneity of the entire site layout and the physical properties of the construction materials – namely, wood – it would be impossible for the site to have remained in use for over three centuries. Therefore, the actual functional chronology of the site can be narrowed to the 6th-5th centuries BC, a period supported by both radiocarbon dates.

The chronology of the Kościuki site aligns with similar three-ring constructions at Podosie and Jednaczewo. This is confirmed by the dating of structural elements from those sites, which place their construction between the early 8th and the end of the 5th century BC (Ościłowski 2015a; 2015b; Grabowski and Muzolf 2016). It appears that large, triple-ringed sites approximately 100 m in diameter emerged somewhat later than smaller, though morphologically similar, double-ringed constructions identified in the Biebrza River basin. This is supported by an extensive series of radiocarbon dates from the Horodnianka site (Suchowola commune, Mońki district). There, a series of ^{14}C analyses correlated with dendrochronological data enabled the determination of the construction time to the 10th-9th centuries BC (Krąpiec *et al.* 2012). The construction of a similar site from Jatwieź Duża is also dated to the early 9th century BC (Żurek *et al.* 2022b, 218).

The site from Kościuki is to some extent representative of the phenomenon, as are 27 similar sites located in the valleys of northern Podlasie and eastern Masovia (Żurek *et al.* 2022a; 2022b). Although it was not the first to be recognised by excavation (*cf.,* Ościłowski, 2015a; 2015b; Grabowski and Muzolf 2016; Żurek *et al.* 2022a; 2022b), the observations obtained here make it possible both to clarify the chronology of the phenomenon itself and to enter into a discussion of the role of ring-shaped structures of a defensive nature in the settlement-social system of the local late Bronze Age and early Iron Age groupings. While in the case of smaller, two-ring sites of this type, the numerous series of radiocarbon determinations (Krąpiec *et al.* 2012; Żurek *et al.* 2022b) and the homogeneous nature of the acquired sources (Żurek *et al.* 2022b) made it possible to determine the chronology unquestionably, the situation was somewhat different for large three-ring sites, among which the one from Kościuki should be grouped. An example of ambiguity can be found in the feature from Jednaczewo, where the presence of fragments of early medieval vessels was documented, which led the authors to erroneous chronological conclusions (Grabowski and Muzolf 2016). Ring-shaped Bronze Age and Iron Age sites share many characteristics, from similar topographical location to construction (Żurek *et al.* 2022a). The differences relate to the materials used in the construction of the embankments and the material traces of the use of the internal space. An example is the site in Jatwieź Duża, where stone structures on the embankment were documented, but no traces of wooden elements were found (Żurek *et al.* 2022b, 217). The opposite is the situation at Kościuki, as well as analogous structures from Jednaczewo and Podosie. Wooden palisades were also present in the structure in Horodnianka (Krąpiec *et al.* 2012). There, however, there was no evidence of any embankments or wide ditches surrounding the whole establishment.

Differences also become apparent in the use of the central space. At Kościuki, the proportionally small central area shows no material traces of settlement-related activity. A similar situation is observed at Podosie (Ościłowski 2015a; 2015b) and Jednaczewo (Grabowski and Muzolf 2016). In contrast, the site at Jatwieź Duża presents a different picture: within its central area, storage pits were documented and interpreted as evidence of food surplus storage and later redistribution (Tymowski 2012; Żurek *et al.* 2022b). This phenomenon has been linked to the period of abrupt climatic cooling and ecosystem instability marked by a series of extreme events, the so-called Iron Age Cold Epoch (Starkel 1977; Kalicki 2006).

Such an interpretation is difficult to apply to the site at Kościuki. If food storage or the sheltering of livestock had indeed taken place within the central area, one would expect to find corresponding material evidence, such as a cultural layer or at least eco- or artefacts. Furthermore, the spatial proportions between the central area and the fortified zone, with three concentric ditches and embankments as well as six rings of palisades, also argue against such a function. The contrast is striking: the central area covers approximately 315 m^2, while the entire fortified space exceeds 7000 m^2. The investment of time and resources required to construct such an extensive fortification system appears disproportionate to the relatively limited area potentially available for storage or livestock containment.

Many doubts also arise regarding the site's potential defensive function. These are again primarily rooted in the pronounced asymmetry, outlined above, between the theoretically protected central space and the constituent elements of the so-called fortification system. It is questionable whether such shallow ditches and low embankments could have realistically fulfilled a defensive role. Likewise, the defensive efficacy of the double palisade, inclined at a 45-degree angle toward the interior of the enclosure, must be called into question. This configuration suggests a greater intent to restrict movement out of the inner space than to prevent access from the outside.

The defensive potential of the site is further diminished by its placement on the flat topography of a peat plain, in the middle of which the Kościuki site is located. While similarly situated fortified settlements are known from roughly the same period in central and southeastern Belarus as well as northern Ukraine (belonging to the Milograd culture), the ratio between the protected area that contained traces of domestic structures and the space occupied by fortifications was markedly different in those cases (Loshenkov 2011). Whereas the flat relief of the Polesian region determined the locations of defensive settlements, the older-glacial, varied topography of northeastern Poland offered a far wider range of locations, including numerous elevations with clearly superior defensive advantages. Such topographic preferences are evident, for example, in the siting of Milograd defensive enclosures established outside the densely settled plains of Polesia (Kukharenko 1961).

It can be assumed that the establishment of structures such as Kościuki is connected to the influence of the Scythian Cultural Circle. However, the fortified structures associated with the latter, such as Chotyniec in the Jarosław district (Czopek 2019), differ significantly in terms of topographical location, size, and construction. There is no clear evidence here, especially given the limited archaeological material recovered from the Kościuki site or the cited Jatwieź Duza site.

In light of the observations outlined above, the most plausible interpretation of the Kościuki site is that it functioned as a kind of ceremonial-ritual or socio-administrative centre, conceptually akin to the Neolithic and early Bronze Age rondels (*cf.*, Řídký *et al.* 2018; Spatzier 2019). Such an explanation could account for the absence of material traces of domestic or economic activity in the central area, which may have been deliberately reserved for deities or ritual specialists. Their cultic practices or ceremonies may have consisted primarily of intangible actions, such as prayer, song, or other performative expressions, leaving little or no archaeological signature.

If this assumption is accepted, the complex system of concentric embankments, ditches, and palisades may be understood as a deliberate demarcation and durable separation of two realms in the worldview of the time: the sacred, enclosed within the interior of the enclosure, and the profane, occupying the surrounding space. The emergence of such elaborate spatial configurations may also materially exemplify the rise, consolidation, and operation of highly organised and hierarchical social structures, probably based on a system of chiefdoms (Tabaczyński 2012).

CONCLUSIONS

The results of the multi-faceted archaeological investigations allow for a reconstruction of both the structural characteristics and the chronology of the Kościuki site. The complex, spatially segregated enclosure, demarcated from its surroundings by three concentric embankments and ditches, and further enclosed by six rings of palisades, was most probably constructed between the 6th and 5th centuries BC. It thus ranks among the latest and largest of such enclosures known in north-eastern Poland.

Together with at least 27 comparable structures, the Kościuki site probably constitutes tangible evidence of both socio-ritual and demographic developments among local communities. These groups were, for the first time in this region, engaged in establishing stable settlement systems sustained by agrarian economies. This interpretation is independently supported by palynological studies indicating that the Late Bronze and Early Iron Ages were marked by the first clear signs of anthropogenic pressure and proxies of extensive grazing and cultivation (Kupryjanowicz 2005).

It appears increasingly likely that ringed enclosures such as the one at Kościuki represented distinct and spatially isolated zones of the sacrum – ceremonial centres or symbolic focal points for local groups inhabiting more or less stable satellite settlements or campsites dispersed throughout the surrounding landscape.

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CHRONICLE

Halina Taras[1]

SOFIA S. BEREZANSKA
(15 May 1924 – 2 May 2024)

After V. V. Otroschtchenko 2014

Professor Sofia S. Berezanska, an outstanding Ukrainian archaeologist, was born on May 15, 1924, in Kamianets-Podilskyi, into a noble family with intellectual traditions. Her father, Stanislav Baranovich, served as an officer in the Russian army and as adjutant to General Aleksei Brusilov. In 1932, the father of Sofia S. Berezanska was arrested, and the family was deported to Astrakhan. Following the German invasion of the Soviet Union, the Baranovich family was resettled in northern Kazakhstan (Cherniakov 2005, 6). Recalling

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those years, Sofia S. Berezanska wrote: 'In the village, the families of deportees were taken in by the Kazakhs as they needed 'slaves'. We ended up with a Ukrainian who, by some miracle, found himself in these lands. My father made me tend cows, turned my mother into a seamstress, and suggested I attend a tractor-driving course in a neighbouring village. (...) The training lasted all winter. In the spring, I climbed onto a tractor. I worked at sowing and later at harvest' (Babirov 2019).

Determined to pursue an education, she left Astrakhan illegally. She travelled to Kyzylorda (in south-central Kazakhstan), where she entered the Faculty of History of the United Ukrainian State University, an institution created from evacuated Kyiv and Kharkiv universities (ed. Zhmudskyi 1959, 368, 369). She completed her degree in history at Taras Shevchenko University in Kyiv in 1948. Immediately afterwards (1948-1949), she worked at the Kherson Historical and Archaeological Museum as a senior researcher, where she organised collections, systematised the library, and updated the archaeological exhibition (Cherniakov 2005, 6, 7; Otroshchenko 2024).

From 1949 to 1953, she pursued postgraduate studies at the Institute of Archaeology of the Academy of Sciences of Ukraine, where she defended her candidate dissertation (equivalent to a PhD in Russian and Ukrainian academic systems) under the supervision of Petr P. Yefimenko. The work was entitled 'Antiquities of the Pre-Scythian Period in the Uman Region and their Historical Significance' ('Пам'ятки передскіфського часу на Уманщині та їх історичне значення') and it focused above all on the Belogrudovo culture and addressed, among other issues, the phenomenon of zolnik (Cherniakov 2005, 6, 7; Otroshchenko 2014, 130; 2024).

In 1953, she joined the Department of Prehistoric Archaeology at the Institute of Archaeology of the Academy of Sciences of the Ukrainian Soviet Socialist Republic (since 1991, the Institute of Archaeology of the National Academy of Sciences of Ukraine) as a junior researcher. She remained at this institution until her retirement in 1997, progressing through the positions of senior researcher (from 1966) and, in the years 1987–1997, principal researcher (Otroshchenko 2024).

In 1977, she obtained the degree of Doctor of Historical Sciences (habilitation). The results of her habilitation thesis, entitled 'Northern Ukraine in the Bronze Age' ('Північна Україна за доби бронзи'), were published within the collective monograph 'Bronze Age Cultures on the Territory of Ukraine' ('Культуры эпохи бронзы на территории Украины'] (Berezanskaya *et al.* 1986). This work offered, for the first time, a comprehensive characterisation of four cultures: the Multi-roller pottery culture, the Sabatinovka culture, the Srubnaya culture, and the Belozerka culture (Otroshchenko 2003 [2025]; 2024).

The scholarly interests of S. S. Berezanska focused primarily on the Bronze Age of northern Ukraine. In this field, she conducted numerous excavations and published most of her works. She participated in approximately 40 archaeological expeditions (Otroshchenko 2003 [2025]). Already as a student, she joined the 'Great Kyiv' ('Великий Київ') expedition (1946-1959). From the early 1960s, she directed fieldwork herself. Among her most significant investigations were excavations at Pustynka, Chernihiv region – a settlement from the late Trzciniec culture (Berezanskaya 1974); at Usovoje Ozero, Donetsk region – a Srubnaya culture settlement (Berezanskaya 1990); and at Hordiivka, Vinnytsa region – a barrow cemetery of the Bronze and Early Iron Ages, excavated in 1987-1988 together with B. I. Lobai and V. I. Klochko (Berezanska and Lobai 1994; Berezanskaja 1998; 1999; Berezanskaja and Kločko 1998; 2011).

Professor Berezanska remained professionally active for more than a decade even after her retirement. At the turn of the 21st century, she conducted her last fieldwork at a Trzciniec culture barrow cemetery in Netishyn, Volhynia (Berezanska *et al.* 2003; Berezanska *et al.* 2004).

Through years of research, both field and analytical, S. S. Berezanska identified and defined several new cultural phenomena, including the Multi-roller pottery and Lebedev cultures. She also significantly extended the eastern range of the Trzciniec culture ('Eastern Trzciniec culture') and deepened knowledge of other groups such as the Bondarycha, Marianovka, Abaschevo and Srubnaya cultures. Through these contributions, she played a significant role in systematising and expanding our understanding of Bronze Age and Early Iron Age communities across the forest, forest-steppe, and, to a lesser extent, the steppe zones of Ukraine.

During her 1960s excavations at Pustynka, she also developed a methodology for identifying and reconstructing the spatial organisation of settlement sites (Otroshchenko 2003 [2025]).

The scholarly output of S. S. Berezanska includes five authored or co-authored monographs (Berezanska 1964; Berezanskaya 1972; 1974; 1982; 1990; Berezanskaja and Kločko 1998; Berezanska and Klochko 2011), five collective volumes (*e.g.*, Berezanskaya *et al.* 1986; 1994), and over one hundred scholarly papers. She was also a co-author of the first monumental publication, 'Archaeology of the Ukrainian SSR' ('Археология Украинской ССР'), for which she prepared nine chapters (Artemenko ed. 1985).

Professor Berezanska's versatility as a researcher is striking. Her interests encompassed the whole of the Bronze Age and the beginnings of the Iron Age across a vast territory. She investigated economic issues (subsistence strategies, resource acquisition, and non-agricultural production such as mining, flintworking, and bronze metallurgy), as well as spiritual culture and the organisation of prehistoric societies. She also engaged with questions of ethnicity (Cherniakov 2005).

Scholars researching her legacy emphasise that she was both an undisputed authority and an informal leader, the founder of a research school under whose guidance doctoral and postdoctoral theses were written (Otroshchenko 2014, 131).

Her work was well known and highly regarded, also among Polish archaeologists (see Gurba 2005). She maintained close scientific and personal ties with colleagues in Poland, especially those in Poznań and Lublin. She gave lectures, both open and obligatory, at the Maria Curie-Skłodowska University in Lublin, and frequently hosted Polish scholars in

Kyiv, providing them with access to her research materials and offering generous assistance.

S. S. Berezanska was a prominent figure in the Ukrainian scientific world (Mezentseva 1997, 37; Otroshchenko 2003 [2025]) and a person of great kindness and integrity.

Professor Sofia S. Berezanska passed away in Kyiv on May 2, 2024. She has left a lasting mark on science and in our memories.

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REVIEWS AND SHORT REVIEW NOTES

Karol Dzięgielewski[1]

(Review) Marcin Maciejewski, János Gábor Tarbay, Kamil Nowak (eds), *Hoards from the European Bronze and Iron Ages. Current research and new perspectives* (= *New Approaches in Archaeology* 4). Turnhout 2024: Brepols Publishers, 175 pp.

Recent years have witnessed the appearance of several volumes devoted to the analysis of metal deposition phenomena, including hoard finds, each characterised by a narrowly focused thematic approach. The editors of the reviewed volume set out to provide an overview of new trends in research on this phenomenon; consequently, despite the relatively modest size of the book (slightly over 160 pages of effective content), its thematic scope is quite broad. Nevertheless, the volume does not, of course, exhaust all aspects of contemporary reflection on deposition processes – such as new typofunctional approaches, analyses of compositional variability, or the chronological range within hoard assemblages.

The reviewed monograph consists of eleven chapters, each written by one (most often) to five authors. It was published as volume 4 of the freshly established series *New Approaches in Archaeology*. The publication opens with a concise introduction by the three editors, outlining the spectrum of both long-standing and recently emerging topics in hoard studies – a special manifestation of the universally attested historical phenomenon of depositing valuable goods. The authors describe the conventional dichotomy between ritual and non-ritual approaches to deposition as barren (p. 13). One also encounters the now-familiar call to 'go beyond the typo-chronology of hoarded artefacts': I would ask not to throw the baby out with the bathwater. The editors advocate for broadening methodological perspectives on hoard research, viewing this as a unique opportunity to create a pan-European research network centred on this universal phenomenon. Credit must, however, be given to the typological and chronological approach, which has so far produced the greatest degree of scholarly integration – most notably within the framework of the *Prähistorische*

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Bronzefunde series. That project, after all, encompassed the full spectrum of depositional practices (not only hoards). Establishing a similarly coherent network today, based on other, more diverse and individualised lines of inquiry, seems to be a challenging task at present.

The introductory chapter continues with a succinct overview of the individual contributions included in the volume and closes with reflections on future research perspectives. The editors primarily locate these developments in the advancement of archaeometric and instrumental analyses, as well as in the application of Big Data and AI-based tools. They express the ambitious hope for a pan-European database of hoards. Their postulate to expand the scope of deposition studies to include objects made of other raw materials (p. 16) could, moreover, be complemented by attention to so-called single finds, which have long attracted archaeological interest across Europe as a complementary phenomenon (*e.g.*, Kubach 1985; Blajer 2001; Becker 2013).

A well-considered editorial decision was to include two generalising papers by recognised scholars in the volume: Wojciech Blajer, whose contribution on the history of research opens the book, and Kristian Kristiansen, whose essay closes it with an attempt at a new conceptualisation of the phenomenon. Blajer's text, 'In an interpretive triangle. Main trends in research on hoards in the nineteenth and twentieth centuries: a Central European perspective' (pp. 21-29) is an excellent study of the evolution of views on the deposition of valuables. It presents a rich selection of literature – often now undervalued – acknowledging the achievements of numerous authors (most frequently from outside the Anglo-Saxon scholarly circle) who, decades ago, had already discussed certain phenomena that are now being 'rediscovered' and vigorously debated (such as the complementarity of metal deposition forms across time and landscape). From the reading, one may get the impression – which Blajer himself explicitly emphasises – that since the 1980s and 1990s, little that is truly new has emerged regarding conceptualisations of the motives behind hoard deposition. The text is so engaging that the reader may feel some disappointment that the author did not undertake an equally extensive commentary on the threads represented in hoard research during the first two decades of the 21st century. On the other hand, the very volume under review is meant to serve as such an overview.

The article by Tiffany Treadway, 'The cognitive development of prehistoric wetland deposition tradition through mnemonics. Case studies of Iron Age Wales and Scotland' (pp. 31-39) is one of the most inspiring yet provocative studies in the book. Research on deposition conducted within the current of cognitive archaeology should focus on the role that acts of deposition played in social processes – in the internalisation of the rules governing a given human group, as well as in the process of adaptation to the natural and political environment. In this approach, hoards themselves constitute a kind of prop, token, and at the same time, a mnemonic sign, accompanying social transactions of which they are, of course, not the essence, but rather a means. Following Joanna Brück, the author states that in the study of deposition rituals, 'archaeologists should not focus on unknown aspects of ritual (*i.e.*, its meaning), but rather on the implications of tradition which are key foundations of social bonding and identity' (p. 32). In other words, our pursuit of motives is somewhat futile, since we lack the tools (*e.g.*, insight into intangible culture) to approach them directly. We can, however, uncover the construction of the ritual – its individual stages and material correlates. The mnemonic aspect of hoards would be emphasised by the choice of only certain places within the landscape, something indeed highlighted by many contemporary archaeologists, not only in this volume (Treadway focuses on wetlands). Indeed, there is no reason why deposition should be excluded from the rules of social learning, with all its consequences. One of them may be that, as in the transmission of style, not all copied elements will be understood by all actors, which over time leads to the forgetting of the original role and to elaboration – the process of endowing the ritual with increasingly rich meanings. In performative events, participation is, after all, more important than understanding. Conversely, after periods of interruption in performance, certain changes may occur in the structure of the ritual (in this case, deposition), which may be discernible in the structure of the finds. Once tested, this attractive middle-range theory could help determine whether deposition was a repetitive activity regulated by strict rules and forming part of a habitus, or merely an exceptional event in the life of a community, governed by only general prescriptions (such a diachronic test, incidentally, the author does not provide). This is precisely what constitutes the provocative feature of the 'memory-based' theory, for as archaeologists we often a priori assign to acts of deposition individual meanings conditioned by specific motives assumed to be comprehensible to all actors (motives that we still seek, for instance by examining the arrangement of objects within a hoard). The mass character, repetitiveness, and structuring of deposition, as revealed by recent research (*cf.*, Fontijn 2020; Gauthier and Piningre, in the reviewed volume), compel us to reconsider the very foundations of such views.

In the empirical part of her article, Treadway focuses on testing another concept – the *method of loci* – and convincingly demonstrates a correlation between specific types of deposited objects and particular landscape types in Iron Age Wales and Scotland (pp. 34-36). Equally accurate is the author's remark that wetlands appear inaccessible and isolated (marginal) only from our modern perspective – they could have held entirely different meanings for participants of those ancient cultures, who utilised their abundant resources and distinctive features (such as valley edges as communication routes, sources of reeds, fauna, *etc.*).

Another interesting observation is that the psychological rules of cognitive processes can be applied when attempting to reconstruct the act of deposition itself: for such an event to become part of collective memory and to be transmitted across generations as a repeated practice, it should have a low-stimulus, repetitive, and co-participant character (p. 35). In her conclusions, the author somewhat retreats from her earlier arguments, acknowledging that functional aims (specific motives) might have played a role as significant as traditionalist ones – that is, repetition grounded in cognitive schemata developed by individual members of the community and reinforced by mnemonic devices. Most researchers of the phenomenon will more easily accept this middle-ground position.

The next chapter, authored by Martina Blečić Kavur ('There is a light that never goes out! New and old hoards from the Northern Adriatic', pp. 41-52), opens the series of regional studies in the volume and concerns northeastern Croatia, Istria, and the islands of the Kvarner Gulf. This is yet another area in Europe where, thanks to recent discoveries, it has become necessary to revise the earlier view that the region lacked evidence of bronze deposition during the Late Bronze Age (LBA) – although such regions, in specific periods, do still exist. The intensity of this phenomenon remains low (fewer than ten hoards), and the region lacks a distinct local stylistic identity, being characterised instead by intersecting influences from Pannonia and the Apennine Peninsula. The area under discussion belongs to those where deposition at the beginning of the LBA was clearly more pronounced than at its end, similarly to southern Bohemia (Chvojka *et al.* in the reviewed volume). As one might expect from a regional rather than thematic study, the presentation has something of the character of a survey of curiosities: these include ceremonial Ansciano-type axes with low tin content and no traces of use, as well as fishhooks – items rarely encountered in hoards (p. 46). The phenomenon of fragmentation, so typical of Alpine and Transdanubian regions, appears here only at the threshold of the Early Iron Age (the hoard from Malinica) (p. 49).

The next macro-region, southern Bohemia, is examined by a team of Czech researchers – Ondřej Chvojka, Jan John, Jiří Kmošek, and Tereza Šálková – in their paper 'The Urnfield-period metal hoards in South Bohemia. Find circumstances, topography, and analyses' (pp. 53-67). A chronological analysis of numerous LBA finds, indicating a distinct decline in deposition toward the end of the Bronze Age, as in the discussed region of the northern Adriatic, as well as, for example, in the French Jura (Gauthier and Piningre, in the reviewed volume) and in Lesser Poland (Dzięgielewski *et al.* 2024), once again suggests that the rhythm of the hoarding phenomenon was influenced not only by global trends but also, to a large extent, by local dynamics requiring explanations that go beyond the pendulum paradigm (the general decline in hoard deposition during periods of intensified grave goods deposition). Other areas within the Urnfield cultural complex experienced a peak in the phenomenon at the same time (*cf.*, Blajer 2001; Dzięgielewski 2023).

The microregional studies from the project referred to in this article provide further examples of 'mountains saturated with hoards', such as Paseky (p. 63). A phenomenon once considered exceptional (*e.g.*, Štramberk-Kotouč in the Moravian Gate region) now appears, with the increase of both systematic and amateur prospection, to have been a constant feature of Bronze Age cultural landscapes in areas with complex topography. In areas lacking natural landscape dominants, such features were created by human activity (*cf.*, Maciejewski, in the reviewed volume). In the conclusion of this interesting, multifaceted study, the authors venture to propose a classification of the analysed hoards into four categories: (1) commercial/production-related, (2) prestige-related, (3) substitute of funerary gifts, and (4) votive offerings. Surprisingly, only the latter are described as 'permanent', thereby referring to older concepts concerning the 'retrievable nature of dry-land deposits' (*cf.*, Blajer, in the reviewed volume). In the context of 'prestige' hoards, the authors draw attention to the association of fortified settlements with elites – an assumption whose obviousness has been increasingly questioned in recent scholarship.

The article by Estelle Gauthier and Jean-François Piningre, 'An active search for hoards? Contributions of a systematic field survey to the knowledge of Bronze Age metal hoarding: The case study of Salins-les-Bains, Jura, France' (pp. 69-90), written with the collaboration of numerous volunteer archaeologists, again concerns a specific region but addresses a narrower range of issues (whereas the previous study discussed both landscape and hoard typology, as well as isotopic provenance). Here, the authors focus on presenting a geographically smaller but certainly more targeted and intensive field project carried out since the early 21st century in a region previously known mainly for its prehistoric salt production, located on the northwestern foothills of the Alps. In close cooperation with amateur metal detectorists, a systematic and goal-oriented survey has been conducted there for over two decades, covering about 52,000 hectares (of which roughly 5,000 hectares have been explored) around the hillfort of Camp du Château and Mont Poupet hill. The spectacular and highly comprehensive results of this ongoing project have almost convinced me – a person generally sceptical of unrestricted, invasive treasure-hunting activity – to consider selective applications of such an approach. For scientific purposes, a pilot study of this kind would indeed be desirable at least once in every 'archaeoregion' (to use the conceptual framework adopted in the Dutch heritage protection system), even though its consequence – this must be explicitly stated – would be the total and irreversible depletion of a region's potential archaeological value in terms of metal deposits. It is, however, difficult to understand why such an undertaking in the Salins-les-Bains area was not tied to heritage protection objectives. As the authors themselves state, the survey focuses on forested areas – *i.e.*, those not threatened (p. 71) – rather than on exposed arable land, where the destruction and displacement of archaeological remains progress most rapidly and where the detection and recovery of artefacts would be most meaningful and necessary from a heritage-management perspective. The scientific rationale for the project is, of course, legitimate, yet it is not fully realised if exposed areas are neglected.

The focus, for understandable reasons, has been placed on locations most promising according to the previously identified regional deposition pattern – namely, elevated and prominent sites. By systematically covering only about 10% of the total area, the survey has already expanded the corpus of hoard finds from seven (in 2001) to seventy-four (in 2021). In terms of object count, the overwhelming majority of these are small hoards comprising fewer than twenty items, while in terms of total bronze weight, two clear groups emerge: small deposits (from a few grams up to 300 g) and large ones (above 1 kg) (p. 73). Chronological attribution produces an interesting result: a clear peak at the transition between the Middle and Late Bronze Age (Br C2-D1) and an almost total disappearance of typologically identifiable assemblages in the final Bronze Age. It must be noted, however, that one-third of the assemblages consist of undatable scrap fragments. The inventories themselves also differ significantly in composition: earlier hoards include fragments of ingots and casting waste, axes, and sickles, more rarely individual personal ornaments, while deposits from the Br D2-Ha A1 phase contain a greater proportion of fragmented finished objects (pp. 73, 74). The authors' observations concerning the hoards' stratigraphic position are equally interesting: most were found at depths of 0-25 cm, which, based on the preceding remarks, seems to reflect their initially shallow deposition (or perhaps even placement on the surface) rather than later disturbance by ploughing. The dispersion of bronzes over several square meters in such contexts (excluding secondary effects of ploughing or erosion) suggests, in the authors' view, that the hoards were deposited initially on the surface or even on above-ground structures (p. 77). This naturally invites association with L. Nebelsick's (2000) concept of ritual, ecstatic deposition. From a landscape perspective, it is clear that topography played a crucial role: the deposition sites were visible from afar – especially assuming a lower degree of forest cover – and, in a strikingly high proportion of cases, they were intervisible with one another as well as with the fortified site at Camp du Château (pp. 79-81).

This valuable and, in many respects, groundbreaking study in landscape archaeology also provides a range of additional detailed observations – for example, the very low rate of conjoining fragments (20 out of 2,500 pieces). This constitutes a strong argument in favour of their 'premonetary' function (*cf.*, below; Ialongo and Lago 2024), while at the same time offering direct evidence of recycling and of the *pars pro toto* principle.

In the following study, authored by Marcin Maciejewski, 'Ice-marginal valleys and hoards: Natural landscapes, cultural practices, and their amazing convergence in different regions of Central Europe (Poland)' (pp. 91-106), the landscape aspect of depositions is once again of primary importance. It must be admitted that, after reading the preceding article on the Jura and its 'active hoard-hunting' methodology, the distribution maps of deposits in this and subsequent papers (as well as in most other microregional analyses of deposition phenomena) inevitably cause some concern, given that they often contain only three or four deposits discovered over a span of 150 years (what corresponds to stage 1, up to year 2000, in the study by Gauthier and Piningre). One is somewhat reassured, however, by the realisation that most of our syntheses – not only those concerning hoards – are based on datasets constructed in precisely this way. Maciejewski, moreover, conducts his research in areas with entirely different conditions from those studied by the aforementioned French scholars. As he himself observes, the past cultural landscapes of this part of Europe – specifically, the eastern section of the North European Plain – are only minimally accessible to investigation, since their physical features have been obscured by centuries of intensive agricultural activity. At the same time, collective memory has been repeatedly disrupted by population displacements. What remains as reference points are only the truly enduring and large-scale features – ice-marginal valleys and their edges (p. 93). These must have been ascribed exceptional meanings in the past, and they may still embody and reveal those meanings today. The contextually analysed concentrations of metal deposition sites along these valley edges – illustrated here by two clusters of hoards from Rosko in the Noteć Valley and Karmin in the Barycz Valley – fully substantiate this perspective. This paper also raises another insightful research question, bringing us back to the issue of the individual versus replicable nature of deposition acts: did the ritual of deposition always convey the same cultural message and hold the same social meaning, given the differing compositions of the hoard? (p. 103).

The study by János Gábor Tarbay, 'Twin hoards and hoard selection from Late Bronze Age Transdanubia' (pp. 107-129), constitutes a recapitulation of the findings presented in the same author's book published two years earlier (Tarbay 2022). It discusses fascinating cases of hoards – or groups of hoards – discovered during systematic searches (again!), which, being exceptionally well contextualised, paradoxically open up new research avenues instead of answering long-standing questions. Within this framework, Tarbay examines the problem of so-called 'twin hoards' – instances where two separate sets of bronze objects are found in proximity (for example, Budakeszi-Őzvölgy-tető, Hoards A and B, just 11 cm apart). Under traditional circumstances, without a fully documented context, such deposits would almost certainly have been treated as parts of a single large hoard. However, they differ significantly in both typology and treatment: the bulk of Hoard A consists of (at the bottom) fragments of 'cake ingots', above which lay other large, fragmented items, mostly 'as-cast' or unused; in contrast, Hoard B is a small group of relatively undamaged, complete objects showing heavy signs of use (pp. 108-116). A similar pattern recurs several times in Transdanubia and beyond. The discussion is illustrated with clear, well-designed infographics – now something of a hallmark of Tarbay's work. He proposes several interpretive models for this phenomenon, including: (1) simultaneous deposition of the entire assemblage by different groups of people, (2) deposition of individual parts in short succession, and (3) return to the same location after a longer interval (effectively forming special cases of 'multi-hoard sites'). The last scenario seems somewhat less convincing, as it would require precise relocation of the first deposit and spatial referencing to it – would that not necessitate its uncovering or disturbance? However, given the shallow depth of deposition and the possibility of surface markers, even this cannot be entirely ruled out (*cf.*, the Late Bronze Age/Early Iron Age doubled hoard marked by an erratic boulder at Kaliska, Pomerania – Szczurek and Kaczmarek 2022).

Tarbay, inclining toward the view that the fragmentation of raw material ('cake ingots') occurred not immediately before deposition but earlier, supports his argument with evidence of worn fracture edges – traces that must have developed well before the act of deposition. However, this reasoning is documented only with examples of fragmented finished objects (such as axes), not with 'cake ingots' themselves. A particularly noteworthy result of the author's multivariate statistical analyses – conducted on a sample of about 30 hoards from Transdanubia dated to the Ha A-B1 phase, and focusing on the share of different categories of artefacts (ingots, foundry waste, as-casts, finished probably unused products, used products) – is the finding that hoards displaying different combinations or dominance of these categories do not cluster microregionally. Instead, they are dispersed across the entire study area. This observation suggests that particular deposition patterns were not the expression of localised cultural traditions but rather manifestations of complementary depositional needs, each carried out under distinct but repeatable circumstances. Thus, we return once again to the central question around which many contributions in this volume revolve: is deposition an individual, uniquely motivated act, or the realisation of a universal pattern? Tarbay's answer is concise – though his paper is anything but short – and unequivocal: deposition *is* a profoundly individual act. Despite recurring formal patterns, we must bear in mind that, as he reminds us, no two identical hoards are known to date (p. 124).

The next study is perhaps the only true case study in the volume. The paper by Kamil Nowak and Nicola Ialongo, 'Late Bronze Age hoard from Nowe Kramsko. Is there a method in fragments?' (pp. 131-148), goes beyond an in-depth micro-analysis of a single hoard to address the widely debated issue of metal fragmentation in the LBA, using as its example an exceptionally well-suited case – the Nowe Kramsko hoard from western Poland. This assemblage, weighing 14 kilograms, comprises 512 artefacts, including 243 fragments. The original publication (Michalak and Orlicka-Jasnoch eds 2019) of this assemblage, which unfortunately lacks contextual documentation such as that available for the hoards discussed earlier, together with subsequent traceological analyses, allowed the authors to concentrate here exclusively on a combination of two analytical approaches: use-wear analysis and statistical analysis of the weight of deliberately fragmented artefacts. Most complete of them (*e.g.*, 39 of 43 sickles) were deposited in an as-cast state. Interestingly, this also seems to apply to most fragments – use-wear traces were observed on only 23 of the 195 pieces. The fragmentation patterns differed by artefact type: sickles were incised with a chisel or saw to predetermine the size of the fragment, and then broken off, leaving a characteristic straight edge on one side and a jagged one on the other. Axes, by contrast, were simply smashed. Bracelets were also fragmented, though in this case the documentation of saw marks is not entirely convincing (*cf.*, Garbacz-Klempka *et al.* 2022, fig. 15.6: 1, 2).

Both as-cast and used products were intentionally fragmented. The observation that fragments do not conjoin confirms, on a microscale (similar to the mesoscale observation for the French Jura discussed earlier), the same pattern identified by N. Ialongo and G. Lago (2021; 2024) in hoards spanning a broad Central European transect from Italy to Jutland. All this supports the hypothesis that fragmentation was not always about ritual 'killing' of objects or reducing them for remelting, but rather about creating new economic and symbolic value. The weight analysis of the fragments from Nowe Kramsko provided an opportunity to test the money hypothesis, regarding the function of copper-alloy fragments as a form of 'hacksilver' of the European Bronze Age (Ialongo and Lago 2024), on a sample originating from a single depositional act – thus chronologically unified, though not necessarily random, as it clearly represents a selected portion of circulating raw material.

At this point, a digression is necessary to situate the discussed study within the framework of the aforementioned hypotheses. Although the economic aspect of fragmentation – including its weight dimension – has long been widely discussed in the literature (*e.g.*, Sommerfeld 1994; Brandherm 2018; 2019), it was only when this phenomenon was linked with the parallel research on weights and weighing systems that N. Ialongo, G. Lago, and L. Rahmstorf (2021) managed to break the deadlock in the study of prehistoric metric systems in Europe. Previously, metal fragments – sometimes suggested as an alternative to a dead end of searching for regularity in the weights of whole objects (including ingots) – had never been systematically studied on a large scale. In 2024, Ialongo and Lago further developed the concept, demonstrating that the weight structure of fragments (and thus their value) follows a log-normal distribution. This means that the average transaction using them involved amounts slightly higher than the smallest ones, while larger transactions were rare. Based on this, they proposed that Bronze Age European societies exhibited economic behaviour similar to that seen in modern household economies (Ialongo and Lago 2024). This is a tempting hypothesis, though one that few specialists would accept uncritically, given that religious and social interpretations of the hoarding phenomenon currently dominate the discourse. Yet, the underlying idea – that various forms of human behaviour, even those that appear 'irrational', are governed by universal economic mechanisms – is not far removed from the principles of evolutionary ecology or human behavioural ecology (HBE). This well-established school in anthropology and archaeology encompasses both biologically oriented concepts (*e.g.*, fulfilling energy needs) and microeconomic theory (economic decision-making based on rational, predictable principles, such as the law of marginal costs) (*e.g.*, Smith and Winterhalder eds 1992; Przybyła 2014; Walsh *et al.* 2019). Attributing such 'rational behaviours' to prehistoric societies does not in any way deprive them of their cultural 'otherness', a point made clearest when examining the reverse side of economic action – not acquiring but consuming goods. Here, the application of modern systems of value becomes practically impossible. Hoarding is the best example: even if the composition of hoards mirrors the structure of circulating material value, this still tells us little about the reasons behind their deposition.

Nevertheless, this promising research idea, when applied to bronze, must eventually confront some specific issues – for example, the diversity of alloys: if metal fragments functioned as money, then the tin or lead content in the alloy would surely have mattered. Another key question concerns regional differences in fragmentation during the Late Bronze Age. Was this merely the result of a selectivity bias (*i.e.*, fragments as 'money' were used everywhere but only entered deposits where such deposition was a culturally sanctioned practice)? Or does it instead reflect varying degrees of integration of European communities into the metal circulation system?

The authors of the reviewed article on Nowe Kramsko draw attention to the universality of 'hackbronze'. Both pieces of raw material, as-cast objects, and used items could serve as carriers of value. Moreover, the conversion between the functions of value storage and raw material was remarkably simple, since these two functions were not mutually exclusive (p. 145) – just as the utilitarian and religious roles of deposits containing fragments could also coexist (Brandherm 2018, 58). The weight analysis of fragments from Nowe Kramsko (n=168) indicates that their pattern closely corresponds to the weight structure of fragments from hoards found in eastern Germany and western Poland (n=761), previously examined by Ialongo and Lago (2021). Both datasets show a concentration of positive values in the Cosine Quantogram Analysis within the 8-12 g range. A subsequent Frequency Distribution Analysis (regrettably, the authors did not include the relevant graph) revealed clusters of positive results around 10 g, 19-22 g, and 31 g, thereby confirming that the fragmentation pattern from Nowe Kramsko aligns with the Pan-European weight unit of approximately 10 g (p. 144). The article concludes that the motives behind deposition, despite results supporting the monetary hypothesis, remain open to interpretation.

The paper authored by Szilvia Gyöngyösi, Péter Barkóczy, Julianna Cseh, Laura Juhász, and Géza Szabó, titled 'Comparative technological analysis of Middle Bronze Age bronze objects from hoards and burials' (pp. 149-169), is the only contribution in the volume with a strictly archaeometallurgical focus. It opens with remarks concerning the context of the analysed artefacts. The authors' concept of a methodologically consistent comparison between bronzes from hoards and burials belonging to the same cultural context – the Transdanubian Encrusted Pottery Culture – deserves full recognition, even though the comparative analysis itself occupies merely the last two paragraphs of the paper (the majority of the article consists of excellent micrographs and their detailed descriptions). Although the sample size is modest (14 bronzes from the Vértesszőlős and Zalaszabar hoards, and 11 from the Bonyhád cemetery burials), the methodological approach renders the results valuable, above all because of the rare opportunity to perform invasive metallographic examinations on polished sections of bronze ornaments, a practice now seldom undertaken. The authors do not observe any technological criteria in the selection of bronzes for particular contexts; instead, the observed differences appear to be typological, implying that the end of a 'life cycle' of the artefact varied depending on its type. However, the lack of use-wear analyses to test this hypothesis is somewhat regrettable. The study clearly demonstrates the limitations of assessing manufacturing technology in the case of cremation burials, since exposure to the funeral pyre has an enormous impact on the acceleration of grain boundary corrosion (pp. 163, 164).

Overall, the analysis revealed that within the group of ornaments – even those functioning as garment appliqués, from which one would not expect enhanced hardness or flexibility (*e.g.*, crescent-shaped pendants) – the dominant operational sequence consisted of treating a cast precursor through cold hammering/deformation, followed by heat treatment. Only three artefacts (omega-shaped pendants) were left unworked after casting. No chemical 'fingerprint' characteristic of a given assemblage was identified; instead, the authors were able to distinguish alloys typical for certain artefact types. This raises a key question: did this reflect the maintenance of different alloy types within the same workshop, each used for specific object categories (p. 168), or rather an intentional alloying strategy?

In the closing essay, 'Re-theorising deposition in Bronze Age Europe' (pp. 171-175), Kristian Kristiansen neatly recapitulates several of the key insights presented throughout the volume, embedding them within his broader vision of European Bronze Age societies as representatives of decentralised, sacrificial economies. He recalls the important observation made by the late David Fontijn, namely that the unprecedented scale of deposition in the Bronze Age demands historically specific conceptualisations (p. 172) and explanations, rather than mere anchoring in general anthropological or palaeo-economic models. By thus calling for historical contextualization – and later proposing that, for various reasons, most hoards were initially intended as temporary deposits, possibly also associated with periods of unrest, while the hoards we know today constitute only the visible tip of an iceberg of once-existing but later retrieved deposits (p. 173) – Kristiansen in fact returns full circle to the starting point of interpretive tradition: political readings of hoarding phenomena (*cf.*, Blajer, in the reviewed volume). While I share the view that some of the so-called 'hoards', especially those discovered under particular circumstances, are closer in character to 'stores' than 'deposits' (*cf.*, Dzięgielewski 2024), Kristiansen's image of the iceberg tip seems to me a little bit exaggerated. The growing intensity of field surveys and the increasing number of discoveries instead suggest that we are indeed dealing with an iceberg's tip – but of the hoards which were, however, deposited without any intention of recovery. However, the openness to the diversity of motives behind deposition and storage – views that a mere decade ago were explicitly rejected (I still recall the atmosphere at the EAA session in Vilnius in 2016) – should be attributed to the wider availability of contextual analyses, conducted at scales ranging from individual hoards to entire landscapes, as well as to archaeologists' growing awareness that economic value not only does not contradict, but is in fact inseparably intertwined with the ritual and social value of metal.

Reading this carefully edited volume is only rarely disturbed by minor editorial slips – such as the poor legibility of charts in figures 3.4 and 3.5 in Treadway's chapter, likely resulting from the conversion of colour graphics to black and white at the printing stage, or the repeated mention of the administrative affiliation of sites in Tarbay's text. The foreign reader may also feel a certain quiet satisfaction upon noticing the several misspellings of the place name Vértesszőlős in the contribution by Gyöngyösi *et al.* – a reminder that the tongue-twisting spelling of Hungarian toponyms poses challenges even to native speakers, who must have seen the text for proofreading.

On the substantive level, the hypotheses and interpretations proposed by all contributors are generally well grounded – the chapters are neither short nor superficial, which deserves emphasis and appreciation. Only a few points caught my attention. One is the commentary to the figure 5.15 in the paper by Chvojka *et al.* While their observation that the lead content (Pb) in 'cake ingots' is slightly lower than in finished objects from the Krtely hoard is valid, can this really be interpreted as evidence of intentional alloying or recycling, given that the average Pb concentration in the finished items is around 0.1%? It would suffice that those objects had been made from a different batch of metal – even if extracted from the same ore source – to explain such variation. Another point of contention concerns the classification of the dagger from the Karmin IV hoard in Maciejewski's article as belonging to the North Caucasian Kabardino-Pyatigorsk type. The entirely different shape of the guard and pommel suggests instead a closer analogy with the Klein Neundorf type, likely bearing Italian rather than Eastern European steppe connections.

To sum up, what we have here is a solid collective work that offers not only a comprehensive overview of current trends in the study of European Bronze Age hoards (and, to a lesser extent, those from the Iron Age), but also stimulates reflection and provides new arguments for ongoing debates concerning the interpretation of metal deposition in prehistory. A recurring theme – echoing throughout the volume – is that of motivation: were the acts of deposition driven more by universal principles or by individual intentions? Each contribution, depending on its analytical perspective, offers fresh confirmations or refutations of one or the other viewpoint. The same can be said of the cultural meaning of hoards depending on their composition and contextual setting. At this point, one must agree with the editors' assessment that the study of deposition phenomena holds great promise for the future – or perhaps is still in its early phase, as suggested by the limited integration of depositional landscapes into settlement studies to date.

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