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IMAGE COMMUNICATION AND CONTEMPORARY VISUALISATION IN THE POPULARISATION OF ARCHAEOLOGY

ABSTRACT

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In modern society where images begin to play a dominant role in the cognitive process, the use of visualisation as a carrier of information about archaeological research becomes more and more important. The main aim of this article is to consider visualisation as a method of education and protection of cultural heritage, as well as the role of image communication in popularising archaeology. These issues will be subject to a critical discussion in terms of advantages, possibilities and challenges resulting from the use of 3D reconstruction of prehistoric objects in museology, the Internet and popular science publications. In order to understand the idea of image communication in popularising the archaeological heritage better, an example of visualisations comprising a graphic part of museum exhibitions will be presented.

Keywords: image communication, visualisation, museology, popularisation of science, archaeological heritage
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INTRODUCTION

The aim of the article is to present the role of visualisation, which is one of the forms of visual communication, in popularising archaeology in museum exhibitions, on the Internet and in popular science publications. Communicating information about the past through spatial reconstructions is an extremely important educational method that propagates knowledge about the need for protection of cultural heritage. The implementation of the set research task requires understanding of what "computer visualisation" and "image communication" are. According to the definition, visualisation is the process of presenting information in a visual way, using digital technologies (London Charter 2009). It is therefore a technique of producing images as a method to create, analyse and convey various messages and meanings. Visualisation is also a graphical representation of information. This means that it performs the same functions as any other pictorial representation. *Image (visual) communication* is this sphere of human activity, the distinguishing feature of which is the transmission of information by affecting the sense of sight (Zajączkowski 2000, 5).

In archaeological research, the methods of data visualisation are currently used in *Geographic Information Systems* (GIS), geophysical analyses, field survey (remote sensing), 3D scanning, photogrammetry, computer simulations and for 3D modelling. The last method of research-three-dimensional modelling, which enables the creation of visualisations of archaeological features, will be discussed further in this paper. Using 3D graphic software, *i.e.* "Autodesk Maya", "Blender" or "Google SketchUp" it is possible to design and model 3D objects in detail.

3D modelling is the basis of two methods of presentation used, among others at museum exhibitions, *i.e.* VR (virtual reality) and AR (augmented reality) techniques (these techniques need to be discussed separately, so in this article they will only be mentioned as one of the visualisation methods). With appropriate simulation of the senses, both of these methods create an illusion of reality. In VR technique, the perception of reality is based solely on virtual, computer-generated information. Conversely, AR combines the real environment, such as the image from cameras, with the digital image, *i.e.* 3D graphics (Anders and Zwirowicz-Rutkowska 2017, 8-9, 12). VR and AR users can get to know the ancient world with the help of screens or special goggles and motion controllers.

According to the architect Sławomir Kowal (2015, 26-28), the message contained in the digital visualisation depends on the purpose for which the model was made and on its degree of similarity to the original. If the goal is to recreate the appearance, we call such a model *iconic*. When the model was created to reflect the principles of operation of the original, it is then an *analogue* model. A *symbolic* model is one that illustrates abstract features and principles. Finally, the *imaginative* model is most often used in archaeological visualisation. It is created on the basis of subjective presumptions and judgments about the lost area of historical reality. The imaginative model requires a creator to formulate hypotheses that facilitate the understanding the relationship between archaeological features, creative complement and the image, based on imagination and knowledge. The reconstruction of the missing data results either from the logic of the system, such as the analysis of the object as a whole, or is based on the experience and knowledge of a researcher using analogies to build the model.

The use of three-dimensional modelling techniques in archaeology dates to the 1980s. These oldest spatial images are quite simple and do not look as realistic as they would today. Computer technology has developed rapidly since the 1990s. In 1990, Paul Reilly (1991, 133-139) introduced the term *virtual archaeology*, referring to the use of 3D modelling to record and analyse the results of archaeological research. Currently, three-dimensional images, created with the help of specialised software, are extremely realistic and resemble photographs. Most of the digital visualisations are posted on the Web. Thanks to the Google SketchUp software, a lot of digital 3D models are created. Collections of three-dimensional objects can be viewed, among others on Sketchfab (2022).

Computer programs for creating 3D graphics support and modernise activities for the protection of archaeological heritage (see for example, Sylaiou and Patias 2004; Hermon and Kalisperis 2011; Barceló 2014; Markiewicz 2014; 2018; 2022; Georgopoulos and Stathopoulou 2017). Three-dimensional reconstructions are an effective means of conveying information about the past. Although archaeologists use this software to test hypotheses and verify data in their research work, digital imaging is primarily intended for the use of the general public. It is through visualisation that an observer/recipient attempts to seek for meanings and values in a given artefact of the archaeological heritage (Szrajber 2016, 24).

Archaeology aims for the protection of cultural goods to provide the public with knowledge of the past (Kobyliński 1998, 9; Pawleta 2016, 119, 120; Vincent *et al.* 2017). In Article 7, of the so-called *Lausanne Charter* (1990), the International Charter for the Protection and Management of the Archaeological Heritage, adopted in 1990 by the International Council on Monuments and Sites ICOMOS at the conference in Lausanne, we read that "the presentation of the archaeological heritage to the general public is an essential method of promoting an understanding of the origins and development of modern societies. At the same time it is the most important means of promoting an understanding of the need for its protection."

One of the tools for creating archaeological knowledge is 3D computer modelling. UNESCO points to goods created and functioning in a virtual environment as an important element of the cultural heritage. In the document of October 15. 2003 – Charter on the Preservation of Digital Heritage (2003), UNESCO has formulated postulates for the protection of the digital heritage, including visualisations, which are a means of popularising knowledge about the past. The term *virtual heritage* in this document is used not only in the context of digital representation of ancient and cultural heritage, but also as having intrinsic value (Koszewski 2015, 104). Likewise, paragraph 5 of the "Cracow Charter" of 2000 states "In the protection and public presentation of archaeological sites, the use of modern technologies, databanks, information systems and virtual presentation techniques should be promoted" (Vademecum 2015, 136).

Modern computer techniques with their ongoing development and improvement allow the general public to familiarise themselves with the resources of cultural heritage in an appealing and interesting way. Spatial visualisations displayed at museum exhibitions, on the Internet and in popular science publications undoubtedly contribute to broadening knowledge in the field of archaeology. Nonetheless, it should be noted that incorrectly made three-dimensional reconstructions that have not been supported by appropriate documentation and knowledge in the field of archaeology may contribute to the dissemination of false iconographic messages. In response to the critical voices in the archaeological community regarding the spatial visualisation of historic objects, an international team of researchers from the Department of Digital Humanities at King's College in London and Science and Technology in Archaeology and Culture Research Centre of The Cyprus Institute, created a set of recommended principles in 2009 (the so-called London Charter).These principles should ensure a reliable application of computer-based visualisations in research, the analysis and interpretation of monuments as well as the protection of cultural heritage. They define control mechanisms that enable the verification of the historical reliability of 3D models. The Charter draws attention to the necessity to document the computer reconstruction process and interpretation processes. In another part of the document, we read that it should be remembered that the visualisations are to facilitate the interaction with inaccessible, lost and previously exposed to destruction historic objects. Research projects must consider the cognitive benefits that can be derived from computer-based visualisations of historic objects.

IMAGE COMMUNICATION AS A MEANS FOR CONVEYING INFORMATION ABOUT ARCHAEOLOGICAL HERITAGE

Contemporary culture is considered a visual/pictorial culture. Since the mid-twentieth century, the primacy of visuality has been growing: the process is known as the "iconic turn" (according to G. Boehm 1992) or the "pictorial turn" (according to W.J.T. Mitchell 1994). Thanks to the Internet, the global circulation of images is expanding, there is a rapid development of media and new technologies. Ernst H. Gombrich (1990, 312) stated that we live in the age of visualism because we are constantly "bombarded" with images. That's why the image is slowly becoming the basic means of interpersonal communication. Visual messages function independently of the verbal sphere or in parallel to it and they are becoming elements of the iconosphere, *i.e.* the whole of the human visual environment (Porębski 1972, 18). Particular attention is drawn to the motive of replacing our surroundings with images, *i.e.* 3D visualisation, simulation or virtual and augmented reality (VR, AR).

Nowadays, it is essential to popularise the past by means of spatial visualisation. Digital reconstruction plays a communicative, scientific and cognitive role. More and more often the image replaces the word, strongly appeals to the human imagination, and quickly becomes memorable. In the visual culture, we can experience the past with the help of our senses (Szpociński 2009, 227-236; Pawleta and Zapłata 2012, 1172; Pawleta 2014, 182, 183). The possibility of showing the results of archaeological research in the form of a pictorial message, *i.e.* visualisation, cannot be overestimated both as a research tool and as a means of popularising historical knowledge (Koszewski 2015, 95).

Modern culture has a significant impact on creating and receiving visual messages. According to the mathematical theory of communication, a set of data containing information (message) must be conveyed using the right medium, *i.e.* channel and code (the model developed by C.E. Shannon and W. Weaver [1949] also includes the concept of information noise disturbing the message). The code should be common for the sender and the recipient, so that the recipient reads the message in accordance with the intention of the sender (Koszewski 2015, 96, 97). In the idealised version, the recipient of the archaeological visualisation could be the whole populace, but in reality many people will not receive such information or will reject it as as irrelevent. Disturbances in popularising archaeology through digitally created images are the reason it is ineffective. The barriers may be some characteristics of the sender and recipient and the differences between them. Features of the sender that prevent proper reception include the unreliability and inconsistency of the information provided. In the case of the recipient, the barrier may be, among others, reluctance to the subject. The remaining obstacles are the differences in the hierarchy of needs and values between the sender and the recipient (Kozakiewicz 2012, 648). Archaeological visualisation is addressed to a wide and diverse group of people, the group is difficult to define precisely. Unfortunately, the wider the range of the message is to be, the less intellectual demands should be placed on the collective addressee. An image is the simplest means of conveying information intellectually that involves basic process of cognition and meaning-making for humans. It should be noted, however, that perception is not only the result of the senses, but also a reflection of previous experiences and cultural codes. The content of perception, therefore, is determined not only by the ability to perceive, but mainly by culture. As Ludwik Fleck put it, “to see, you have to know”. It is culture that has the final word in shaping what and how is given in the act of seeing (Rydlewski 2016, 12, 13).

Digitalisation brings a chance to enter the hitherto hidden dimension of visibility. From the perspective of the viewer-oriented theory, it can be said that digital images introduce us to a new dimension, offer a new level of vision, and provide an additional point of reference that goes beyond the perspective of visual perception (Stawowczyk 2002, 149, 156). It should also emphasized that a very realistic visualisation carries the risk of falsifying history. Spatial visualisations are immersive images. According to L. Wiesing (2012, 123) “An immersion image shall mean this kind of images that make the observer believe that a thing showed in a depiction is really present”. The authors of 3D models strive to make the visualisation they create as realistic as possible. The digital image is like hyperreality. It is difficult to distinguish between preserved and reconstructed elements. It happens the visualisation is so idealised that the viewers, when they encounter the 'original' at a museum exhibition, feel disappointed. This phenomenon can be defined as the *aestheticisation of the past*, as the type of activities that lead to the colouring of reality (Pawleta and Zapłata 2011, 347; Rączkowski 2018, 229).

Modern imaging techniques allow researchers to re-construct, digital images of past, because, as Włodzimierz Rączkowski (2018, 225) put it, 'visualisations in archaeology are an imagined, modelled world materialised with the help of computer technologies'. In modern science, the problem of the system of representing these images remains open. Can visualisations created with the help of computers, which do not exist in the real world, be considered images or only the effects of algorithmic processes (Baudrillard 2001; Stawowczyk 2002, 53-54)? This kind of images Jean Baudrillard (2001) called a *simulacrum*. According to him it is a depiction that does not have any reference to substantial reality. This means that it is a copy, without the original.

Nowadays, it is postulated to re-conduct the discussion about the image and imagery. Currently we are dealing with two opposing attitudes in science: from admiration for new media, to the feeling of crisis or even the end of the image. H. Belting (2007, 50) asks 'Can we still talk about an image as if it could still be related to an object that expresses its relationship to the world in it ?' He notes that the virtual image negates the analogy with the empirical world. The image no longer exists in the traditional sense (image-reflection), because due to new technologies the classic 'combination between the image, the subject and the object' Is broken. Despite the so-called technological revolution, the methods of researching archaeological sources will remain unchanged. The traditional research method based on the analysis of the acquired knowledge is independent of the technology that only supports thought processes (Kowal 2015, 21).

ARCHAEOLOGICAL VISUALISATION IN THE MUSEUM. CASE STUDY

An example of the use of three-dimensional visualisation to present the results of archaeological research in museum exhibitions are digital reconstructions of several graves from the Hallstatt period necropolis in Domasław.

The cremation cemetery from the Early Iron Age (750 – to around 450 BC) was discovered in the south-western part of site No. 10/11/12 in Domasław in the district of Wrocław (Fig. 1).The research was conducted by the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in Wrocław. Over eight hundred graves were examined, of which around three hundred were chamber burials, very richly equipped. People buried in this necropolis belonged to an outstanding stratum of the society at that time. This ceme-

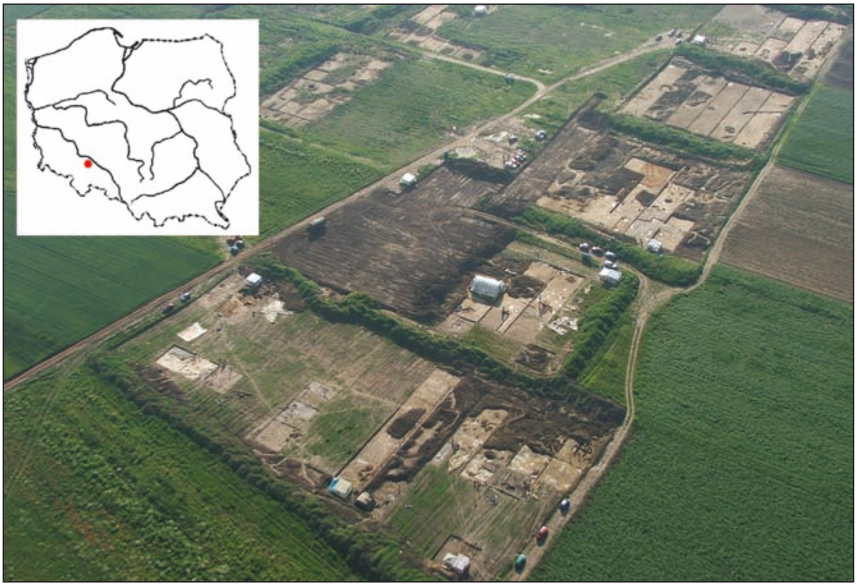

Fig. 1. Archaeological research at the site No. 10/11/12 in Domasław, Wrocław county (photo: J. Zipser; archives of IAE PAS in Wrocław)

tery stands out against the background of other sites in Poland and Central Europe. The uniqueness of this discovery is demonstrated by the unusual grave architecture, as well as the number and variety of items used in burials (Figs 2, 3). In the graves, in addition to clay vessels (from a few to over fifty), there were products made of gold, amber, glass, bronze and iron items, *i.e.* vessels, tools, weapons (including seven swords) and ornaments (Gediga and Józefowska 2018a; 2018b; 2018c; 2019, 2020; Gediga and Józefowska *et al.* 2020 – further literature there).

Immediately after the end of archaeological research in 2008, the artefacts from Domasław were presented at exhibitions at the Commune Office in Kobierzyce ("Treasures of the Kobierzyce Land"), the Museum in Biskupin ("Silesia – the Province of Hallstatt Culture"), and in 2014 at the Silesian Museum in Katowice ("Hallstatt Province – Silesia"). In 2014, the employees of the Archaeological Rescue Research Team of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences and the City Museum in Wrocław prepared an exhibition "Domasław – Necropolis of Aristocracy from the Early Iron Age (8^{th}-6^{th} Century BC)" from the collections obtained during the research. This exhibition in 2014-2020 was shown in several cities in Poland, incl. in the Archaeological Museums in Wrocław, Poznań, Łódź, Kraków and Gdańsk, as well as in the Upper Silesian Museum in Bytom, the Leon Wyczółkowski Museum in Bydgoszcz, the Museum of Jan Dzierżon in Kluczbork, the Fr. Dr. Władysław Łęga Museum in Grudziądz, the Museum of

Fig. 2. Chamber tomb No. 521 discovered during excavations carried out in the Early Iron Age cemetery in Domasław (photo by A. Zwierzchowska; archives of IAE PAS in Wrocław)

Fig. 3. Chamber tomb No. 4270 discovered during excavations carried out in the Early Iron Age cemetery in Domasław (photo by A. Zwierzchowska; archives of IAE PAS in Wrocław)

Fig. 4. The exhibition "Domasław – the Necropolis of the Aristocracy from the Early Iron Age (8th-6th Century BC)" at the Leon Wyczółkowski District Museum in Bydgoszcz (photo W. Woźniak; MOB archives)

Opolian Silesia in Opole and also in museum exhibition halls in Gliwice, Racibórz, Prudnik and Będzin.

The exhibition presenting the most valuable artefacts discovered during the excavation works, was supplemented with numerous illustrations (boards) and photographs, in which the authors of the research recorded the chamber tombs that no longer exist today. For the purposes of the exhibition, a traditional reconstruction of an Early Iron Age burial was prepared and taking into account the undoubted attractiveness of digital visualisations, 3D models of selected graves were made (Fig. 4). Spatial reconstructions have been realised in a form that allows them to be made public in the form of Internet presentations and multimedia exhibitions.

Three-dimensional reconstructions were made with the use of 3D graphics software – *Autodesk 3ds Max* with the *V-ray Adv for 3ds max (Chaos Group)* rendering engine. Thanks to the latest digital techniques, the chamber graves No. 521 (Figs 5, 6) and No. 4270 (Fig. 7) were recreated. The intention of the three-dimensional reconstruction was to present the appearance of the graves spatially with regard to the arrangement of the grave goods. Creating 3D visualisations of the burials from Domasław, as faithful to reality as possible, was also guided by educational and popularising goals.

The resulting spatial visualisation of the cremation burials reflects the current state of knowledge. The spatial presentation of the structure of the Hallstatt graves allows the recipient

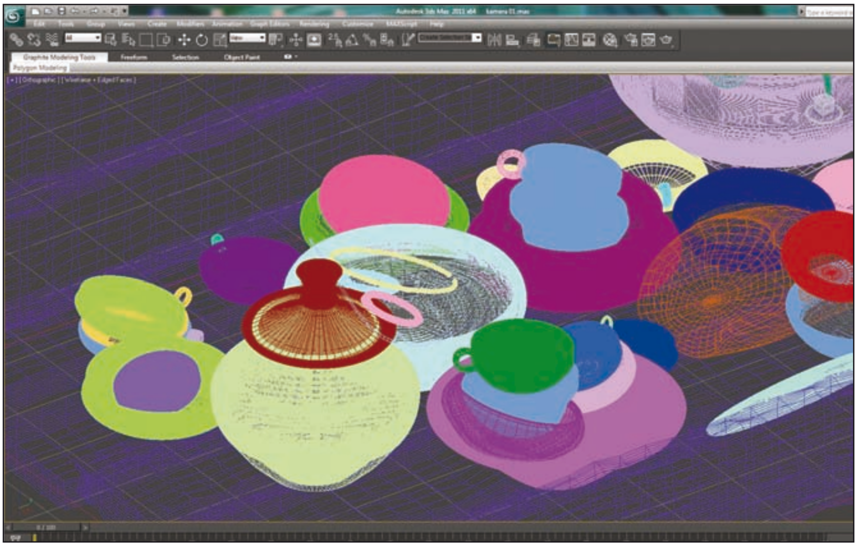

Fig. 5. Three-dimensional model of the tomb No. 521
(made by M. Markiewicz; archives of IAE PAS in Wrocław)

to better understand the message. Thanks to spatial imaging, we can "see more" than when the analysis of the results of archaeological research lacks this visualisation. The 3D model made it possible to accurately trace the method and sequence of placing individual vessels into the chamber, as well as the arrangement and distribution of the remaining grave goods. The third dimension opened up new possibilities. People see the world in three dimensions, therefore the process of creating a spatial model often leads to additional discoveries that may change the perceptual comprehension of a given issue (Stróżyk 2012, 252). In this case, the three-dimensional model of the grave becomes a source of new understanding because visualisation allows us to discover the so far hidden dimension of visibility and thus our perception is broadened.

According to P. Sztompka (2006, 16) in the visual era in which we live today, contemporary sensitivity and the way of perception are moving from verbal to visual. Archaeology also departs from traditional record and looks for multidimensionality. It develops the pictorial, graphic and spatial side of the message (Minta-Tworzowska 2011, 322). However, it should be remembered that the three-dimensional models of graves are an interpretation of archaeological data. They are a construct, a computer-generated vision. This message is only one of the possible options and it cannot claim to be historical evidence. The three-dimensional images of the burials from Domasław were presented in such a way that the recipient could read the information in accordance with the intention of the sender-researcher. A visual message does not require specialist preparation for reading it. The image in the form of a visualisation is complete, which means that it leaves no room for

Fig. 6. 3D visualisation of the chamber tomb No. 521
(made by M. Markiewicz; archives of IAE PAS in Wrocław)

Fig. 7. 3D visualisation of the chamber tomb No. 4270
(made by M. Markiewicz; archives of IAE PAS in Wrocław)

a wider interpretation. It is the researcher who imposes a vision of the recreated object. As Włodzimierz Rączkowski (2018, 232) put it:

> "the visualisation, once prepared, becomes a kind of 'obligatory' representation of a given object/site/landscape. According to M. Heidegger, it 'covers' a real object and makes it difficult to create new, alternative imaginations. The visualisation created and 'devoted' to the recipient as a form of interpretation of reality, although it is subject to the recipient's assessment, it also acquires a kind of agency. By its sheer existence, it shapes/influences our imagination in some way."

Therefore, when formulating a visual message that carries information about the cultural heritage, the creator must maintain a critical distance from the analysis performed. It should be remembered that the obtained results are not a reproduction of the past, but a plausible version of it (Koszewski 2015, 99). Based on similar sources, different visions of the same archaeological site can be built. The process of data interpretation and processing depends on the researcher, which means that the finally created 3D model is marked by decisions made by the author (Szrajber 2014, 115). Thus, the 3D visualisation of the graves from Domasław was created based on the sum of knowledge and abilities that the graphic-reconstructor possesses, making it something subjective and individual. Moreover, it should be noted that the three-dimensional reconstructions are aimed primarily at a recipients who do not have adequate historical knowledge. They are unable to evaluate critically the vision presented to them. The ability to understand and notice messages presented in a visual form is the domain of the so-called "visual literacy", *i.e.* a set of acquired competences in the field of interpretation and creation of an imagery message (Koszewski 2014, 102). These competences are crucial when it comes to visualising archaeological objects. This applies to both the creators of spatial historical reconstructions and their recipients. It is archaeologists and museum professionals who are responsible for the quality and reliability of the message. It seems that digital spatial images of historic buildings should not exist without verbal description. Correct reading of the information contained in the image depends primarily on the knowledge possessed by the recipient, and only thanks to it, can one count on the correct reception of the content contained in the visualisation. In postmodern society, popularising the past by means of visualisation is extremely important. However, it should be ensured that the content conveyed in these images is accompanied by an appropriate commentary. It is extremely important to consider the influence of contemporary culture on the creation and reception of visual messages while making visualisations. Recognition of effective ways of coding image messages and creating a precise message, adequate to cultural conditions, are important aspects of the effectiveness of activities in popularising knowledge.

VISUALISATION AND POPULARISATION OF KNOWLEDGE

What is *popularisation* and what role does it play in research and protection of the cultural heritage? Popularisation is an activity aimed at introducing and explaining to people to whom it is addressed the concepts related to a given field and getting them to further expand their body of knowledge and use their own potential. Popularisation activities are part of marketing activities and, in addition to their educational and cultural role, they also fulfil an informative function. Science can be popularised by appropriately influencing the recipient's thinking, attitudes, opinions and behaviours (Kozakiewicz 2012, 645, 646). The development of civilisation has led to the formation of many ways to impact the beliefs and thinking of people. The examples may be teaching or impingement through the image (advertising, film or television). Promotion of archaeology using visualisation in museology, popular science publications or the Internet (websites, social media and blogs) is shaping the viewer's awareness through intellectual and emotional factors, because when convincing, it affects not only the intellect, but also feelings. The process of influencing recipients consists of several stages:

– influencing the perception of a given group of people,
– transformation of beliefs and opinions,
– shaping the desired attitude,
– the emergence of expected behaviours.

In the case of archaeology, the expected behaviours of recipients include participation in discovering the past and the willingness to expand knowledge and own abilities (Kolczyński and Sztumski 2003, 10, 29; Kozakiewicz 2012, 647). The conducted research shows that the archaeological community in Poland feels obliged to popularise archaeological knowledge, both in relation to the research they conduct and the general knowledge of archaeology. However, researchers should be supported by cultural institutions and journalists (Report 2021, 48).

Education should play an important role in popularising archaeology. However, the research carried out in 2007 on a group of 226 Poles showed that as many as 90.4% of respondents learn about archaeology from television (the research was carried out by means of a telephone questionnaire interview. They covered all voivodeships of Poland). Based on the survey, it was found that museum exhibitions, book publications and then the Internet are important in popularising archaeology (Kozakiewicz 2012, 649). Similarly, the NEARCH survey conducted by the Harris Interactive Research Agency from December 29, 2014 to January 6, 2015 on 4,516 adults from nine European countries (including Poland; a sample of approx. 500 people) showed that in Poland 89% of respondents watch films about archaeology, 72% visit exhibitions and 68% read books or archaeological journals (*Kajda et al.* 2017, 101, 108). The media, however, represent one-way communication. Other types of dissemination activities, such as exhibitions and lectures, are a model of two-way communication, which is easier to understand the information being communicated

(Kozakiewicz 2012, 649). As already mentioned, archaeologists and museum staff are responsible for impartial and reliable knowledge about the past. In postmodern society images become the basis of communication, hence the great influence of television and the Internet in popularising archaeology. Photographer Andreas Feininger aptly noted that "[...] people are becoming more anxious today, impatiently waiting to move on. The language of words – reading – is slow and therefore generally loses its importance in favour of the language of image – television" (after: Sztompka 2012, 21, 22). Due to the universal nature of the message and the use of images and sounds, television has a strong influence on emotions. However, despite its culture-forming and educational mission, like the Internet, it is not free from archaeological pseudo-information.

Thanks to the Internet, everyone can examine 3D reconstructions. The Internet has become an important tool of global communication serving to popularise knowledge about the past and cultural heritage. The network is currently one of the best sources of knowledge about archaeological research to a mass audience. This is a positive phenomenon, but it requires a critical attitude towards the increasing amount of data. After entering search terms related to the subject 3D model into the Google search engine, over 2.5 billion websites appear! The huge resources of graphics on the Web are not free from disinformation, false or manipulated images. Unfortunately, the repeated duplication of unreliable information creates the danger of perceiving it as true. In this case, we are dealing with an information crisis and a phenomenon that can be called visual overload.

Contemporary museum exhibitions are saturated with new technologies, which is in line with the expectations of visitors to these institutions (Chlebicki and Kowalska 2016, 220). The presentation of exhibits in a traditional, static way is slowly becoming a thing of the past. The authors of the exhibitions focus on the multi-sensuality of the museum. Visitors to the exhibition not only want to see the artefacts, but also expect interactivity. Therefore, at the exhibitions, beside the sense of sight, hearing and touch are also activated. The Stefan Woyda Museum of Ancient Mazovian Metallurgy in Pruszków (Woyda Museum 2022) and the M. Radwan Museum of Ancient Metallurgy of the Świętokrzyski region in Nowa Słupia (Radwan's Museum 2022), popularise knowledge of iron metallurgy in Barbarian Europe, combining traditional display methods with state-of-the-art technology to create a narrative appreciable with all the senses. These modern exhibitions function as educational centres. In order to arouse interest among viewers, exhibition creators use numerous forms of communication, *i.e.* text, sound and image in the form of 3D visualisation and animation. Traditional museum exhibitions are diversified with virtual models which, combined with authentic artefacts, provide viewers with fuller and more interesting information (Chowaniec 2010, 146, 180).

Virtual reality (VR) and augmented reality (AR) technologies are increasingly used in museum exhibitions. The interactive properties and immersive contact with the digital environment give the feeling of being present in the virtual world. These systems allow users to have direct contact with 3D models and to manipulate them, *i.e.* navigation in real time (Zawadzki and Filipczuk 2014, 227). With the help of VR and AR, through interactive exploration of virtual, computer-generated worlds, museum visitors can learn about prehistory. Therefore, new technologies used in the exhibitions play not only educational but also entertainment functions, becoming a way of spending free time.

The growing popularity of multimedia creates new opportunities for the promotion of archaeology. New media make it possible to present in a simple way complicated processes (*i.e.* the development of settlement over time, the role of stratigraphy) and methods (*e.g.* aerial archaeology), and also facilitate the presentation of artefacts in a broader social, historical or economic context (Economou 2003, 371, 372). Interactive multimedia applications used to convey information about archaeological research take many forms such as computer games to VR and AR technologies and create a specific relationship between education and entertainment. The boundary between learning and enjoyment is often blurred, leading to the emergence of artistic visions and creative interpretations of the past that deviate from the historical truth. The public presentation of archaeology must combine teaching with the imaginative use of multimedia that will encourage the audience to explore the past actively and enjoyably.

An example of an exhibition where digital technologies dominate is the display under the Old Market Square in Krakow. The underground exhibition presents both the history of Krakow and its connections with the commercial and cultural centres of medieval Europe (Kraków 2022). One is introduced to the past history of the Old Market Square with the help of multimedia kiosks, where the viewer can watch the virtual reconstructions, 3D models of monuments and substantive texts presenting the history of old Krakow. In the exhibition, images are displayed on a water curtain (fog screen), and the atmosphere of this place is built with the help of sound.

A similar project is accessible in Wroclaw. In the Royal Palace (Branch of the City Museum of Wrocław), the exhibition “1000 Years of Wrocław” presents the history of the city from the Middle Ages to the present day (Wrocław 2022). Thanks to the visualisation at the City Museum of Wrocław, visitors can learn about the most ancient history of the city. Many specialists in various fields such as archaeology, history, history of art and architecture were involved in the three-dimensional reconstruction of the pre-chartered city of Wrocław (10th century – 1226; Kuroczyński and Madera 2012, 381-414). The reconstruction of urban structures was highly labour-intensive, time-consuming and costly. The problem that the authors had to deal with was to show the history of the city in a 3D animation that lasts only a few minutes. There was a dilemma how to select the information. Which information is the most important? Which information should be chosen and which, unfortunately, to skip? With this type of visualisation, there is often a compromise between graphic designers and specialists from other fields. The image created is very effective, but the information provided is sometimes incomplete.

Interactive exhibitions definitely attract visitors, but new technologies should not replace traditional ways of displaying, but only diversify them. To meet the expectations of viewers, museums conduct professional sociological research. Audience surveys are a valuable source of knowledge about the preferences and expectations of museum visitors (Kajda *et al.* 2017).

M. Stróżyk (2012, 255, 256) asked the respondents two questions in an online survey on the public perception of the reconstruction of archaeological objects:

1. What is your attitude towards recreating of historic objects (the archaeological, historical ones)?

2. What form of reconstruction: a – traditional or b – virtual is more attractive for you? In response to the first question, 86.29% of the respondents stated that their attitude to the restoration of historic objects was positive. On the other hand, 81% of respondents stated that the traditional, *i.e.* real, form of reconstruction is more attractive to them. Only 19% of the respondents were in favour of a virtual, digital form of reconstruction of historic buildings. The survey, in which 124 people participated, did not take into account the division into social and age groups, *i.e.* factors differentiating the approach to a given topic. It should be expected that a decade after the survey was conducted, the preferences of the respondents have changed. Among young people, the percentage in favour of virtual reconstruction would probably be higher. In recent years, the process of digitising society has accelerated rapidly. Not without significance for this development was, among others, COVID-19 pandemic, which led to the global increase in the role of the Internet in education and culture.

In line with the requirements of the present day, visualisation offers a method of education about the past world and archaeology of interest to the younger generation. The knowledge of the past contained in the images helps to develop a special sensitivity and competence that can be called historical imagination. Through the contact of the viewer with the visualisation, an interest in the past is born, which, in turn, increases the awareness of the public regarding the need to protect cultural heritage.

CONCLUSIONS

Since the 1970s, as Gottfried Boehm (2014, 172) put it, images have had a good streak. The digital revolution has increased the role of the image in the modern world. New visual technologies have meant that "the world has become an image" (Heidegger 1977, 143). Thanks to modern visualisations, our perceptual abilities are expanding, new visual stimuli create our perception and cognition. Graphic programs are becoming an invaluable tool for scientists who can test hypotheses in areas such as architectural resolutions, the reconstruction of historic objects and the transformation of settlements over time and who can popularise the results of their research. As a result, digital images become new forms of narration that allow us redefine the prehistoric world (Minta-Tworzowska 2011, 323-324). Visualisations created with the use of computer graphics are a form of interpretation, showing an image of the past from the perspective of modern image thinking, namely discursive thinking. The new technology in this case has broadened our perception.

Digitally produced images fulfil important social and educational functions. Visualisation is a simple form of transferring knowledge to a greater number of recipients, as well as helping to obtain information from museum professionals and archaeologists. Therefore, the main goals of the popularisation of archaeology, through 3D visualisations, at museum exhibitions, media and popular science publications, are primarily education about the past, as well as informing recipients about the results of excavation works. These activities are intended to help the public understand historical processes. Disseminating knowledge about archaeology arouses curiosity and contributes to creating a positive image of this discipline of science. The more people are interested in the past, the stronger the need to protect the archaeological heritage.

Visualisations popularising archaeology are presented on the Internet, on monitor screens (*e.g.* multimedia kiosks) at museum exhibitions, or in the form of printouts in popular science publications. However, 3D models can also be used to build mock-ups using 3D printing technology (López-Menchero Bendicho *et al.* 2017, 41, 42), and they can also be the basis of other, previously mentioned, methods of presentation, *i.e.* the techniques of virtual reality (VR) and augmented reality (AR). Modern technological achievements also allow for the publication of spatial models in the form of holograms with the use of appropriate projectors. It should be noted that cultural heritage objects, mainly architecture, recreated using 3D graphics software, are used in computer games (*e.g.* "Assassin's Creed") and 3D animations (*e.g.* "Asterix and Obelix"). The presented spatial reconstructions are extremely attractive for viewers due to their interactivity and photorealism. As the researcher of image culture Nicholas Mirzoeff (2016, 20) put it, "whether we like it or not, the emerging global society is a visual society". It seems that contemporary archaeology must correspond with popular culture (Holtorf 2007). The image becomes the essence of the most important social process – interpersonal communication. Visualisation used in museology reaches the mass audience in an engaging way, which is why it perfectly fulfils the tasks of presenting and popularising knowledge about archaeological heritage in society.

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PALYNOLOGY AS AN IMPORTANT TOOL FOR THE RECONSTRUCTION OF DIET, DISEASES AND FOLK MEDICINE OF THE POPULATION OF THE CLASSICAL PERIOD SETTLEMENT NAMCHEDURI II (WESTERN GEORGIA)

ABSTRACT

Kvavadze E., Chichinadze M., Kakhidze A., Surmanidze N. and Nagervadze M. 2022. Palynology as an Important Tool for the Reconstruction of Diet, diseases and Folk Medicine of the Population of the Classical Period Settlement Namcheduri II (Western Georgia). *Sprawozdania Archeologiczne* 74/2, 29-51.

Layers of the Namcheduri II settlement (Western Georgia) dated from the 5th-4th centuries BC have been studied by the palynological method. It revealed that cereals represented the main component of the population's diet in the discussed period. The nutritive ratio included chestnut, hazel, walnut, and grapes. The majority of the plants apparently used for medical purposes represent medicinal remedies against rheumatism, arthritis, and diarrhea. Presumably, malaria, diabetes, and epilepsy occurred rarely since the medicinal remedies used against them were poorly evidenced.

Plenty of eggs of parasitic worms discovered in the group of non-pollen palynomorphs in some samples and their taxonomic variety indicates at wide spreading of helminthosis in the population in the period under discussion. Eggs of *Trichuris trichuira*, *Ascaris lumbricoides*, *Capillaria*, *Enterobius vermicularis*, Yokogava fluke were present. The abundance and diversity of eggs of parasitic worms in the obtained material gives grounds for supposition that this part of the settlement was used as a latrine.

Keywords: Palynology, Classical Period human feces, Palaeodiet, Paleopharmacology, Georgia
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INTRODUCTION

Palynological investigation of the archaeological material proved that human fossilized excrement, *i.e.* coprolites, contained well-preserved pollen grains and plenty of non-pollen palynomorphs (Matsui *et al.* 2003; Oeggl 2008; Brinkkemper and Haaster 2012; Kvavadze 2016; Deforce 2017; Kvavadze *et al.* 2020). It is notable that at present material of this type is predominantly examined in the form of organic residues evidenced in the abdominal area or by the sacrum of the deceased.

As for the fossilized faeces material, it is more carefully investigated by means of the paleobotanical method, since the material in question contains lots of plant seeds and macroscopic remains of insects (Matsui *et al.* 2003).

The rich composition of the palynological spectrum of fossil faeces is helpful not only in reconstruction of the detailed paleoecological environment (in the case of herbivores), but, in addition, relying upon its data, it becomes possible to reconstruct a precise human diet. Besides this, medicinal plants used by ancient humans can be identified. On the grounds of pollen grains of the medicinal plants discovered in the excrement, it is available to define types of cured deceases, since humans in many cases both in the past and the present have been using one and the same medicinal plants.

The best examples of such assumption are well-known yarrow (*Achillea*) and cornflower (*Centaurea*) – good remedies for treatment of gastrointestinal and gallbladder problems in folk medicine (Al-Snafi 2015a; Fortini *et al.* 2016) – already familiar to the Palaeolithic humans. In the Upper Palaeolithic, the humans dwelling in the caves of Dzudzuana, Satsurblia, and Kotias Klde collected and kept there the aforementioned plants (Martkoplishvili and Kvavadze 2015). Pollen grains of yarrow and cornflower were found in the Middle Palaeolithic cave Shanidar IV, in Iraq (Leroi-Gourhan 1975; Lietava 1992), implying that the humans of that period suffered from problems of abdominal cavity organs. Pollen grains of plants, medicinal properties of which are recognized at present, have been found in the course of research at other archaeological sites as well (Merlin 2003; Chaves and Reinhard 2003; Kvavadze *et al.* 2010a; 2013; 2016).

It is remarkable that large amounts of pollen of edible plants, medicinal herbs and eggs of parasitic worms are frequently simultaneously evidenced in palynological spectra of organic residues collected from the abdominal areas of humans (Kvavadze 2016; Kvavadze *et al.* 2013; 2015; 2020).

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Fig. 1. Map of Georgia and the location of the Namcheduri II settlement

No palynological – and generally no palaeobotanical – research has ever been carried out to study ancient faeces from cesspit or latrine materials in the region of Transcaucasia. Both single human faeces and ancient latrines are more frequently studied in other regions by paleoparasitologists whose main goal is to reveal helminthosis (Araújo *et al*. 1981; Han *et al*. 2003; Le Bailly and Bouchet 2006; Ledger *et al*. 2020).

This discussion concerns the organic remains collected from the settlement of Namcheduri II located in the south-western part of Georgia (the territory of Adjara) in the course of the archaeological excavations carried out in the summer of 2019 (Fig. 1). The site in question is incorporated into the Pichvnari complex. The habitation layers studied palynologically were dated to the 5th-4th centuries BC on the basis of the archaeological artefacts. The archaeological investigation both of Namcheduri II and the Pichvnari site have a long history (Mikeladze and Khakhutaishvili, 1985; Vickers and Kakhidze 1999; 2006; Kakhidze 2001; 2020).

MATERIAL AND METHOD

Five samples obtained from Namcheduri II dated to the period in question were studied palynologically (Figs. 2, Table No 1). Of them, two samples (No 2 and 3) were collected near the remains of wooden beams in square N 31 (sector CD-1/76) of the site. It is notable that the beams bore traces of processing as their tips were sharp. From the archaeological point of view, they probably represent a wattle and daub type of wooden construction. The palynological spectra of the aforementioned two samples (Nos 2, 3) cardinally differed from those collected from the plaster and floor of the same square.

The fossilized spectra were compared with those of the present-day soil (sample No 1) in order to avoid cases of contamination of the material. The palynological spectra of all mentioned samples are presented in the diagrams (Figs. 2 and Table No 1). The material was processed in the Palynological Laboratory of the Georgian National Museum by means of the standard method (Erdtman 1969; Moore *et al*. 1991). At the initial stage, the material was boiled in a 10% solution of potassium hydroxide (KOH) for 10-15 min. To get rid of the solution of potassium hydroxide, the material was washed for 24 hours. In the second stage, the material was centrifuged in a heavy liquid for separation of the organic and the mineral materials. In the third stage, the material was washed to get rid of the heavy liquid and the acetolysis was performed resulting in repeated cleaning of the microscopic remains and acquisition of their darker colour.

Identification of the palynomorphs, their counting, and photographic documentation were performed using a Olympus BX 43 light microscope. The obtained results were statistically processed by means of the program 'TILIA' (Grimm 2016).

RESULTS OF THE STUDY

The samples No 2 and **3** collected in one and the same layer revealed nearly similar palynological spectra. Of arboreal plants, pollen grains of alder (*Alnus*) and chestnut (*Castanea sativa*) dominated in both samples. Coniferous plants were rather well presented, among which pollen grains of pine (*Pinus*) prevailed. Less prominent was spruce (*Picea orientalis*), while fir-tree (*Abies nordmanniana*) was represented by single pollen grains (Fig. 2).

Small amounts of deciduous plants were defined. Among them were: beech (*Fagus orientalis*), oak (*Quercus*), hornbeam (*Carpinus betulus*), lime (*Tilia*), elm (*Ulmus*), zelkova tree (*Zelkova fraxinifolia*), walnut (*Juglans regia*), and ash (*Fraxinus*). Single pollen grains of birch (*Betula*), grapevine (*Vitis vinifera*), guelder-rose (*Viburnum*), willow (*Salix*), blackberry (*Rubus*) were also found (Fig. 2). Of herbaceous plants, pollen grains of wheat and other cereals for sowing prevailed and they dominated in the spectrum. Goosefoot (*Chenopodium album*, Chenopodiaceae), chicory (Cichorioideae), cornflower (*Centaurea*), nettles

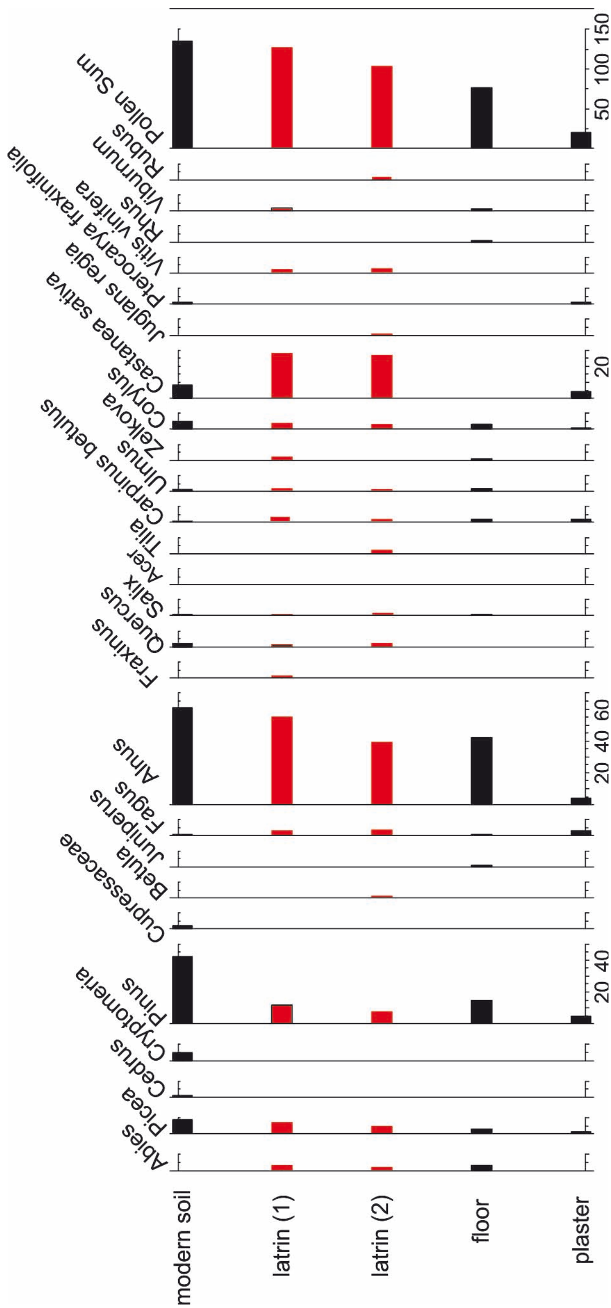

Fig. 2. Arboreal pollen diagram of the organic remains of the Namcheduri II settlement (medicinal plants pollen dyed red)

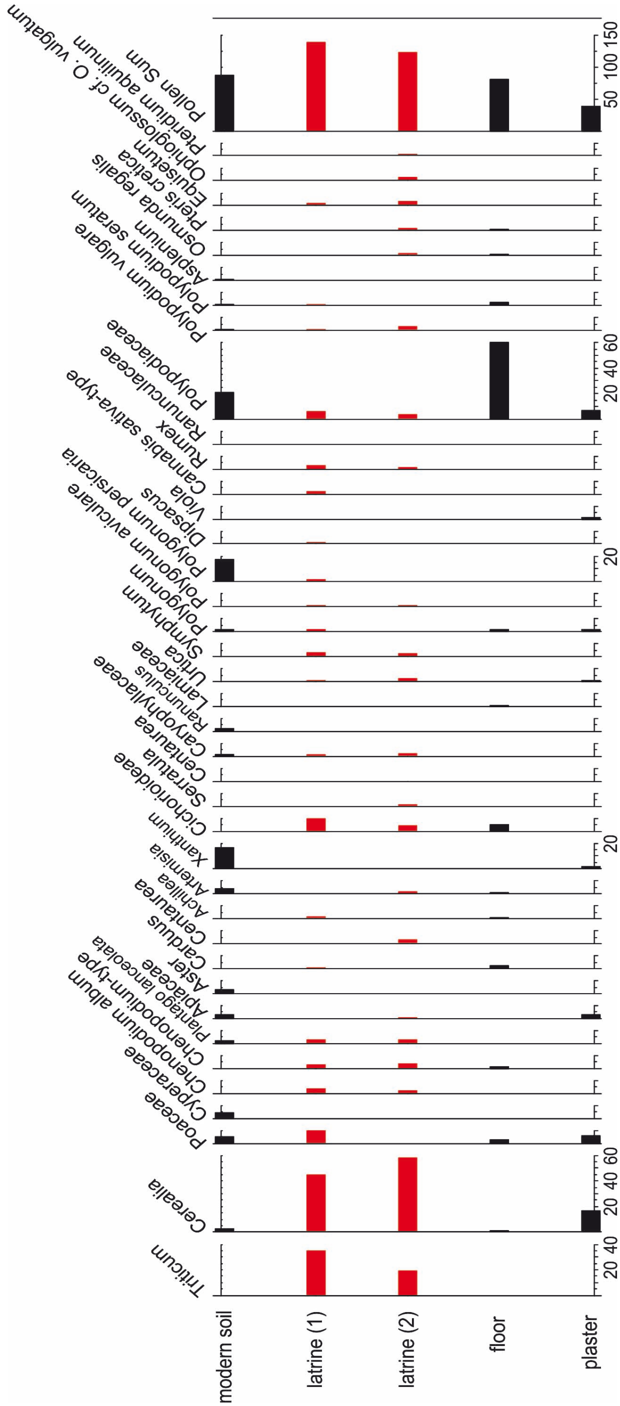

Fig. 3. Non arboreal pollen diagram of the organic remains of the Namcheduri II settlement (medicinal plants pollen dyed red)

(*Urtica*), wild sorrel (*Rumex*), knot-grass (*Polygonum*, *Polygonum aviculare*, *Polygonum persicaria*) were well represented. Pollen grains of yarrow (*Achillea*), thistle (*Carduus*), hemp (*Cannabis*), great plantain (*Plantago*), teasel (*Dipsacus*), comfrey (*Symphytum*), wild grasses (Poaceae), legumes (Lamiaceae), cloves (Caryophyllaceae), wormwood (*Artemisia*), saw-wort (*Serratula*), umbellifers (Apiaceae), Cyperaceae, Fabaceae, and aster (*Aster*) were also found (Fig. 3).

Spores of forest ferns were identified in the palynological spectra of the two samples under discussion. Among them were: adder's fern (*Polypodium vulgare*), black spleenwort (*Polypodium serratum*), adder's tongue fern (*Ophioglossu vulgatum*), pteris (*Pteris cretica*), woolly bracken (*Pteridium aquilinum*), royal fern (*Osmunda regalis*), and horsetail (*Equisetum*) (Fig. 5).

The spectra of both groups of the non-pollen palynomorphs (NPP) resembled each other. Disintegrated tracheal cells of wood prevailed. At this stage of research parenchymal cells of pine (*Pinus*) and elm (*Ulmus*) were defined (Fig. 2). Lots of eggs of the parasitic worms, namely, trichura (*Trichuris trichiura*) and ascaris (*Ascaris lumbricoides*) were identified in the spectra (Figs. 3 and 6). There were also eggs of other parasitic worms. Among them were: *Capillaria*, *Enterobius*, *Yokogawa*. Eggs of unspecified worms were evidenced, too (Table 1 and Fig. 6). Great amount of insect hairs, their epidermis, and other microscopic residues were also found (Table 1).

It is remarkable that bee hairs were evidenced in both samples. An animal hair was found in sample No 3. Fungal spores were revealed in small amounts. Among them were: *Brachysporium*, *Chaetoium*, *Cercophora*, *Gelasinospora*, *Podospora*, and *Sordaria*. Starch grains, remains of moss and other plants were defined. Fibres of linen fabric were found in both the samples. A fibre of cotton fabric was evidenced only in the sample No 2. A testate amoeba *Arcella* that lives in wet moss was found in the sample No 3. Remains of the freshwater aquatic plant *Pseudoschizaea* was identified in both the spectra, while an aquatic plant *Dinoflagellata* – only in the first one (No. 2).

The sample collected from the building floor (*Sample No. 4*). As has already been noted, all in all 20 taxa were defined in the sample under discussion. This figure was twice less than those in samples No 2 and No 3, where pollen grains of 45 taxa were identified. Pollen grains of 10 arboreal plants were discovered in the organic remains collected from the floor. Alder (*Alnus*) prevailed. No pollen grains of chestnut (*Castanea sativa*), dominating in the palynological spectra of the previous samples No 2 and No 3, were evidenced.

Pollen grains of fir-tree (*Abies nordmanniana*), spruce (*Picea orientalis*), and pine (*Pinus*) were numerous. Pollen grains of juniper (*Juniperus*), beech (*Fagus orientalis*), willow (*Salix*), hornbeam (*Carpinus betulus*), elm (*Ulmus*), and hazel (*Corylus*) were in small amounts.

Among herbaceous plants were: goosefoot (*Chenopodium album*), knot-grass (*Polygonum*), wormwood (*Artemisia*), and thistle (*Carduus*). It was especially remarkable that plenty of pollen grains of forest ferns (Polypodiaceae), playing a dominant role there, were evidenced in the spectrum in question.

Table 1. Quantitative composition of Non-Pollen- Palynomrphs from the organic remains of the Namcheduri II settlement

Namcheduri	1	2	3	4	5
Non Pollen Palynmorphs	modern soil	latrine 1	latrine 2	floor	plaster
Undiff. ascospores	19	9	10	72	9
Sporormiella				4	
Chaetomium	1	2	3		
Sordaria		6			
Gelasinospora		5	3		
Brachysporium	15	2	1	4	
Cercophora		7	9		
Podospora		2			
Glomus	12				
Tracheal cells of undiff. wood	62	85	98	87	89
Tracheal cells of *Pinus*		2	6		2
Tracheal cells of *Ulmus*		4	3		3
Wood vessel			2	5	
Starch grains	98	13	12	61	27
Starch of cerealia	38				15
Fibre of flax	4	3	4	10	23
Fibre of wool					1
Fiber of cotton		2		3	7
Fiber of cannabis					3
Seeds	3				
Phytoliths				2	2
Plant epidermis		11			
Zoomaterial	14	10	20	4	
Zooepidermis	28	15	15	6	6
Hear of bee		2	2		
Hair of insecta	5	6	8		1
Claw of insecta	3				
Chela of acari					1
Hair of acari	2				
Cuticle of butterfly wing		1			
Hair of animal			2		
Pseudoschizaea	1	3	4	2	
Dinoflagellata		2			
Spirogyra	1				
Arcella			2		
Moss remains	3	9	7		
Eggs of *Trichuira*		23	17		
Eggs of *Ascaris lumbricoides*		7	6		
Eggs of *Capillaria*		2			
Eggs of *Enterobius vermicularis*		2			
Eggs of *Yokogawa fluke*			2		
Undiff. eggs			2		
Total NPP Sum	309	235	238	260	189

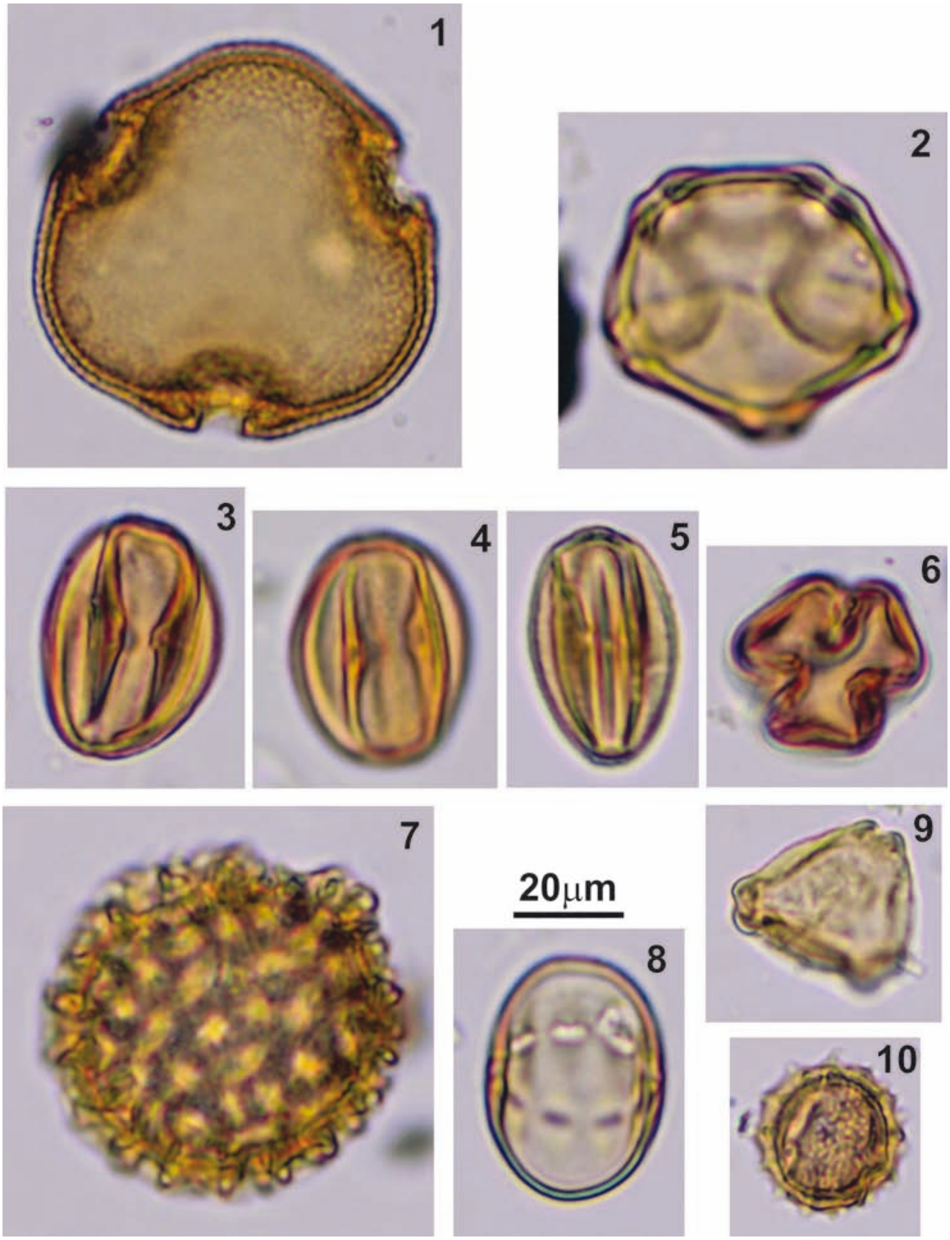

Fig. 4. Pollen grains from organic remains of Namcheduri II settlement (sample No 2, 3):
1 – *Tilia;* 2 – *Alnus;* 3-6 – *Vitis vinifera;* 7 – *Polygonum persicaria;* 8 – *Symphytum*); 9 – *Betula;* 10 – *Achillea*

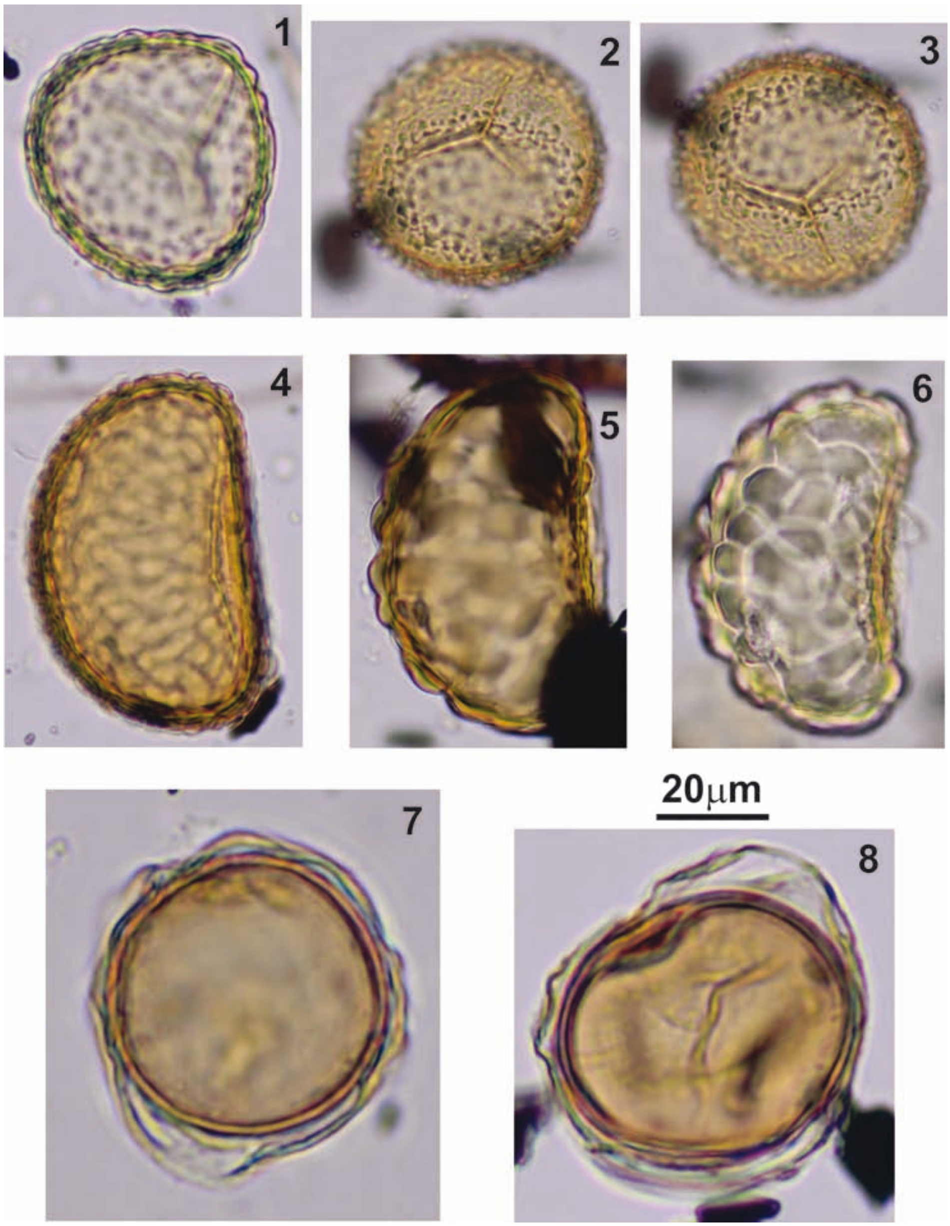

Fig. 5. Fern spores from organic remains of Namcheduri II settlement (sample No 2, 3):
1 – *Ophioglossum vulgatum;* 2, 3 – *Osmunda regalis*; 4 – *Polypodium serratum;* 5, 6 – *Polypodium vulgare;* 7, 8 – *Equisetum*

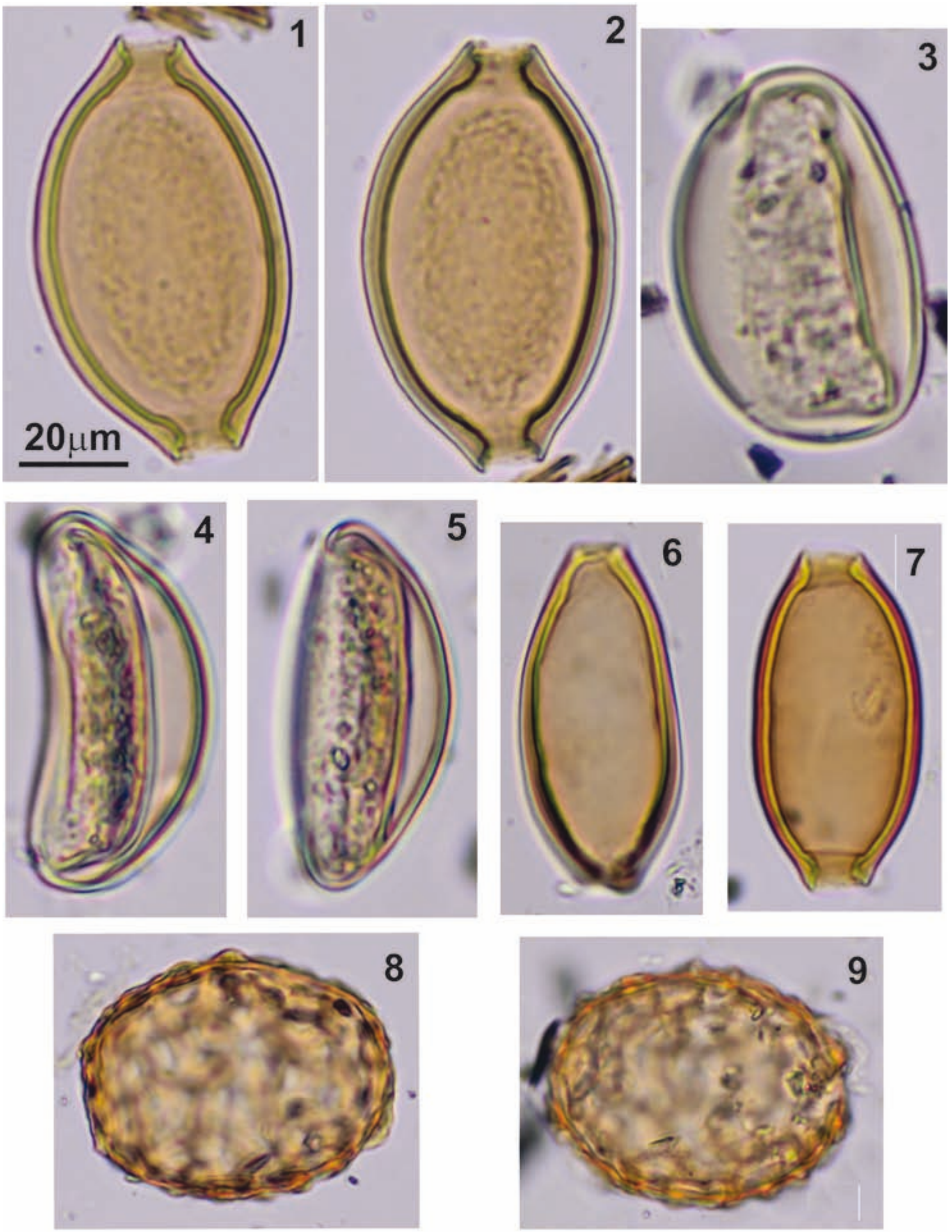

Fig. 6. The eggs of the parasitic worm from sample No2,3 of Namcheduri II settlement:
1, 2 – *Capillaria;* 3-5 – *Enterobius vermicularis;* 6, 7 – *Trichuris trichiura*; 8, 9 – *Ascaris lumbricoides*

Charcoaled cells of wood, fungal spores, and starch prevailed among non-pollen palynomorphs (Table 1). Fibres of linen and cotton fabric were rather well represented. Remains of phytoliths, zoomaterials and an aquatic plant *Pseudoschizaea* were defined in small amounts.

The sample collected from the plaster (*sample No. 5*). Its palynological spectrum appeared extremely poor. Pollen grains and spores of only 13 plants were found. Of arboreal plants, there were pollen grains of spruce (*Picea*), pine (*Pinus*), beech (*Fagus orientalis*), alder (*Alnus*), hornbeam (*Carpinus betulus*), and chestnut (*Castanea sativa*). There were relatively few of herbaceous plants. Cereals for sowing (Cerealia), wild grasses (Poaceae), knot-grass (*Polygonum*), cockleburs (*Xanthium*), nettles (*Urtica*), Apiaceae, and ferns (Polypodiaceae) were evidenced. Remains of non-pollen palynomorphs were well represented. Disintegrated cells of wood dominated. Wood parenchymal cells of pine and elm were defined. Lots of cereal starch and fungal spores were found. Fibres of linen fabric were well represented. Cotton fibers were numerous. Microscopic residues of insects and ticks were few.

Pollen spectra of modern soil (*sample No. 1*). Pollen grains of artificially planted coniferous plants, widely spreading in the region under discussion, prevailed in the palynological spectrum of the sample collected from the present-day soil. Among them were: cryptomeria (*Cryptomeria*), cedar (*Cedrus*), spruce (*Picea*), and some species of pine (*Pinus*). Various species of spruce and pine occurred in the soil from the artificially planted coniferous plants which were brought from various countries for decorative purposes.

Elements of forest massifs naturally preserved here were well represented in the palynological spectrum of the soil. First of all, among them were groves where alder (*Alnus barbata*), wing-nut tree (*Pterocarya fraxinifolia*), and willow (*Salix*) grow. Besides, pollen grains of beech (*Fagus orientalis*), oak (*Quercus*), hornbeam (*Carpinus betulus*), elm (*Ulmus*), and chestnut (*Castanea sativa*) were evidenced in the spectrum. Of herbaceous plants, pollen grains of the weeds, growing at rubbish places or by roads and paths, prevailed. Among them were cockleburs (*Xanthium*), wormwood (*Artemisia*), great plantain (*Plantago*), Cyperaceae and wild grasses (Poaceae). Pollen grains of maize were in small amounts. There were nearly no pollen grains characteristic of areas under crops or gardens. The composition of the non-pollen palynomorphs of the soil spectrum was absolutely different. Starch dominated, especially starch of the field cereals. There were many fungal spores but the fungus Glomus (*Glomus*) was evidenced only here. This fungus grows only in erosive, dug soil, and in this case, there is a trace of human activity (van Geel 1998). Besides, rather great amounts of fungus *Brachysporium* were determined. This fungus grows on the wood of a dead tree (van Geel 1998). There were found remains of moss as well. Microscopic residues of insects and other invertebrate were also evidenced in rather great amounts. Freshwater aquatic plants *Spirogyra*, *Pseudoschizaea* were present in small quantities.

As was mentioned above, samples No. 2 and No. 3 were characterized by their absolutely different palynological spectra compared to those collected from the floor or the plaster (Fig.

2, 3). Pollen grains and spores of 45 plants were identified in the two aforementioned samples. Of them, 18 belonged to arboreal plants and bushes, while 27 – to herbaceous plants.

These figures represent very high benchmarks, since it is well known that, generally, archaeological material is characterized by a low composition of pollen grains. In addition, it should be determined that only 20 taxa were identified in the sample collected from the floor, and a much smaller number – in the plaster sample, where pollen grains of 13 plants were defined.

Preservation of pollen grains and spores in the samples Nos 2, 3 was exceptional. This is clearly visible in the presented photos (Figs. 4 and 5). The same picture is presented in the group of non-pollen palynomorphs in which both taxonomic composition and quantity of taxa reach higher levels. Thirty types of fossilized non-pollen palynomorphs were identified in samples No. 2 and No. 3, while only 12 – in each sample collected both from the floor and the plaster (Table 1).

DISCUSSION

The palynological description of the presented material has shown that the studied samples drastically differ. One clear conclusion is the absence of any traces of contamination of the archaeological samples by the present-day soil. The latter is absolutely of different type. Both the present-day landscape plants, among which prevail preserved segments of mixed deciduous forest (Nakhutsrishvili 1999; 2013; Zazanashvili *et al.* 2000) and such kinds of introduced decorative species as, for example, various species of cedar (*Cedrus*), cryptomeria (*Cryptomeria*), spruce (*Picea*), and pine (*Pinus*) are evidenced in it.

As for the herbaceous plants, the weeds that widely spread on areas abandoned by humans, prevail in this group. Cockleburs (*Xanthium*) and knot-grass (*Polygonum aviculare*) are the best examples of this. As has already been noted this area is not inhabited nowadays.

Comparison of the palynological spectra of the organic residues collected from the settlement of Namcheduri II reveals many interesting facts. Taking into consideration the studied palynological spectra, the first two samples (Nos 2 and 3) that are connected to the beams drastically differ from those obtained from the floor and the plaster (Fig. 2, 3). Pollen grains of edible plants prevail in the palynological spectra of these samples, especially of wheat and other field cereals. Here pollen grains of chestnut are evidenced as well.

The palynological research of the archaeological material prove that any edible plant food contains pollen grains of these plants. For instance, plenty of pollen grains of wheat and other cultivated cereals, phytoliths and starch are found in the cereal porridges, remains of which are found in archaeological vessels or in the abdominal areas of the deceased (Kvavadze and Narimanishvili 2006; Kvavadze *et al.* 2010a, 2020; Kvavadze and Martkoplishvili 2018).

It is of great interest that pollen grains of wheat and starch are preserved in fossilized flour and products made of it. The bread and biscuit found in the Early Bronze barrow No 2 at Tetritsqaro, Georgia, dated to 2474-2335 BC, represent the best examples of this. These artefacts are preserved in the reserves of the Georgian National Museum (Kvavadze *et al.* 2016; Kvavadze *et al.* 2020).

Plant pollen grains also accompany human drinks. Research has proved that, for instance, great amount of grapevine pollen grains existed in the archaeological vessel, in which wine was kept (Rösch 2005; Kvavadze *et al.* 2010b; 2014; 2019; 2020; Bitadze *et al.* 2011; Chichinadze *et al.* 2012; McGovern *et al.* 2017). The abundance of pollen grains of melliferous plants in ancient vessels, represents good evidence for the existence of honey there (Rösch 1999; Pokorny and Marik 2006; Kvavadze *et al.* 2007; Kvavadze 2016; Chichinadze *et al.* 2017; 2019).

Numerous plants defined in both the studied samples obtained at the Namcheduri II settlement belong to edible ones. Of arboreal species, there are chestnut (*Castanea sativa*), beech (*Fagus orientalis*), oak (*Quercus*), walnut (*Juglans regia*), hazel (*Corylus*), grapevine (*Vitis vinifera*), blackberry (*Rubus*), and guelder rose (*Viburnum*). Of herbaceous plants, there are well-known herbs such as goosefoot (*Chenopodium album*), nettles (*Urtica*), thistle (*Carduus*), wild sorrel (*Rumex*), Cichorioideae (Rivera *et al.* 2012a, b). Thus, to sum up, the pollen grains of 14 edible plants are evidenced in the spectrum.

Nearly all of the rest of the palynological spectrum components represent pollen grains and spores of plants that have medicinal uses. Their number reaches 32, exceeding twice the number of taxons of the edible plants. These data might imply that the population of the period in question had certain health problems. Of arboreals, 11 are medicinal plants, while 17 – herbaceous ones.

Pollen grains of alder (*Alnus*) prevail. This plant is used for treatment of gastrointestinal diseases even today, namely of dysentery (Duke *et al.* 2002; Quattrocchi 2012). Pine (*Pinus*), fir-tree (*Abies*), and spruce (*Picea*) are used for treatment of respiratory organs. All three taxa are well presented in the palynological spectrum. Drugs prepared from flowers, cones, and conifer needles are used for treatment of lung inflammation, tuberculosis, asthma, and other respiratory diseases in folk medicine (Khare 2007; Alarcon *et al.* 2015; Bussmann *et al.* 2016).

Discovery of pollen grains of lime (*Tilia*) and birch (*Betula*) in the palynological spectrum of our sample indicates that the ancient population was familiar with the medicinal properties of these plants, particularly with their temperature reducing property (Demiray 2009; Güler *et al.* 2015). Birch is also used against epilepsy and cystitis (Adams *et al.* 2012; Papp *et al.* 2014). Juniper (*Juniperus*) is also used for treatment of epilepsy (Alarcon *et al.* 2015). It also is evidenced in the palynological spectrum, however, in a small quantity. There are quite a lot of pollen grains of hornbeam (*Carpinus betulus*) in the palynological spectrum. Drugs used against diarrhoea, skin diseases and for reducing temperature are prepared from its bark (Hatfield 2004; Quatrocchi 2012).

Decoction of willow (*Salix*) leaves and its bark is a good remedy for treatment of malaria (Norn *et al.* 2009; Rivera *et al.* 2012b). Pollen grains of elm (*Ulmus*) and Zelkova tree (*Zelkova*) are rather well evidenced in the palynological spectrum. The medicinal properties of the zelkova tree are under investigation by pharmacologists. Its pollen grains are frequently encountered in ancient rubbish pits, on scrubbing stones, and in the abdominal areas of the deceased (Bitadze *et al.* 2011; Chichinadze *et al.* 2019; Kvavadze *et al.* 2020). Pollen grains of the zelkova tree are found in an Early Bronze Age wooden box, containing plenty of first aid drugs (Kvavadze *et al.* 2013; 2015). Therefore, since the elm and zelkova tree belong to one and the same genus, their medicinal properties could be similar. Research shows that a remedy is prepared from the leaves and shoots of elm used as an expectorant as well as for the healing of wounds and burns (Khare 2007; Kültür 2007). The same properties could be characteristic of the zelkova-tree.

Plenty of medicinal plants are in the composition of herbs, of which ones with properties to cure diarrhoea are represented in a greater variety (Alacron *et al.* 2015; Fortini *et al.* 2016). Among them are: yarrow (*Achillea*), saw-wort (*Serratula*), comfrey (*Symphytum*), hemp (*Cannabis sativa*), and ribwort (*Plantago lanceolata*). Plants used against rheumatism and arthritis are also well presented in the pollen spectra (Said *et al.* 2002; Dahui 2012; Wiersema and Leon 2013). Cornflower (*Centaurea*), wormwood (*Artemisia*), and teasel (*Dipsacus*) belong to them. Wormwood (*Artemisia*) is a good remedy against malaria (Hayta *et al.* 2014; Bussmann *et al.* 2016). As for the cornflower (*Centaurea*), along with arthritis and rheumatism, it treats diarrhoea, various gastro-intestinal diseases, and inflammations (Al-Snafi 2015a). Saw-wort (*Serratula*), is also used for treatment of diarrhoea (Uphof 1968; Adnan Hölscher 2010). Teasel (*Dipsacus*) is a good medicinal plant for rheumatism, asthma, and diarrhoea (Dahui *et al.* 2012; Wiersema and Leon 2013).

Pollen grains of the Caryophyllaceae family are widely presented in the palynological spectrum of the human faeces from the latrine found at Namcheduri II (Fig. 2). Many representatives of this family have medicinal properties (Chandra and Rawat 2015), namely they treat cancer, inflammation, fungal and viral diseases. Besides, they have antibacterial and antioxidant properties (Chandra and Rawat 2015).

Pollen grains of plants treating diabetes are presented in small amounts. Of them, only yarrow is evidenced (Alarcon *et al.* 2015; Fortini *et al.* 2016). The two plants – goosefoot and nettles – previously included in the group of nutritive plants should be specially noted. Goosefoot (*Chenopodium album*) is widely used for treatment of plenty of diseases. Among them are arthritis, rheumatism, diarrhoea, uremia, abdominal pains, and helminthiasis. Rather rich literature exists concerning this issue (Jabbar *et al.* 2007; Yadav *et al.* 2007; Altundađ and Özhatay 2009; Egamberdieva *et al.* 2012; Meuninck 2013; Polat *et al.* 2015; Bibi *et al.* 2014; Al-Snafi 2015b). Nettles (*Urtica*) are very popular in the ethnomedicine, being used for treating rheumatism, asthma, bleeding, inflammation and anemia. There is much research dedicated to these issues (Asgarpanah and Mohajerani, 2012; Quattrocchi

2012; Wiersema and León, 2013; Bibi *et al.* 2014; Zlatović *et al.* 2014; Fontini *et al.* 2016; Kregiel *et al.* 2018).

As for the spore plants, including 8 taxons in their group, nearly all of them are also used in the folk medicine. For instance, horse-tail (*Equisetum*) that is well represented in the spectra, was a remedy used in the Middle Ages and in the course of the whole historic period to defeat rheumatism, however, later research has revealed that horse-tail can also be used to fight against cancer, diabetes, pain, and fungal diseases (Asgarpanah and Rochi, 2012). Adder's fern (*Polypodium vulgare*) is a good painkiller. Lots of its spores are also in human faeces from latrines (Said *et al.* 2002; Allen and Hatfield 2004; Black 2004; Kültür *et al.* 2007; Jarić *et al.* 2011; Dar *et al.* 2012; Quattrocchi 2012; Wiersema and León 2013). Besides, it treats asthma, skin diseases, and comprises a good expectorant (Kvavadze *et al.* 2020). Fern adder's tongue (*Ophioglossum vulgatum*) is a good antiseptic remedy. Its spores were defined in the recently obtained material (Duke *et al.* 2002; Allen and Hatfield, 2004; Hatfield, 2004; Mannan *et al.* 2008; Quattrocchi 2012). The woolly bracken (*Pteridium aquilinum*) also is known to have antiseptic properties; in addition, it is used for treatment of inflammation, angina, and rheumatism (Vetter 2010; Menale and Muoio 2014; Baydoun *et al.* 2015; Fontini *et al.* 2016). Royal fern (*Osmunda regalis*) is used against rheumatism. Its spores are also discovered in recently found organic remains (Molina *et al.* 2009). It is notable that today fern *Pteris cretica* is used against cancer and other types of tumour (Kiran *et al.* 2018).

As already noted, eggs of parasitic worms of several types were evidenced in the group of non-pollen palynomorphs (Table No 1 and Fig. 6). Eggs of the nematode *Trichuris trichiura* prevailed in it. This kind of helminthosis is considered a tropical disease as its spread is more frequent in tropical and subtropical zones. Eggs of *Trichuris trichiura* ripen only in warm and wet climatic conditions (Araújo *et al.* 1981; Bouchet 2003). It is remarkable that in the territory of Georgia traces of *Trichuris trichiura* have been discovered in Upper Palaeolithic layers (Kvavadze *et al.* 2011). This period was characterized by the climatic optimum of the Late Glacial period. Eggs of *Trichuris trichiura* were encountered in the habitation layers of the Neolithic site of Gadachrili Gora (Kvavadze *et al.* 2014) as well as by the sacrum of a buried individual in the Early Bronze Age barrow of Ananauri (Kvavadze 2016). In all these periods, as well as in the Classical Period of western Georgia, the climate was warm and humid, causing the spread of trichuriasis (Chichinadze *et al.* 2019; Kvavadze and Chichinadze 2020).

Plenty of eggs of ascaris (*Ascaris lumbricoides*) are in the palynological material (Table No 1). Eggs of parasitic worms *Capillaria*, *Enterobius vermicularis*, *Yokogava fluke* are presented in small amounts (Figs. 3 and 6). Traces of all aforementioned helminths were found for the first time in the archaeological layers dated to the Classical Period of Georgia. It should be noted that eggs of *Trichuris trichiura*, *Capillaria*, *and Ascaris* were discovered in the Hellenistic layers of the Elaia site in Turkey (Shumilovskikh *et al.* 2016). Of great interest is the fact that, as in Namchederi II, the Elaia spectrum of non palynological palynomorps is dominated by the *Trichuris trichiura* eggs.

The abundance of eggs of parasitic worms in the obtained material from Namcheduri II gives grounds for supposition that this part of the settlement was used as a latrine or a cesspit.

CONCLUSION

The palynological study of the layers at the site of Namcheduri II dated to the Classical Period have shown that the population in the period in question actively consumed products made of cereals and even preferred such food. Chestnut also occupied a significant part in the human diet. Hazel, walnut, acorn, and beech fruits were used as food by the ancient population. They used grapes and products made of it. They are blackberries, guelder rose, and, possibly, other kinds of berries as well.

Evidently ethnomedicine was at a rather high level of development in the period under discussion since remains of plenty of medicinal plants were discovered in fossilized human faeces. The analysis of the examined palynological materials showed that the majority of them represent medicinal remedies of rheumatism and arthritis.

Residues of medicinal plants treating diarrhoeal and other gastrointestinal diseases abound in the material. From our point of view, this abundance was stipulated by the widespread of helminthiasis closely connected to the humid and warm climatic conditions. It is well known that the wet and warm soil preserves eggs of parasitic worms for a long period of time.

Spreading of malaria is connected to wet climatic conditions. Its existence is proved by discovery of medicinal plants used for treatment of malaria in the palynological spectrum.

Of great interest is the fact that, according to the composition of the revealed medicinal plants, epilepsy and diabetes were not widely spread in the population of the period in question.

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GUEST FROM THE WEST: EARLY HALLSTATTIAN HOARD WITH ORNAMENTS DISCOVERED NEAR NISPORENI

ABSTRACT

Topal D. and Sîrbu M. 2022. Guest from the West: Early Hallstattian hoard with ornaments discovered near Nisporeni. *Sprawozdania Archeologiczne* 74/2, 53-74.

A deposit of bronze items was discovered in 2019 on the territory of a forest area near Nisporeni in the western part of the Republic of Moldova. The artefacts (about 150 items) were discovered in a pit, about 50 cm deep and among them were: two fibulae of Röschitz-Sanislău type, seven necklaces, 12 rings, 22 tubes, 23 bracelets, about 80 appliqués, a coral bead, a wild animal tusk pendant and 21 amber beads. The objects from this deposit are of western origin, with known analogues in deposits from Poland, Hungary, Serbia, Slovakia and less in Romania. Apparently, despite the wider dating of the deposit within HaA2-HaB1-2, the date of deposition was probably closer to the upper limit. In addition, the Nisporeni deposit perfectly illustrates the cultural dynamics of the region in the Early Iron Age, that is, the fundamental change in the vector of cultural influences from Eastern to Western.

Keywords: Early Iron Age, Hallstatt, hoard, deposit, Röschitz-Sanislău type
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The last decades in the post-Soviet area have been characterized by a real treasure hunting boom, which led to the appearance of a huge number of "stray finds", or archaeological objects "found by chance and with little or no associated archaeological context" (Darvill 2003, 410). An example of this is a significant number of swords and daggers of the Scythian period are "stray" (Topal 2017, 260, 261). Unfortunately, the same fate has befallen most of the known deposits from the Eneolithic to the Medieval period. The chance discovery of artefacts before the metal detectors era was quite normal: archaeological finds were found in the process of agricultural or construction work, unintentionally, and usually later handed over to museums. With the advent of metal detectors, the discovery of artefacts is the result of intentional actions leading to the destruction of sites, the removal of artefacts from their archaeological context and their commercialization. The ethical problem of introducing such finds into scientific circulation has been called by Leo Klejn "the Mellaart syndrome" after James Melaart who was involved in several scandals, *e.g.* notably concerning the Dorak treasure or "Dorak affair". Besides, James Mellaart

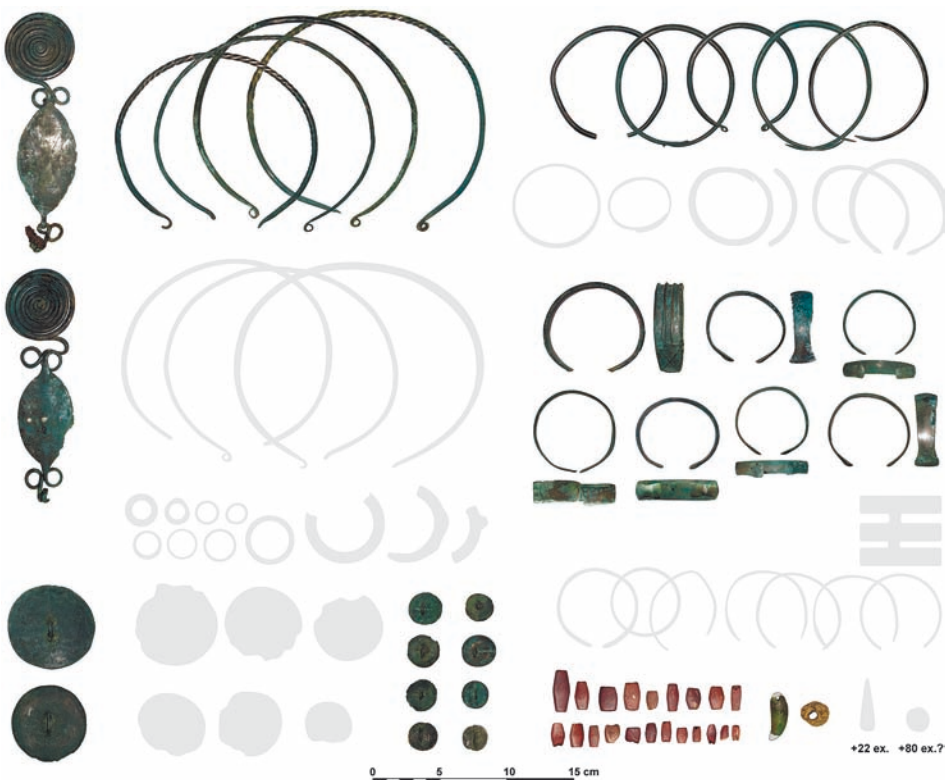

Fig. 1. Reconstruction of the Nisporeni hoard. Illustrated by D. Topal

made the main discovery of his life in a clear violation of generally accepted ethical rules by acquiring various finds, hence the Çatalhöyük he studied is often sarcastically called a "bazaar find".

Returning to treasure hunters, it is worth noting that they often sell their "catch" to one or more collectors, thus dispersing their deposits. Collectors in turn can be seen as people who, by purchasing artefacts, motivate the illegal activity of treasure hunters, but on the other hand they are also the ones who save these pieces, some of them allowing their documentation and publication by archaeologists and even donating some collections to museums. However, none of the above excuses the activity of treasure hunters. Often, the cooperation of archaeologists with collectors is criticized. However, as archaeologists, we are aware that in some cases these "partnerships" are the only way to reach, evaluate and disseminate information about the artefacts. This is especially true for rare objects or objects that can change the configuration of the area where certain types of artefacts are found.

The deposit we are presenting here was discovered in 2019 on the territory of a forest area near Nisporeni, part of it was later acquired by the collector Vladimir Parnov. The latter allowed us to document and publish the bronzes to introduce them into the scientific circuit. According to the owner, the bronzes were discovered in a pit, about 50 cm deep, and are part of a larger lot of pieces discovered together (about 150 items): two fibulae, seven necklaces, 12 rings, 22 tubes, 23 bracelets and about 80 appliqués (*phalerae* or button-shape ornaments). The entire deposit represented only ornaments, typologically being a deposit of a single functional category (Fig. 1). Subsequently, these finds were dispersed and acquired by various collectors. V. Parnov managed to acquire only 51 pieces from this lot: 12 bracelets, nine appliqués (phalerae or button-shape ornaments), four necklaces, two fibulae, a disc-shaped bronze plate with a hole (the chemical composition of this piece showed indications of a contemporary alloy, for which reason it was further excluded from the text and not shown graphically), a coral (?) bead, a wild animal tusk pendant and 21 amber beads. These objects were proposed for documentation and introducing to specialists at the National Museum of History of Moldova.

DESCRIPTION OF OBJECTS

The numbers of the items in the catalogue correspond to the numbers on figures (Figs 2-7) and tables (Tabs 1-2).

1. Röschitz-Sanislău type fibula with *Passementerie* disc and shield (Fig. 2: 1, Tab. 2: 1): massive, with the spiral disc made of elongated oval rod in section, finished in a straight bar, on which the foliform shield is fixed. The shield is provided at one end with an extension in the form of a wire rectangular in cross-section, twisted into a figure of 8 and fixed to the bar with another wire. The opposite end of the shield is similarly thinned and twisted, retaining a fragment of the spring of the fibula to which a heavily oxidized iron rod is attached.

The shield is fitted with an hourglass-shaped ornament, the frame of which forms a set of incised lines between two other dotted lines made by striking with a punch. The pin is missing but there are traces of repair at one end of the shield. The surface of the object is covered with green patina. The total length is 17.8 cm, diameter of the disc – 5.2 cm, length of the shield – 8.0 cm, width of the shield – 4.4 cm, thickness of the shield – 0.1 cm. Weight – 42 g.

2. Röschitz-Sanislău type fibula with *Passementerie* disc and shield (Fig. 2: 2; Tab. 2: 2): massive, with the spiral disc made of elongated oval rod in section. The fibula is made in one piece. The rod continuing from the disc takes a curved shape, after which its section becomes rectangular and is twisted into a figure of 8, after which it expands to form the foliform shield. The latter is oval with an hourglass-shaped ornament, the frame of which forms a set of incised lines framed between two other dotted lines made by punching. In the central area, there are three holes 0.1-0.2 cm in diameter, made in a slightly oblique line. The shield is finished with a rectangular rod in section, twisted in the shape of an 8, which continues into the spring in three spirals, the last spiral being circular in section and continuing in the shape of a needle. The needle is broken together with the spring coil. The surface of the object is covered with green patina. Total length is 17.1 cm, diameter of the disc – 5.2 cm, length of pin – 12.8 cm, length of shield– 7.0 cm, width of shield – 4.1 cm, shield thickness – 0.1 cm, weight – 52 g.

3. Massive appliqué (phalera) worked from a thin bronze plate with a thickness of 0.15 cm (Fig. 3: 3; Tab. 2: 3): circular in plan and slightly convex in section, with the edge barely bent inwards. It is provided on the inner side with a lug semi-oval in plan and a hole diameter of 0.6 cm. The surface of the object is covered with a thin layer of green patina. Diameter 6.5 cm, weight – 27 g.

4. Massive appliqué (phalera) made of a thin bronze plate with a thickness of 0.15 cm (Fig. 3: 4; Tab. 2: 4): circular in plan and slightly convex in section, with the edge barely bent inwards, chipped in some places. It is provided on the inner side with a lug semi-oval in plan and a hole diameter of 0.4 cm. The surface of the object is covered with a thin layer of green patina. Diameter 5.6 cm, weight – 21 g.

5. Appliqué (button-shape ornament) made of thin bronze plate 0.12 cm thick (Fig. 3: 5; Tab. 2: 5): circular in plan and slightly convex in section, with the edge barely bent inwards. It is provided on the inner side with a lug semi-oval in plan and a hole diameter of 0.2 cm. The surface of the object is covered with a thin layer of green patina. Diameter – 2.4 cm, weight – 3 g.

6. Appliqué (button-shape ornament) made of thin bronze plate 0.12 cm thick (Fig. 3: 6; Tab. 2: 6): circular in plan and slightly convex in section, with the edge barely bent inwards, chipped in places. It is provided on the inner side with a lug that is semi-oval in plan and cross-section, with an orifice diameter of 0.3 cm. Under the rim, the inner side is decorated with a dotted line in repoussé style. The surface of the object is covered with a thin layer of green patina. Diameter – 2.3 cm, weight – 3 g.

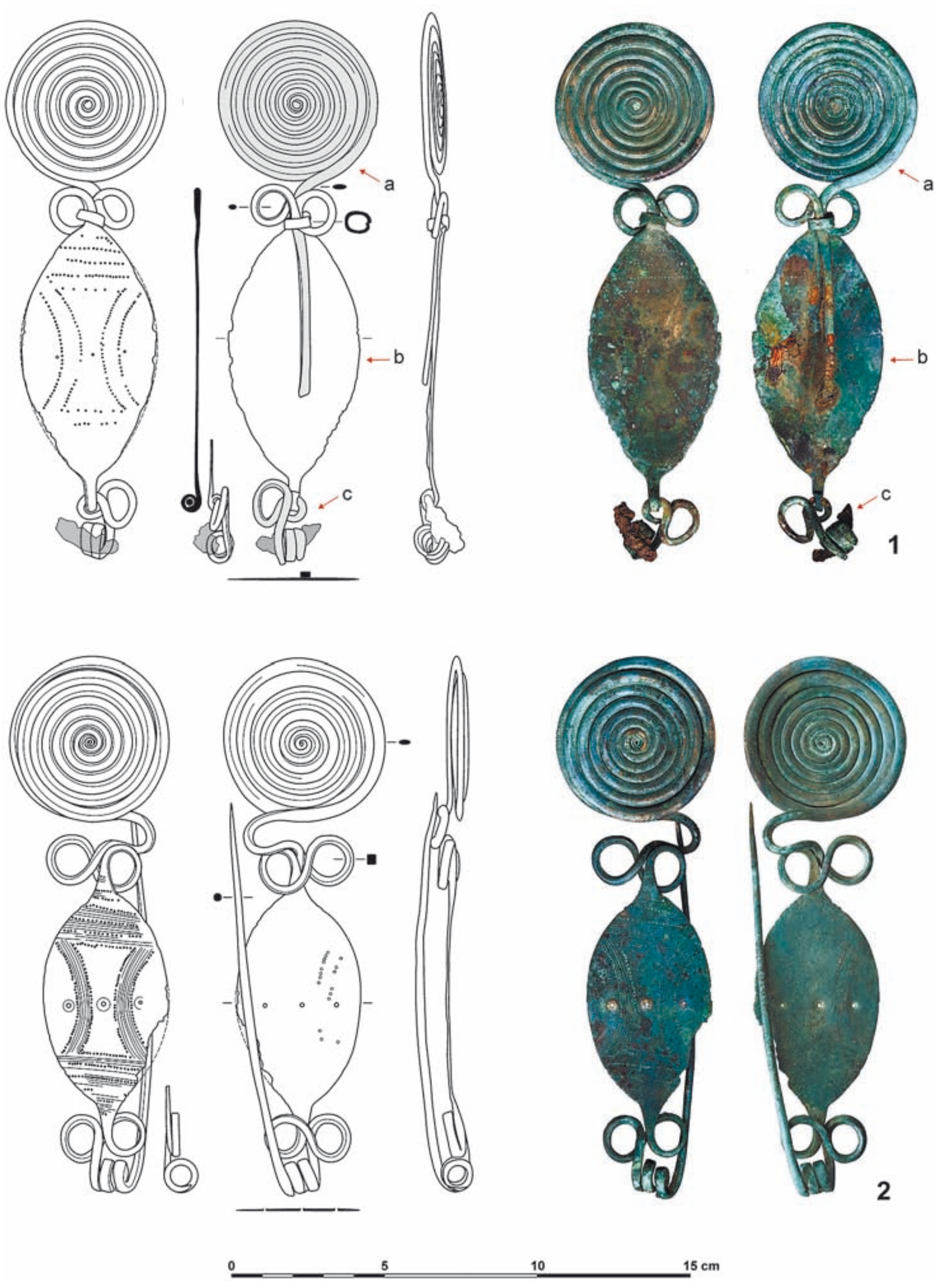

Fig. 2. Fibulae (1-2) of the Nisporeni hoard (a, b, c – elements of fibula 1).
Illustrated by D. Topal

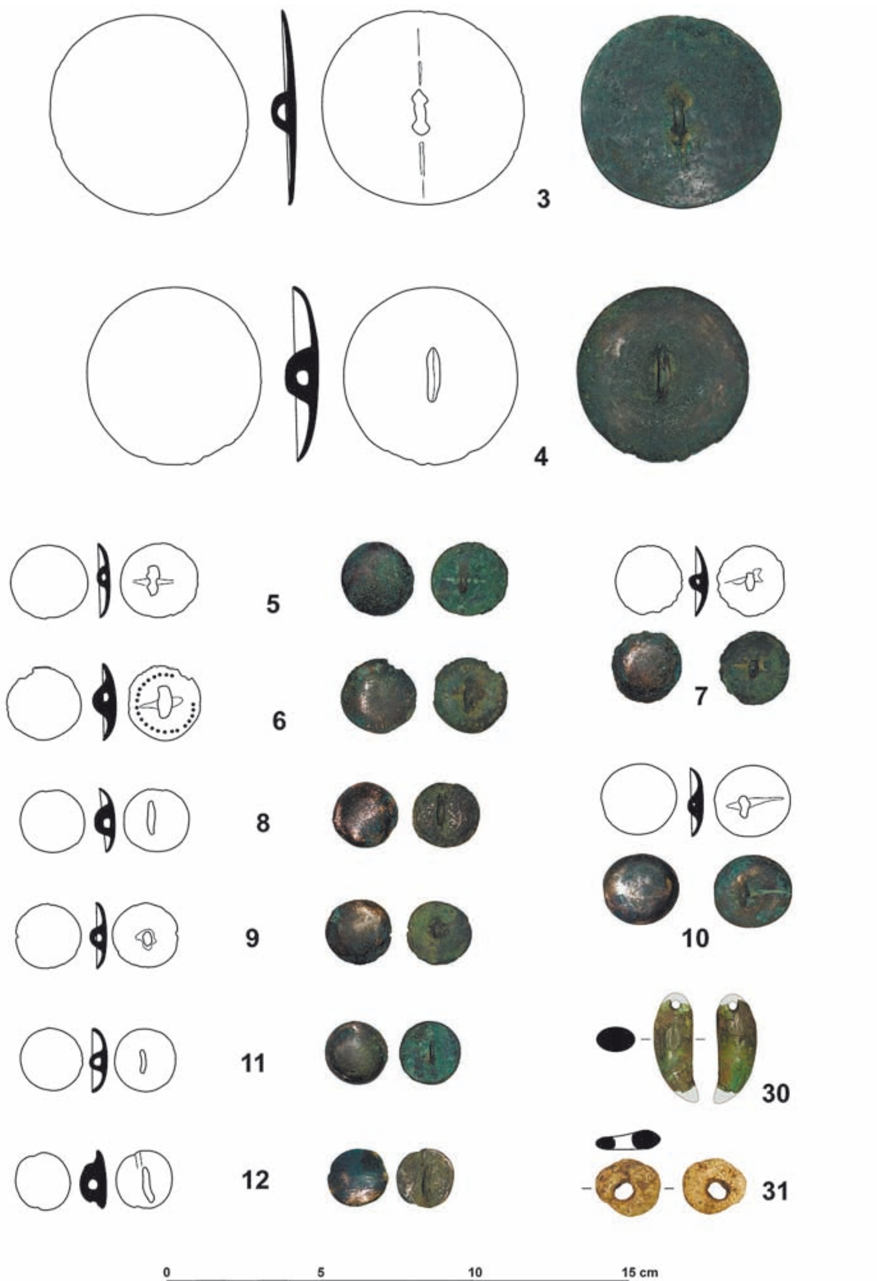

Fig. 3. Appliqués (3-12) and pendants (30, 31) from the Nisporeni hoard.
Illustrated by D. Topal

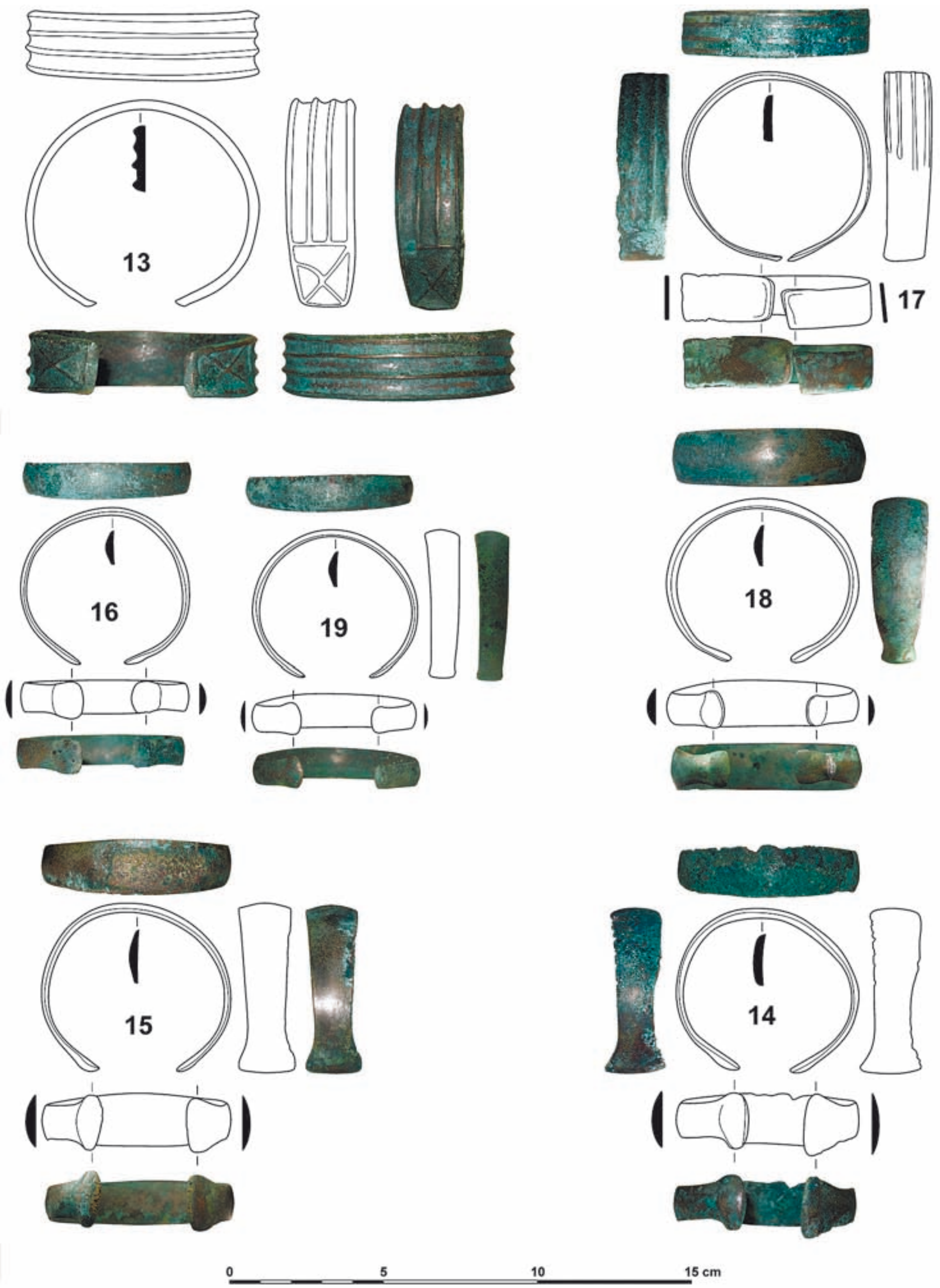

Fig. 4. Bracelets (13-19) from the Nisporeni hoard.
Illustrated by D. Topal

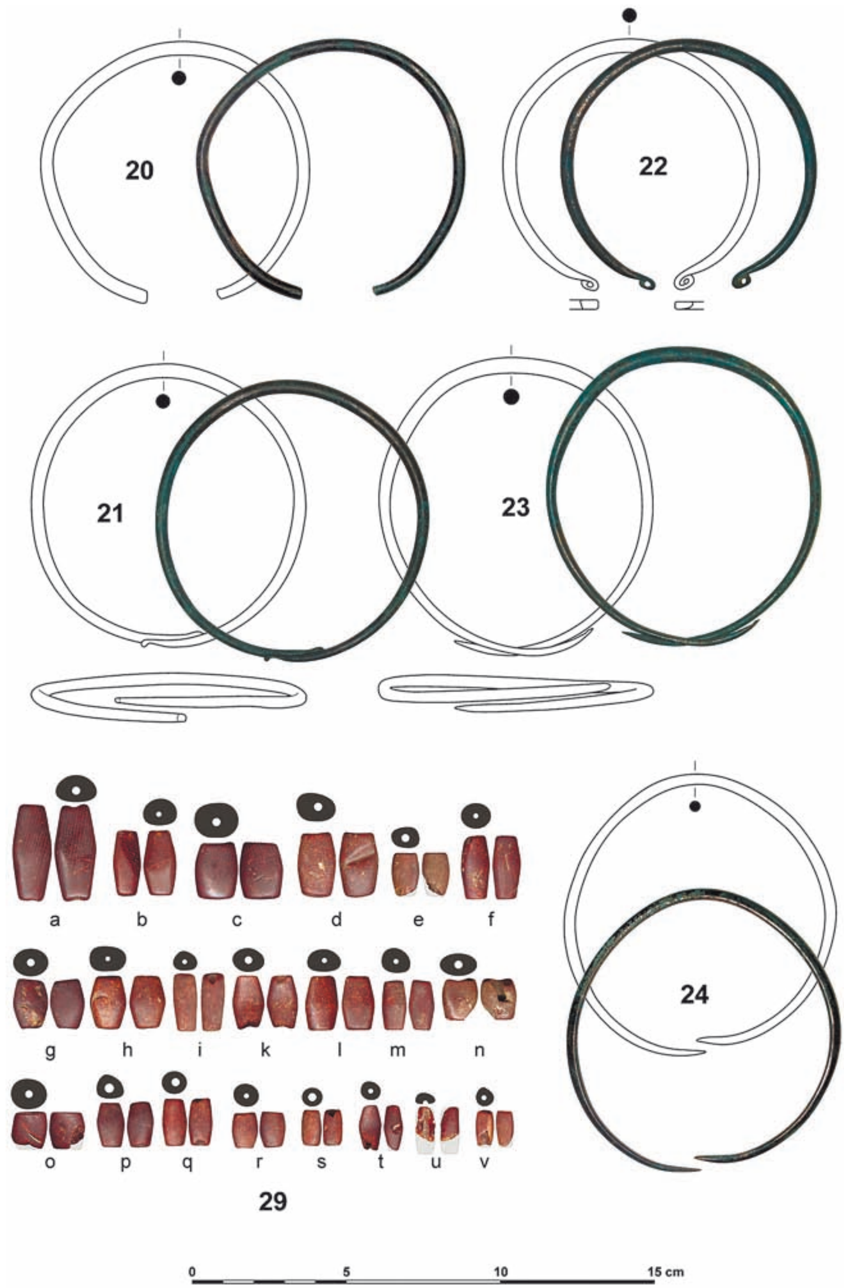

Fig. 5. Bracelets (20-24) and amber beads (29a-v) from the Nisporeni hoard.
Illustrated by D. Topal

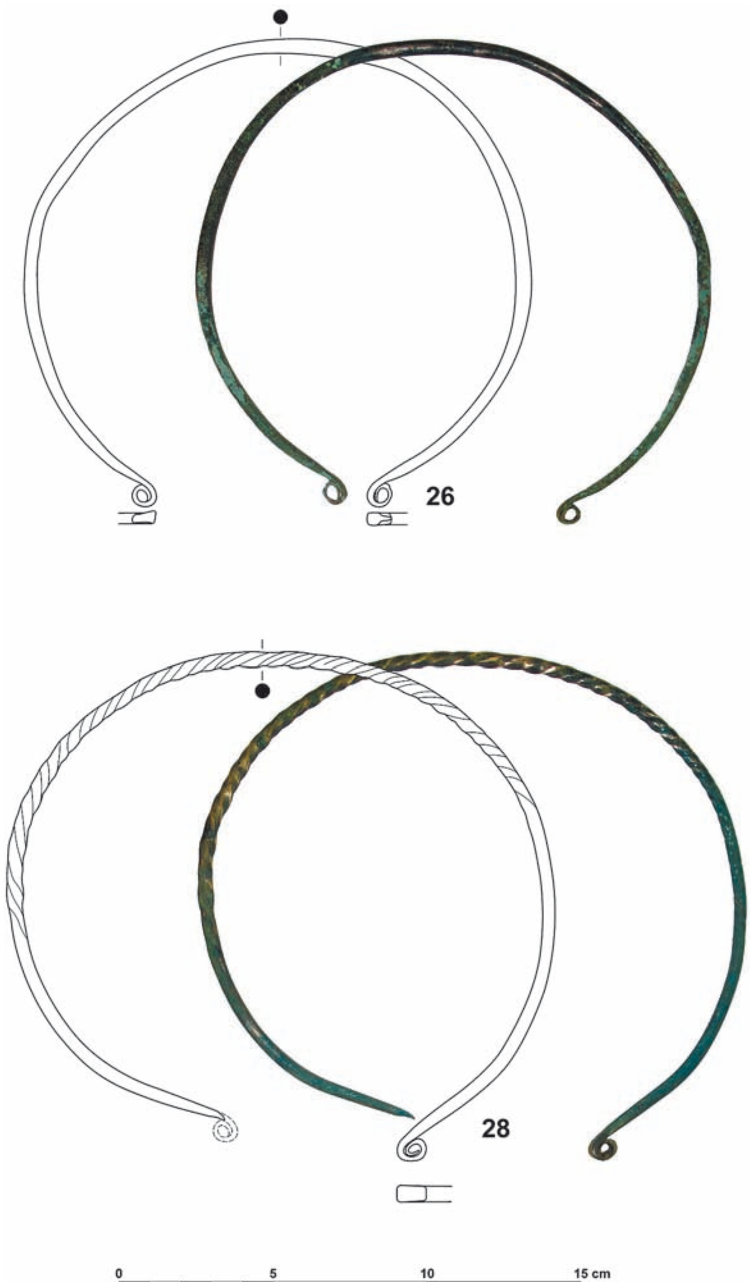

Fig. 6. Necklaces (26, 28) from the Nisporeni hoard.
Illustrated by D. Topal

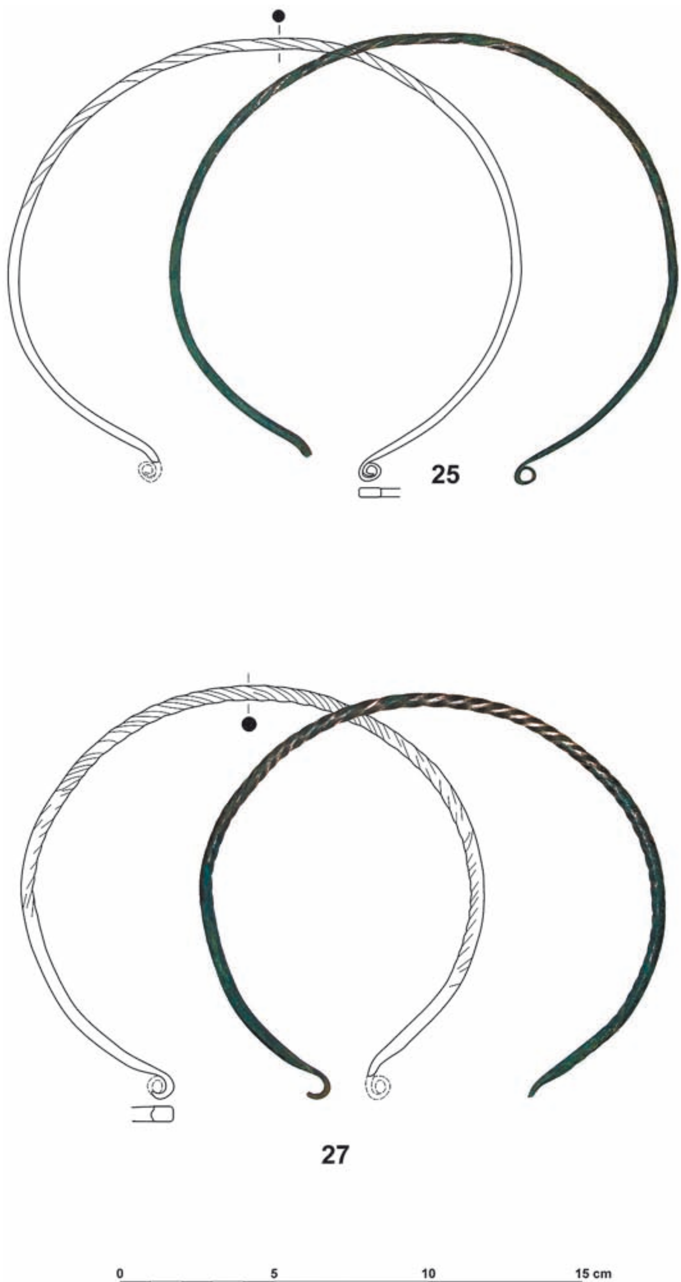

Fig. 7. Necklaces (25, 27) from the Nisporeni hoard.
Illustrated by D. Topal

7. Appliqué (button-shape ornament) made of thin bronze plate 0.12 cm thick (Fig. 3: 7; Tab. 2: 7): circular in plan and slightly convex in cross-section, with the edge barely bent inwards, chipped in places. It is provided on the inner side with a lug which is semi-oval in plan and cross-section, with a hole diameter of 0.2 cm. The surface of the object is covered with a thin layer of green patina. Diameter – 2.2 cm, weight – 2 g.

8. Appliqué (button-shape ornament) made of thin bronze plate 0.12 cm thick (Fig. 3: 8; Tab. 2: 8): circular in plan and slightly convex in section, with the edge barely bent inwards, chipped in places. It is provided on the inner side with a lug semi-oval in plan and cross-section and an oval aperture of 0.3 × 0.35 cm. The surface of the object is covered with a thin layer of green patina. Diameter – 2 cm, weight – 2 g.

9. Appliqué (button-shape ornament) made of thin bronze plate 0.12 cm thick (Fig. 3: 9; Tab. 2: 9): circular in plan and slightly convex in section, with the edge barely bent inwards, chipped in places. It is provided on the inner side with a semi-circular lug, with a hole diameter of 0.25 cm. The surface of the object is covered with a thin layer of green patina. Diameter – 2 cm, weight – 2 g.

10. Appliqué (button-shape ornament) made of thin bronze plate 0.12 cm thick (Fig. 3: 10; Tab. 2: 10): circular in plan and slightly convex in section, with the edge barely bent inwards. It is provided on the inner side with a lug, semi-oval in plan and cross-section, with a hole diameter of 0.2 cm, placed offset from the centre point of the piece. Also on the inner side, there is a groove probably left by the wire with which the lug was pierced. The surface of the object is covered with a thin layer of green patina. Diameter – 2.4 cm, weight – 3 g.

11. Appliqué (button-shape ornament) made of thin bronze plate 0.12 cm thick (Fig. 3: 11; Tab.2: 11): circular in plan and slightly convex in section, with the edge barely bent inwards. It is provided on the inner side with a lug semi-oval in plan and oval aperture 0.3 × 0.35 cm. The surface of the object is covered with a thin layer of green patina. Diameter – 2cm, weight – 2g.

12. Appliqué (button-shape ornament) made of thin bronze plate 0.12 cm thick (Fig. 3: 12; Tab. 2: 12): circular in plan and slightly convex in cross-section, with the edge barely bent inwards, chipped in places. It is provided on the inner side with a semi-oval, deformed lug with a 0.4 cm hole. The inner side has a rib on which the lug is fixed. The surface of the object is covered with a thin layer of green patina. Diameter – 1.8 cm, weight – 2.0 g.

13. Massive bracelet with lenticular-sectioned bar slightly narrowed towards the open ends (Fig. 4: 14; Tab. 2: 14). This has the outer side ornamented with 4 longitudinal ribs (2 of which highlight the edges) continuing to near the ends, ornamented in turn with two crossed x-shaped ribs. The piece is covered with a thin layer of green patina. Dimensions are 6.8 × 7.3 cm, length of the bar – 19.4 cm, width of the bar – 1.9 cm (1.5 cm at the ends), weight – 61 g.

14. Bracelet with lenticular-sectioned bar slightly narrowed towards one end (Fig. 4: 18; Tab. 2: 18). The ends are close together, one cut obliquely and the other in a straight line. It has the outer side ornamented with 4 longitudinal ribs (2 of which highlight the edges) which continue to near the ends. The piece is covered with a thin layer of light green patina. Dimensions are 5.8 × 5.9 cm, bar length – 18.3 cm, bar width – 1.3 cm (at one end – 1.1 cm), weight – 22 g.

15. Bracelet with lenticular-sectioned bar, slightly narrowed towards open ends, highlighted by a sharp expansion and rounded corners (Fig. 4: 15; Tab. 2: 15), one end is thickened. The bar is semi-oval in cross-section, with the edge being ragged in places. The surface of the piece is covered with a layer of green patina. Dimensions are 5.0 × 5.4 cm, length of the bar – 15.6 cm, width of the bar – 1.0-1.3 cm (1.6 cm at the ends), weight – 24 g.

16. Bracelet with lenticular-sectioned bar, slightly narrowed towards open ends, highlighted by a sharp expansion and rounded corners. One end is thicker (Fig. 4: 16; Tab. 2: 16), the bar is semi-oval in section. The surface of the piece is covered with a layer of green patina. Dimensions are 5.0 × 5.8 cm, length of the bar – 15.4 cm, width of the bar – 1.0-1.5 cm (1.6 cm at the ends), weight – 23 g.

17. Bracelet with lenticular-sectioned bar, slightly narrowed towards open ends, highlighted by a slight expansion and rounded corners (Fig. 4: 17; Tab. 2: 17). Ends are thickened, the bar is semi-oval in section. The surface of the piece is covered with a layer of green patina. Dimensions are 5.3 × 4.9 cm, length of the bar – 15 cm, width of the bar – 0.9-1.1 cm (0.9 and 1.1 cm at the ends), weight – 14 g.

18. Bracelet with lenticular-sectioned bar, slightly narrowed towards open ends, highlighted by a sharp expansion and rounded corners (Fig. 4: 19; Tab. 2: 19). One end is thickened and the bar is semi-oval in section. The surface of the piece is covered with a layer of green patina. Dimensions are 5.9 × 5.2 cm, length of the bar – 16.0 cm; Width of the bar – 10.8-1.6 cm (1 cm at the ends), weight – 32 g.

19. Bracelet with lenticular-sectioned bar, slightly narrowed towards open ends, highlighted by a sharp expansion and rounded corners (Fig. 5: 20; Tab. 2: 20). One end is thickened; the bar is semi-oval in section. The surface of the piece is covered with a light green patina. Dimensions are 4.7 × 5.2 cm, length of the bar – 13.6 cm, width of the bar – 0.7-1.0 cm (0.7 and 0.8 cm at the ends),weight – 13 g.

20. Bracelet worked from bronze wire circular in section, with open ends, one of them slightly tapered, both cut straight across (Fig. 5: 21; Tab. 2: 21). The piece is slightly deformed and has the surface covered with a thin layer of dark green patina. Dimensions are 8.8 × 8.3 cm, length of the bar – 25 cm, diameter of the bar – 0.4 cm (0.3 at one end), weight – 26 g.

21. Bracelet made of bronze wire circular in cross-section, with tapered and overlapping ends, finished in the shape of a hook (Fig. 5: 22; Tab. 2: 22). The surface of the piece is covered with a layer of green patina. Dimensions 8.8 × 8.9 cm, length of the bar – 30.5 cm, diameter of the bar – 0.4 cm (at the ends 0.3 cm), weight – 26 g.

22. Bracelet made of bronze wire circular in cross-section, with open ends finished by flattening and twisting in the form of twists forming an oval-shaped hole measuring 0.2 × 0.3 cm (Fig. 5: 23; Tab. 2: 23). The surface of the piece is covered with a layer of open-green patina. Dimensions are 8.1 × 8.15 cm, length of the bar – 23.2 cm, diameter of the bar – 0.45 cm, weight – 24 g.

23. Bracelet made of bronze wire circular in cross-section, with pointed and overlapping ends (Fig. 5: 24; Tab. 2: 24). It has a surface covered with a layer of green patina. Dimensions are 9.2 × 8.9 cm, length of the bar – 33.2 cm, diameter of the bar – 0.5 cm (0.3 cm at the ends), weight – 29 g.

24. Bracelet made of bronze wire semi-oval in section, with pointed and slightly overlapping ends (Fig. 5: 24; Tab. 2: 24). The piece is slightly deformed and has the surface covered with a layer of green patina. Dimensions are 8.6 × 8.5 cm, length of the bar – 27.5 cm, width of the bar – 0.4 cm (0.2 cm at the ends), weight – 23 g.

25. Necklace made of bronze wire circular in section, with open, flattened and twisted ring-shaped ends, the diameter of rings is 0.4 cm and 0.5 cm (Fig. 6: 26; Tab. 2: 26). The surface of the piece is covered with a layer of open-green patina. Dimensions are 16.7 × 15.5 cm, length of the bar – 44.5 cm, diameter of the bar – 0.5 cm (0.4 cm at the ends), weight – 50 g.

26. Necklace worked from bronze wire circular in section, twisted 2/3 of its length (Fig. 6/28; Tab. 2/28). It has open ends, one flattened and twisted into a ring shape (diameter of the ring is 0.4 cm) and the other broken. The surface of the piece is covered with a layer of green patina. Dimensions are 16.3 × 14.2 cm, length of the bar – 43 cm, diameter of the bar – 0.4 cm (0.25 cm at the ends), weight – 24 g.

27. Necklace worked from bronze wire circular in section, twisted 2/3 of its length. One flattened and twisted into a ring shape (diameter of the ring is 0.4 cm) and one broken (Fig. 7: 25; Tab. 2: 25). The surface of the piece is covered with a layer of greenish patina. Dimensions are 14.8 × 13.0 cm, length of the bar – 39 cm, diameter of the bar – 0.4 cm, weight – 38 g.

28. Necklace worked from bronze wire circular in section, twisted 2/3 of its length. It has open ends, one flattened and twisted into a semicircle (diameter is 0.4 cm) and the other broken (Fig. 7: 27; Tab. 2: 27). The surface of the item is covered with a layer of greenish patina. Dimensions are 17.8 × 15.4 cm, length of the bar – 48.9 cm, diameter of the bar – 0.5 cm, weight – 51 g.

29. Amber beads, 16 whole and 5 fragments (Fig. 5: 29) have an elongated biconical shape and various sizes. They are reddish-brown, the length is 1.1-3.1 cm, width 0.6-1.4 cm, thickness 0.6-1.1 cm, hole diameter 0.2-0.3 cm (Tab. 1).

30. Pendant made of a carnivore canine (according to Dr. A. Bălăşescu) tooth (Fig. 3: 30) with both ends broken off, visible is part of the 0.4 cm diameter hole in the wider part. It is greenish as a result of its storage with the bronze pieces. Length– 3 cm, width – 0.8-1.2 cm, thickness – 0.8 cm.

Table 1. Amber beads, *cm*.

No.	Length	Width (max.)	Thickness (max.)	Hole diameter
29a	3,1	1,2	0,8	0,3
29b	2,1	1,1	0,8	0,2
29c	1,8	1,4	1,1	0,3
29d	2,1	1,2	0,9	0,3
29e	1,4	0,9	0,7	0,3
29f	2,1	0,9	0,8	0,2
29g	1,6	1,1	0,9	0,3
29h	1,7	1,1	0,8	0,2
29i	1,8	0,8	0,6	0,2
29k	1,7	1,0	0,8	0,3
29l	1,8	1,0	0,7	0,2
29m	1,6	0,8	0,8	0,2
29n	1,4	1,1	0,7	0,3
29o	1,2	1,1	1,0	0,3
29p	1,4	0,9	0,8	0,3
29q	1,5	0,8	0,7	0,3
29r	1,1	1,1	0,7	0,2
29s	1,2	0,7	0,6	0,3
29t	1,4	0,7	0,6	0,2
29u	1,1*	0,6*	0,3*	0,25
29v	1,1	0,6	0,6	0,2

31. Pendant made of coral (?) (Fig. 3: 31): this is of irregular oval shape and has a circular hole with a diameter of 0.6 cm. It is yellowish-grey and has a spongy side and a side covered with paint (?) which gives it a sheen. Dimensions are 1.8 × 2.0 cm, thickness – 0.3-0.6 cm.

DISCUSSION

The fibulae from the Nisporeni deposit belong to the Röschitz-Sanislău type (Bader 1983, 29; Novotná 2001, Taf. 1-2; Gedl 2004, Taf. 84). According to the typology by T. Bader, this type of fibula is divided into two variants each with several sub-variants: A – fibulae with an oval or elongated oval shield, (Bader 1983, 29) and B – fibulae with a rather round shield (a, b) (Bader 1983, 29). According to this typology, the fibulae from the Nisporeni deposit belong to variant B, sub-variant b, which is characterized by the hourglass-shaped decoration made on the shield. The area of distribution of the Röschitz-Sanislău type fibulae (Fig. 8) comprises the territory between the Middle Danube area to the west, Moravia to the north, the Republic of Moldova to the east and the north of former Yugoslavia to the south (Bader 1983, 31, Taf 42: B; Tarbay 2017, 88, Fig. 26). Most finds of this type are known from the territory of Hungary, and are also present in the Czech Republic, Slovakia, Poland, more sporadically in Germany, Austria, Croatia, Bosnia and Herzegovina, Serbia, Ukraine, Romania and the Republic of Moldova (Bader 1983, 30; Moszolics 1985, Taf. 25: 6; Řihovský 1993, Taf. 1: 16; 7: 72, 75; Vasić 1999, 21, Taf. 3: 40, 43, 61; Moszolics 2000, Taf. 108: 7; Novotná 2001, 22, Taf. 26; Gedl 2004, Taf. 51: 217, 84: nr. 217; Kašuba 2008, 216, Abb. 19; Tarbay 2017, 88, Figs 16: 44-47; 24: 2, 26). They are dated differently (Schránil 1928, 184) but mainly to HaA_1 (Pittioni 1954, 410, 460; Müller-Karpe 1959, 103; Bader 1983, 30; Mozsolics 2000, Abb. 3). Analyses have shown that fibulae with oval shields are assigned to HaA_1 and fibulae with rounded shield belong mainly to HaA_2-HaB_1 (Bader 1083, 31; Tarbay 2017, 88). However, M. Bandrivskii considers that the easternmost, Podolian complexes (Nedeliska, Yargorov), as well as the Valea Rusului deposit with Röschitz-Sanislău type fibulae, belong to the HaA_2 period (Bandrivskii 2014, 145).

The bracelets are represented by massive items with a flat bar and ornamented with ribs; bracelets with broad bar flat-convex in section and dilated ends; simple open bracelets with overlapping ends with round or semi-oval bar section. Bracelets with flat bar ornamented with ribs are known from deposits in Hungary, Serbia, Poland, Romania dated to HaA_1-HaB_1 (Moszolics 1967, Taf. 59: 5, 6; Garašanin 1975, T. 5: 6; 6: 4; 55: 1; Petrescu-Dîmbovița 1977, Pl. 191: 8, 11, 13; 368: 10; Moszolics 1985, Taf. 243: 15; Gedl 2004, Taf. 110: 7, 8). The bracelets with a flat-convex broadened bar in section and dilated ends are also of western provenance, being present in deposits from the territory of Hungary, Serbia dated to HaA-HaB (Garašanin 1975, T. 56: 6, 8-15; Moszolics 1967, 60: 4-9; 63: 3-6; Moszolics 2000, Taf. 3: 3-5, 7, 8, 10). Analogies of the bracelet with a round bar in section and open hooked ends are known from the territory of Hungary and dated back to BrD (Köszegi 1988, Tab. 47) and from the deposit at Fundul Galbenei (Topal and Sîrbu 2016, fig. 4/8). Bracelets of this type with an bar oval-elongated in section are known from the Băleni deposit discovered on Romanian territory and similarly dated within BrD (Dragomir 1967, R18m: 188, 192-198). Also, in the above-mentioned area we find analogies for the bracelet with a rounded bar in section and distant ends, dated to BrD-HaA_1 (Petrescu-Dîmbovița 1977, Pl. 58: 10, 72: 15; Köszegi 1988, Tab. 47; Topal and Sîrbu 2016, Fig. 4/8-9). The bracelets with a bar round or semi-oval in section and overlapping ends are typical for HaA_1-HaA_2/B_1(or even later, for HaD) being known from deposits in north-eastern Hungary, Poland, Transylvania and Transcarpathian Ukraine (Petrescu-Dîmbovița 1978, Taf. 100: B12; 102: A50; 133: A12; 204: 1186; 224: 38, 41, 43; 240: 31, 34, 41; Kobal 2000, Taf. 91: 14; 92: 43, 47; Moszolics 2000, Taf. 28: 10, 47: 5-7; Gedl 2004, Taf. 106: 10, 11; Soroceanu 2012, Taf. 31: 7; Tarbay 2017, fig. 26).

Discoidal applications are presented in deposits dated from BrD to HaB_3 found in Hungary (Moszolics 1985, Taf. 108: 10; 140: 15, 17, 33; 201: 17; 228: 13, 14; 229: 2-7; Moszolics 2000, Taf. 7: 4; 44: 11-13; 46: 6-8), Romania (Petrescu-Dîmbovița 1977, Pl. 46: 3; 55: 2;

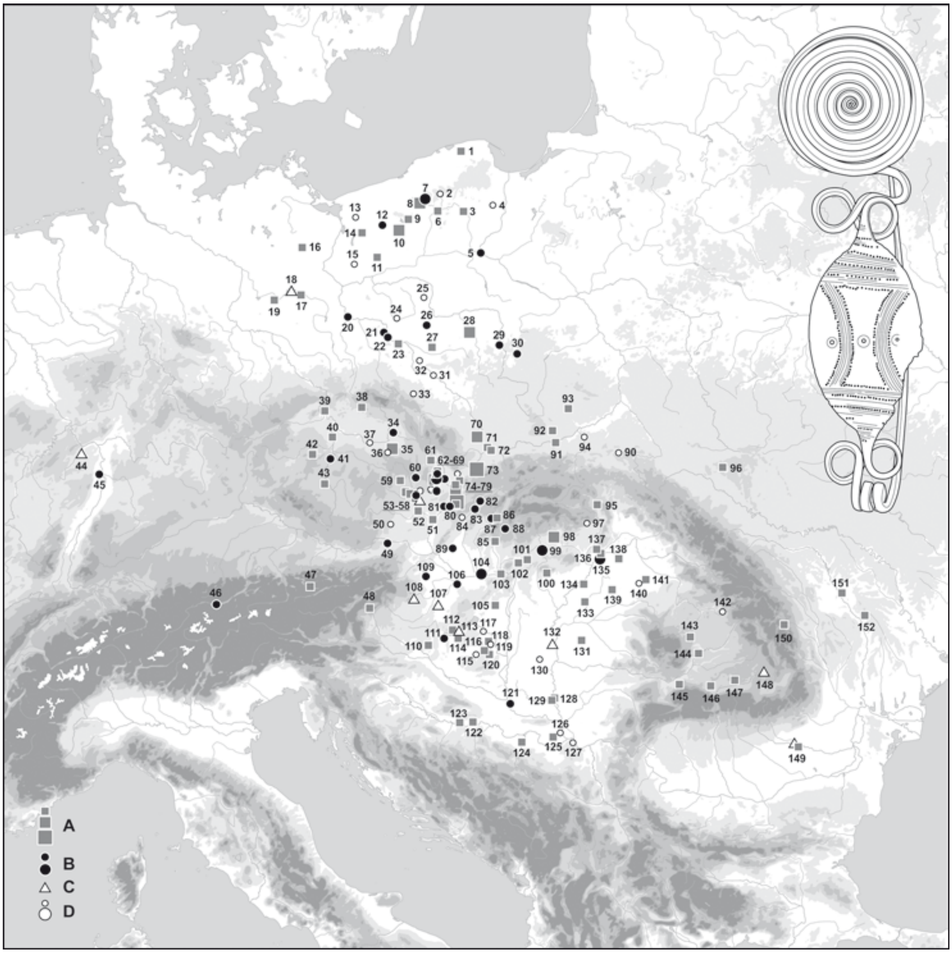

Fig. 8. Distribution of Röschitz-Sanislău type fibulae and other"Blattbügelfibel" in Europe. A – hoards (1-3 ex.); B – graves (1-2 ex.); C – settlements; D – stray finds (1-2 ex.). 1 – Kopaniewo, 2 – Piaszczyna, 3 – Rytel, 4 – Pączewo, 5 – Czarnowo, 6 – Rzeczenica, 7 – Sępolno Wielkie, 8 – Grąbczyn, 9 – Komorze, 10 – Wierzchowo, 11 – Chłopowo, 12 – Brzeźniak, 13 – Węgorza, 14 – Stara Dąbrowa, 15 – Renice, 16 – Herzfelde, 17 – Berlin-Spindlersfeld, 18 – Wilmersdorf, 19 – Werder, 20 – Krzesin, 21 – Otyń, 22 – Siedlisko, 23 – Głogów, 24 – Obra, 25 – Dąbrowa, 26 – Krzywiń, 27 – Słupia Kapitulna, 28 – Gołuchów, 29 – Sucha, 30 – Buczek, 31 – Wrocław-Osobowice, 32 – Bożeń, 33 – Świdnica, 34 – Nepasice, 35 – Přestavlky, 36 – Práčov, 37 – Lžovice, 38 – Jenišovice, 39 – Liščín, 40 – Praha-Suchdol, 41 – Záborná Lhota, 42 – Záluží, 43 – Vrcovice, 44 – Bad Kreuznach, 45 – Eppstein, 46 – Insbruck-Hötting, 47 – Brandgraben, 48 – Peggau, 49 – Gemeinlebarn, 50 – Röschitz, 51 – Kostice, 52 – Mušov, 53 – Blučina, 54 – Ořechov, 55 – Ostopovice, 56 – Brno-Obřany, 57 – Rosice, 58 – Tetčice, 59 – Kundratice, 60 – Lysice, 61 – Loštice, 62 – Slatinice, 63 – Čelechovice na Hané, 64 – Kostelec na Hané, 65 – Určice, 66 – Křenůvky, 67 – Tovačov, 68 – Luleč, 69 – Bohdalice, 70 – Gamów, 71 – Gorzyce, 71 – Grąbczyn, 72 – Podgórnik-Godów, 73 – Štramberk, 74 – Týn nad Bečvou, 75 – Bystřice pod Hostýnem, 76 – Holešov, 77 – Sazovice, 78 – Drslavice, 79 – Vlčnov, 80 – Uherský Ostroh, 81 – Bzenec, 82 – Mikušovce, 83 – Skalská Nová Ves, 84 – Lubina, 85 – Madačka, 86 – Prievidza-Hradec, 87 – Diviaky nad Nitricou, 88 – Žiar nad Hronom, 89 – Veľký Grob, 90 – Strzyżów,

88: 17; 177: 11-13; Petrescu-Dîmbovița 1978, Taf. 124: 25, 26; 159: A12; 194: 888, 898, 901, 902; 268: 3, 4), Poland (Gedl 2004, Taf. 109: B2), Serbia (Garašanin 1975, T. 1: 4, 52: 6, 8-10, 53: 1-12), Ukraine (Kobal 2000, Taf. 36: 21; 47: 23, 24; 79: B9.15, 16).

The necklaces are represented by three twisted items and a plain, untwisted one. The first twisted necklaces appear only in BrD-HaA$_1$, although twisting of bronze or gold wires appeared as early as the Middle Bronze Age (Rusu 1967, 87, 88). M. Rusu developed a typology of necklaces found in Transylvania, which attributes untwisted necklaces to variant I and twisted ones to variants IIIa – mechanically worked by hand, with uneven twists and untwisted portions round in section, and IIIb – with false twists, cast in "á cire perdue" moulds with evenly rendered twists and untwisted portions of rhombic shape and only rarely round in section (Rusu, 1967, 95). The hand-twisted variant appears at the end of BrD beginning of HaA$_1$, sometimes occurring parallel to the cast ones that gradually replace them continuing until HaB-HaC (Rusu 1967, 96, 97). As a rule, the necklaces have flat and twisted ring-shaped terminals, less often having straight ends. They are present in deposits found in Italy, Germany (M. Rusu, 1967, 12), Poland (Gedl 1980, Taf. 95: 1-4), the Czech Republic (Hüttel 1981, Taf. 36: 18, 19, 26), Hungary (Mozsolics 1985, Taf. 39: 30, 36; 92: 25, 27; 238: 3-5; Neugebauer-Maresch and Neugebauer 1996, 111, Abb. 7: 9; Mozsolics 1985, Taf. 28: 7, 109: 4, 7, 8; Mozsolics 2000, Taf. 6: 1; 47: 12; 49: 1-3; 70: 8; 83: 4, 5; 86: 23-26; Tarabay 2017, fig. 12: 22), Serbia (Garašanin 1975, Taf. 51: 1-7), Romania (Rusu 1967, 88, fig. 1-5; Petrescu-Dîmbovița 1977, Pl. 2: 6; 7: 1-5; 17: 11-15; 258: 12, 13, 15; 381: 1; 387: 1-4; 388: 1-5; Soroceanu 2012, Taf. 56; 57; 62: 1-5). In the territory of the Republic of Moldova, necklaces of this type are known from the Fundul Galbenei deposit (Topal and Sîrbu 2016, Figs 4: 1, 4, 5, 11, 12).

Depositing pendants and beads of non-metallic origin alongside bronzes in deposits is a rare practice. Perforated animal tusks are found very sporadically in the composition of deposits known in Hungary at Bölcske and Orosipuszta dated to the Early Bronze BIII period (Mozsolics 1967, 131, 153, 154, Taf. 34: 44-47; 70: 10-15). For the pendant, no analogies are known. While in the Early and Middle Bronze Age amber beads represented extremely rare finds, usually from settlements or burial inventory, towards the end of the BrD a considerable number of amber objects begin to be ritually deposited in caves or deposits (Gogâltan 2016, 147, 148, 153, figs 2; 5; 6). Amber beads are contained in several

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91 – Podłęże, 92 – Słomniki, 93 – Motkowice, 94 – Żabno, 95 – Prešov, 96 – Nedilyska, 97 – Jasov, 98 – Veľký Blh, 99 – Radzovce-Monosa, 100 – Gyöngyössolymos-Kishegy, 101 – Csitár, 102 – Érsekvadkert, 103 – Esztergom-Szentgyörgymező, 104 – Chotín, 105 – Nadap, 106 – Győr-Ménfőcsanak, 107 – Celldömölk-Sághegy, 108 – Velem, 109 – Illmitz, 110 – Oltárc-Márki-rét, 111 – Vörs-Battyáni disznólegelő, 112 – Badacsonytomaj-Köbölkút, 113 – Balatonboglár, 114 – Kisapáti-Lengyeltóti, 115 – Kapospula, 116 – Kurd, 117 – Felsőnyék, 118 – Keszőhidegkút, 119 – Gyönk, 120 – Nagyvejke, 121 – Dalj, 122 – Brodski Varoš, 123 – Pričac, 124 – Kućišta, 125 – Šimanovci, 126 – Novi Banovci, 127 – Vinča, 128 – Domaniža, 129 – Novi Bečej, 130 – Ruzsa, 131 – Csorvás, 132 – Baks-Temetőpart, 133 – Karcag, 134 – Egyek-Kendertag, 135 – Taktabáj-Erdőalja, 136 – Bodrogkeresztúr, 137 – Tállya, 138 – Kemecse, 139 – Debrecen, 140 – Sanislău, 141 – Căpleni, 142 – Bistrița, 143 – Vâlcele, 144 – Uioara de Sus, 145 – Cugir, 146 – Gușterița, 147 – Cincu, 148 – Augustin, 149 – Dridu, 150 – Bicaz, 151 – Valea Rusului, 152 – Nisporeni

BrD-dated bronze deposits in the eastern half of Slovakia (Novotná 1970, 106, 107) and Transdanubian Hungary (Mozsolics 1967, Taf. 34: 7-43; Mozsolics 1985, Taf. 26: 1-4; 30: 22). Analogies are known from the Cioclovina cave in Romania (Gogâltan 2016, 154, 155, fig. 11). Starting from the Iron Age, amber pieces disappear for about 300 years from the Carpathian Basin, reappearing here with the penetration of Scythian elements (Gogâltan 2016, 156, 157). A similar situation occurred in eastern Hungary, with only an insignificant number of amber pieces known for the central and western Balkans (Gogâltan 2016, 156). Bronze tubes are known in Batina, Dalj-Busija, grave 72 (Metzner-Nebelsick 2002, Taf. 28: 17-25; 51: 17; 62: 8, 9; 90: 11; 96: 8, 9; 98: 24; 101: 7).

CONCLUSIONS

In the BrD period deposits formed from a single functional category comprise only 40.11% of their number, with this decreasing by half (23.76%) in HaA_1, increasing again to 30.46% in HaB_{1-2} and 39.04% in HaB_3-C (Bratu 2009, 34, figs 1-4). The decrease in the number of this type of deposit in HaA_1 is most likely explained by the boom in the practice of depositing deposits formed by complex or heterogeneous associations (Bratu 2009, 34). The hoards with ornaments constitute only 4.94% for HaB_{1-2}, their number increasing in HaB_3-C to 22.22% (Bratu 2009, 34).

According to the number of pieces (about 150), the Nisporeni deposit represents a unique find for the territory of the Republic of Moldova. Equally unique for this area is the presence of whole Röschitz-Sanislău type fibulae, types of bracelets, discoidal applications as well as the deposition alongside bronzes of amber beads, animal tusk and coral (?) pendants. The objects from this deposit are of western origin, with known analogues in deposits from Poland, Hungary, Serbia, Slovakia and less in Romania (Petrescu-Dîmbovița 1977) dated in these areas within BrD-HaB_1 (Mozsolics 2000, Abb. 3).

The ornaments from the Nisporeni deposit are distinguished by a rather high and varied percentage of impurities, according to XRF (Tab. 2). Spectral analysis was performed using *Xenemetrix X-Calibur* X-ray fluorescence spectrometer at the Institute of Applied Physics, Republic of Moldova, Laboratory of Materials for Photovoltaics and Photonics. The samples were excited by X-rays up to 45 keV with a current of 10 μA, and the exposure time was 60 s. The boundaries of the fluorescent field formed an area of 7.07 mm^2. The obtained spectra were analyzed using the manufacturer's programs in the mode of simulation of the basic parameters of the sample components. Thus, the average value of copper in the alloys is 90.5%, with the lowest impurity indicators in a necklace (cat. 26; Cu 96.7%) and one of the bracelets (cat. 13; Cu 94.7%). The highest values of the impurities are for tin – the average is 5.4%; the minimum is for one necklace (cat. 26; Sn 1.56%), the maximum is for one appliqué (cat. 4; Sn 11%) and one of the fibulae (cat. 1, Sn 10.3%). It is worth mentioning the high antimony content – on average about 1.7%, in half of the artefacts (especially bracelets and appliqués) the percentage of antimony is higher than the natural limit. The

Table 2. Chemical composition of the items of Nisporeni hoard, %

No.	Object	Cu	Sn	Pb	Zn	Ag	Sb	As	Fe	Ni	Co	Bi	Mn	Au
1	Fibula (“spiral”)	87	10,3	1,35	0	0,18	0,19	0,46	0,2	0,24	0,06	0	0,04	0,04
	Fibula “schield”)	90,1	8,3	0,51	0	0,09	0,45	0,2	0,1	0,2	0,06	0	0	0
2	Fibula (“spiral”)	88,3	9,21	0,08	0	0,14	0,86	0,79	0,1	0,54	0	0	0,01	0,01
3	Applique	87,1	3,87	0,68	0	0,85	4,97	2,11	0,03	0,27	0,09	0	0,09	0
4	Applique	86,2	11,1	0,25	0	0,47	0,89	0,4	0,13	0,53	0,03	0	0,01	0
5	Applique	92,2	3,66	0,3	0	0,67	1,9	0,76	0,13	0,3	0,01	0	0	0,03
6	Applique	93,4	3,54	0,31	0	0,43	1,2	0,86	0,07	0,16	0	0	0	0,03
7	Applique	90,3	5,45	0,51	0	0,47	1,71	1,17	0,05	0,29	0,02	0	0	0
8	Applique	93,5	2,95	0,49	0	0,57	1,43	0,73	0,05	0,3	0	0	0	0
9	Applique	90,1	6,2	0,57	0	0,44	1,35	0,81	0,03	0,44	0,03	0	0	0,03
10	Applique	93,2	3,31	0,35	0	0,48	1,68	0,66	0	0,36	0,01	0	0	0
11	Applique	91,9	3,31	0,45	0	0,84	2,35	0,87	0,07	0,21	0,02	0	0	0,02
12	Applique	85,4	9,17	0,42	0	1,01	2,51	1,02	0,08	0,27	0,07	0	0,08	0
13	Bracelet	94,7	2,77	0,62	0	0,35	1,01	0,28	0,15	0,13	0	0	0	0,04
14	Bracelet	92,4	3,15	1,08	0	0,64	1,76	0,49	0,03	0,41	0	0	0	0,06
15	Bracelet	91	2,59	2,06	0	0,71	2,58	0,76	0,02	0,21	0,01	0	0,07	0
16	Bracelet	88	7,27	0,86	0	0,71	2,14	0,67	0,04	0,26	0,03	0	0,05	0
17	Bracelet	91,2	2,56	0,94	0	0,63	3	1,18	0,04	0,38	0	0	0,08	0,03
18	Bracelet	87,1	9,36	0,82	0	0,33	1,43	0,39	0,17	0,29	0,05	0	0,05	0
19	Bracelet	90,8	4,73	0,63	0	0,58	1,86	1,06	0,11	0,21	0	0	0,03	0
20	Bracelet	92,4	4	0,74	0	0,28	1,19	0,46	0,63	0,25	0	0	0,04	0,05
21	Bracelet	92,2	5,04	0,21	0	0,38	1,37	0,5	0,08	0,26	0	0	0	0
22	Bracelet	86,9	9,19	0,51	0	0,55	1,54	0,78	0,04	0,39	0	0	0,06	0
23	Bracelet	92	4,93	0,47	0	0,38	1,1	0,56	0,09	0,39	0,01	0	0	0,04
24	Bracelet	87,7	6,95	0,77	0	0,83	2,47	1,01	0,1	0,17	0,02	0	0,02	0
25	Necklace	90,9	5,82	0,68	0	0,57	1,16	0,59	0,06	0,16	0,02	0	0	0,03
26	Necklace	96,7	1,58	0,12	0	0,35	0,77	0,15	0,03	0,16	0,03	0,05	0,05	0,07
27	Necklace	92,9	3,93	0,35	0	0,4	1,35	0,57	0	0,41	0,04	0	0	0,01
28	Necklace	88,5	7,82	0,33	0	0,23	1,49	0,58	0,28	0,65	0	0	0	0,1

maximum antimony is contained in appliqués and bracelets (Sb 4.97-1.54%; cat. 3, 5, 7, 10-12, 14-17, 19, 22, 24), minimum – for fibulae and necklaces (Sb 0.19-0.77%, cat. 1, 26). Also, for example, it is possible to distinguish the rather high percentage of lead in the pieces from the Nisporeni deposit compared to the bronze objects from the BrD period (Sîrbu *et al.* 2020, tab. 1). In contrast to the bronzes of the previous period, the percentage of silver (especially in appliqués and bracelets) is also higher, reaching almost 1% and nickel, the average value of which is 0.3%, and the maximum is 0.65% for one of the necklaces (cat. 28). Possibly, this is due to the lower demands on the technical characteristics of the ornaments (compared to weapons or tools) and consequently less rigour concerning the technological process. Most likely, the high impurity content is because there was no special recipe for this type of artefact, which would imply control over the content of certain impurities. We can assume that the ornaments were made by secondary melting of other objects. Apart from the composition of the chemical elements of the artefacts being quite different, it is noticeable that many of them have traces of use or repair, suggesting that the objects in the deposit were collected over a long period. We can suppose that the items were worn by individuals of different age groups, taking into account the variability of sizes of, for example, the bracelets. According to another scenario, these items would have belonged to a person who collected these jewels throughout his or her life, moving from one social age to another.

In addition, the Nisporeni deposit perfectly illustrates the cultural dynamics of the region in the Early Iron Age, that is the fundamental change in the vector of cultural influences from Eastern to Western. In contrast to the Late Bronze Age, the Middle Danube traditions, located in the western regions of Hungary, act as a determining factor in cultural development to the East of Carpathians (Dergachev 1997, 52). Most probably, the bearers of the Middle Danube traditions penetrated the territory between Siret and Dniester along the Danube, bypassing the Southern Carpathians (Smirnova 1993, 92). The formation of the first Hallstattian cultures in the Carpathian-Dniester area, judging from the distribution of metal items, is associated with the route through Transylvania and the Eastern Carpathians (Dergachev 1997, 54). The HaA_2 period was characterized by a complete rejection of earlier traditions of metalworking in the Noua environment and the beginning of a complete redesign of the “cultural façade” of the Carpathian-Dniester region. This *Hallstattization process* was already completed in the HaB period, with this time being associated with several deposits, as well as stray finds of Middle Danube or even Central European ornaments and weapons. The bronze deposit from Nisporeni district is well placed in this horizon, belongs to the Early Hallstatt and can be synchronized with other “Danubian fibulae” hoards from the Carpathian-Dniester region like Rafaila (Petrescu-Dîmbovița 1977, Pl. 339: 9-12), Bârlad (Petrescu-Dîmbovița 1977, Pl. 357) on the right bank of the Prut and Fundul Galbenei (Topal and Sîrbu 2016, figs 2, 3), Valea Rusului (Dergačev 2002, Taf. 48) on the left bank of Prut river. Similar to the Nisporeni deposit, the Valea Rusului hoard also contained a *Röschitz-Sanislău type* fibula fragment (a later variant), while the antennae sword fragments from the deposit belong to the HaB_2 period

(Leviţki 1994, 133; Kemenczei 1996, 251, 269). Apparently, despite the wider dating of the deposit within HaA_2-HaB_{1-2}, the date of deposition of this assemblage should be placed near the upper limit.

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Olena Fialko[1]

WEAPONS OF LONG DISTANCE COMBAT IN THE ARSENAL OF SCYTHIAN FEMALE WARRIORS

ABSTRACT

Fialko O. 2022. Weapons of long distance combat in the arsenal of Scythian female warriors. *Sprawozdania Archeologiczne* 74/2, 75-91.

Archaeological finds, supported by data from the literary tradition, indicate that women were presented among the Scythian army. 303 burials of Amazons have been recorded on the territory of European Scythia. A characteristic feature of their burials is the mandatory presence of weapons in the accompaniment sets. In the graves of the Amazons there are almost all types of attack weapons, dominated by the items of long-distance combat. The weapons of the female warriors completely corresponded to those in the arsenal of the Scythian army.

Keywords: female warriors, Amazons, weapons of long-distance combat, European Scythia
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INTRODUCTION

Before discussing the armament of the Scythian female warriors, who we usually call the Amazons, I would like to note three points.

1. Legends about military women have been the subject of research for almost 3.5 centuries. Among the first works specifically devoted to the Amazons is a treatise by the French

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publicist Pierre Petit "Reflections on the Amazons", published in 1685 in Latin and in 1718 in French translation. In it, the Amazons were seen as those who really existed (Petit 1718; Cosven 1947, 27).

2. One of the sources of information about the Amazons are the works of ancient authors – mythological legends and ethnographic information. The latter are especially interesting for us. For example, Pomponius Mela wrote in his "Geography" that the Amazons were engaged in the same activities as men and were not even exempted from military service. "Men serve in infantry and in battle throw arrows, and women engage in horse fighting and fight not with iron weapons, but "throw ropes at enemies and destroy them by dragging" (Mela I. 19. 114; here it is cited by: Latyshev 1949, 821). Hippocrates in his "On Airs, Waters and Places" says that the Amazons ride horses, shoot bows, and throw darts while sitting on horses (Hp. Aer. 24; here is cited by: Latyshev 1947, 295). Herodotus in his book "Histories" provides similar information when describing Sauromatic women. The historian noted that these women went hunting on horseback with or without men, went for fighting campaigns and wore the same clothes as men (Hdt. IV. 116; here it is cited by: Herodotus 1993, 206).

Therefore, according to ancient Greek authors, *the weapons* of the Amazons were bows with arrows, axes, darts, spears and small light shields in the shape of a crescent.

3. Very similar information is brought to us by the works of ancient masters. Today, about 1300 images of Amazons are known in the battle scenes alone (Worrall 2014), not counting domestic episodes. These characters were depicted in fact everywhere – from the friezes of temples (reliefs and statues), sarcophagi and funerary urns, ceremonial painted utensils to small jewelry and coins. And the images of these characters correspond are fully to the literary sources.

So, after getting a certain idea of how the ancient Greeks saw the Amazons, and most importantly their weapons, we should look at the archaeological realities.

THE DATA SET AND ITS QUALITY

In the territory of European Scythia, nowadays I am aware of 303 burials of Scythian female warriors from 267 kurgans, excavated in 116 burial mounds (Fig. 1). More than half (55%) of these graves were not robbed. According to the modern administrative division, these are the territories of seven regions of Ukraine (Mykolayiv, Dnipropetrovsk, Zaporizhzhia, Kherson, Odessa, Kirovohrad, Kharkiv, Cherkasy regions and the Autonomous Republic of Crimea), several districts of Moldova and some parts of Russia (Belgorod, Voronezh and Rostov regions). According to the territorial principle, burial complexes are divided into five main groups: 1. Lower Dnipro steppe (or Steppe); 2. Crimea Foothills; 3. Danube-Dniester steppes (or Transnistria); 4. Forest Steppe Dnipro area (or Forest Steppe); 5. Don region (Steppe and partly Forest Steppe). In some necropolises, the

Fig. 1. The graves of Scythian women warriors on the territory of European Scythia

number of Amazons graves fluctuates from one – two up to 27 (Elizavetovsky burial mound) and 35 (burial mound near the village of Hlyne), respectively in Don region and Transnistria.

A characteristic feature of such burials is *the mandatory presence of weapons* (as opposed to jewelry) in the material accompaniment of the deceased. Among the 293 inventory sets available for consideration, the so-called male group, in addition to horse ammunition and cauldrons, is represented by the weapons found in each female warrior's grave (Fig. 2).

At first glance, the range of weapons used by women is somewhat limited. However, in the graves of the Amazons there are almost all types of offensive weapons with a predominance of the items for remote combat – arrows (95% of graves) and bows (1.4%), spears (23%) and darts (9%).

Starting the review of the weapons of the Scythian female warriors, I would like to note the number of weapons in one burial complex (Fig. 3). *One type of weapon* (mostly arrows or a spear, sling stones, occasionally a dart, an ax or a mace) is found in 65% of burials*, two*

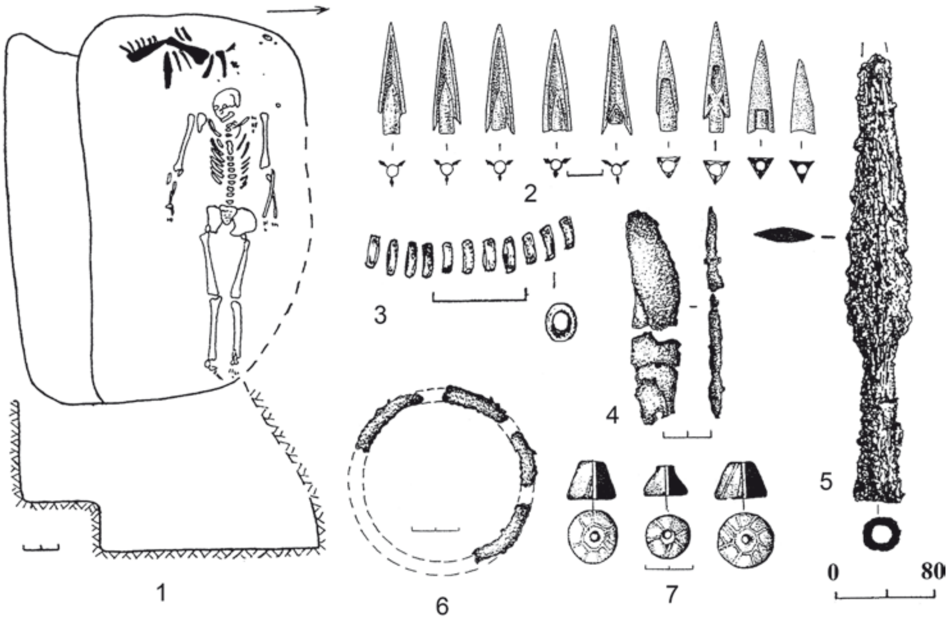


Fig. 2. The burial 3 of kurgan 54 in Mamai-Hora burial mound:
1 – plan and section of the grave; 2-7 – the set of burial implements

types (mostly arrows and a spear or a dart, rarely arrows and sling stones or sword) in 24,2% of burials, *three types* (arrows, either a spear and a sword or a dart or sling stones) in 10.5%, *four types of weapons* (arrows, a spear, a sword and sling stones) were found in only one burial (kurgan 37 of Elizavetovsky mound), which represents 0.3% of the total number of graves.

Bows and arrows were the most popular types of small arms of female warriors. However, the degree of preservation of the two components of such a set is very different. Therefore, the remains of *wooden bows* were noted only in four graves: in one from the Steppe group (Nikopol, kurgan 20, burial 2) and in three graves from the Crimean group (village Volodymyrivka, kurgan 1, burial 4; village Frunze burial 1; village Ogonki – group of Tribratni kurgans – kurgan 2, burial 3) – respectively for a child, an adolescent and two women. However, I would like to remind that even in male graves bows are seen quite rarely. Bows are usually divided into simple (which are made of a simple solid bar) and complex or multiple components ones (made of several bars and overlays) (Lukyashko 2015, 36). The Scythians used both types of bows (Melyukova 1964, 15). This situation is also relevant for Amazons. In the child's burial (in Nikopol) the fragments did not allow to establish the shape of the bow. In the female grave (near Frunze village), based on the remains, the bow was simple; in the case of a woman from the paired tomb n.3 (village Ogonki) there was a complex segmental bow – 64.5 cm long (Fig. 4: 1); and in the grave of

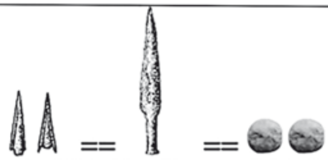
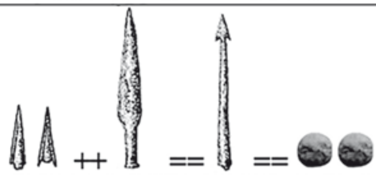
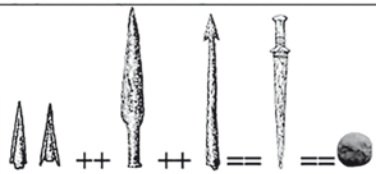
Number of kinds	Variants of weapons in a set	Number of graves	%
1		186	65
2		69	24,2
3		30	10,5
4		1	0,3
Total number of graves		286	100

Fig. 3. The number of weapons in the individual burials of the warriors

a teenage girl (Volodymyrivka village) – a complex sigmoid bow 55 cm long (Fig. 4: 2). In the last two cases, the bows had a spiral winding, made respectively of bark and leather. Probably, different types of bows are due to different conditions of combat – simple were used in infantry, and complex – from a horse.

There was one arrow with a bow in the child's grave, in the other three cases the bow was combined with a quiver with arrows (5, 32 and 52 specimens, respectively).

In this context, it is worth mentioning the relatively rare finds – *quivers*. These are narrow elongated cases made of wood and leather, which were usually placed near the hand (sometimes behind the head) of the deceased woman. In one case (Glynoe village, kurgan 104, burial 1) it is a product made of birch bark 55 cm long (Fig. 5). Remains of quivers have been found in 43 graves (20 in the Steppe Group, four in Crimea, nine in Transnistria, six in the Forest-Steppe and four in Don region). In two of them (group of Tribratni kurgans, kurgan 2, grave 3; village Zhuravka kurgan 406, burial 1) the presence of a quiver is evidenced by the findings of characteristic clasps. Such cases were decorated in various ways, for example, a leather quiver (measuring 45 x 13 cm) from the burial 3,

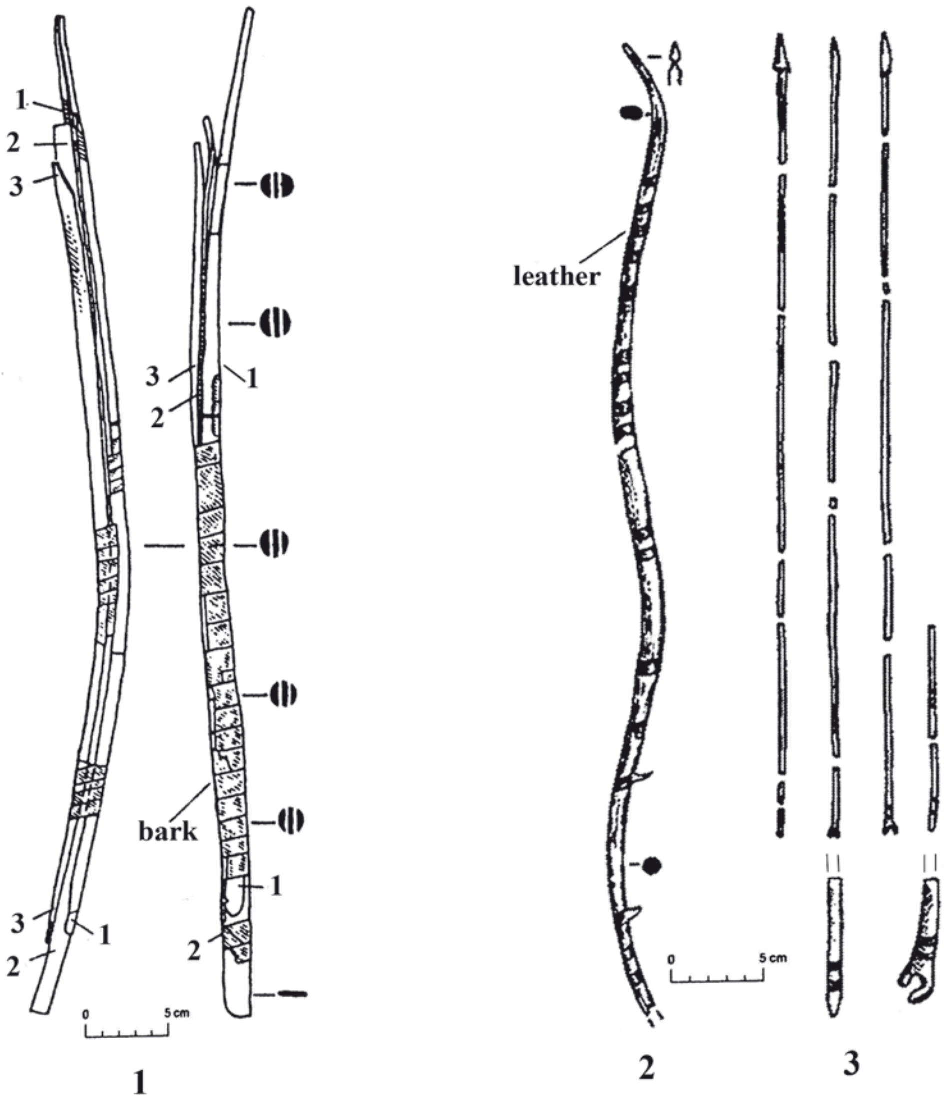


Fig. 4. The remains of wooden bows: 1 – village Ogonki (group of Tribratni kurgans) kurgan 2, burial 3; 2-3 – village Volodymyrivka, kurgan 1, burial 4 (bow and wooden arrows)

kurgan 10 near the village of Velyka Znamianka had a fur lining. The quiver from the burial 3, kurgan 38 near the village Lubimivka was preserved better than the other ones. It was a leather-covered wooden frame measuring 62 × 15 cm, the lower part of which was decorated with thin electrum plates. The utensils of this quiver, in addition to 135 arrows with bronze points, included an iron knife with a bone handle. Often a special compart-

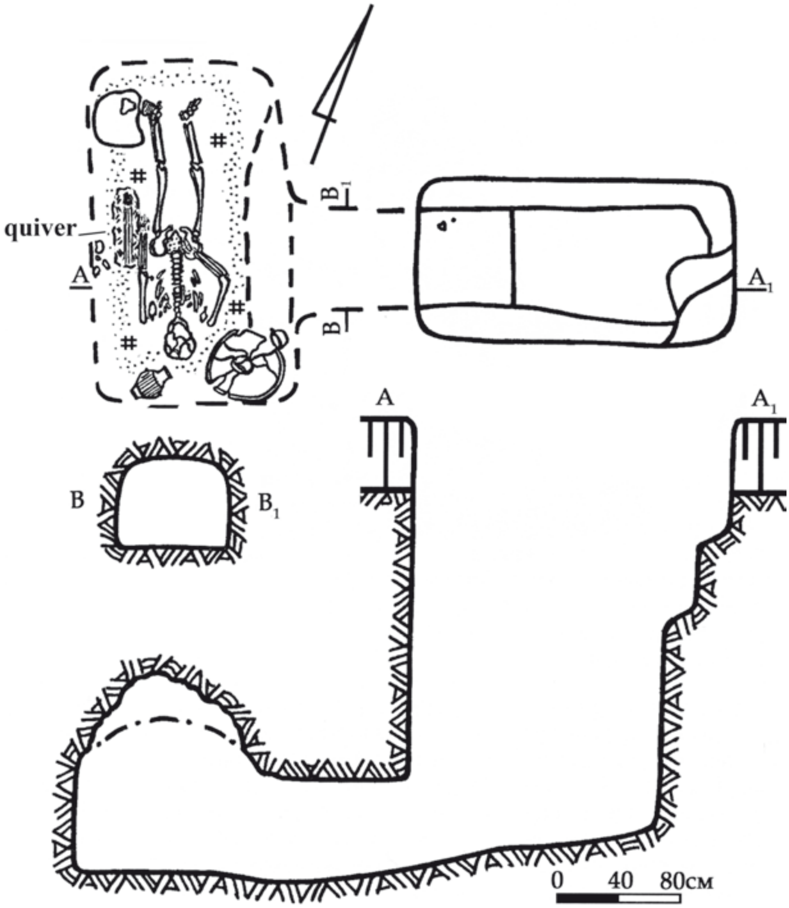


Fig. 5. The birch bark quiver from burial 1 of kurgan 104 near village Glynoe
(by: Telnov *et al.* 2016, fig. 347: 3)

ment – a pocket – was arranged for a knife in a quiver (Chernenko 1981, 43). In the necropolis near the village Glynoe (Transnistrian group) quivers are related to iron quiver awls, which are found in six female sets (Fialko 2017). No such connection has been observed in other Amazon complexes.

Arrows are represented by quiver sets, in bundles and by single specimens. They are present in 268 (95%) female burial complexes of all regional groups. Only the points remained, the shaft and their plumage were not recorded. Only in three cases in the Steppe group (Velyka Znamyanka village, kurgan 10, burial 3) and in Crimea (Volodymyrivka village, kurgan 1 burial 4; Ogonki village, kurgan 2, tomb 3) the wooden poles (up to 40-45 cm long) with colored markings were preserved (Fig. 4: 3). In the first two cases, the ends of

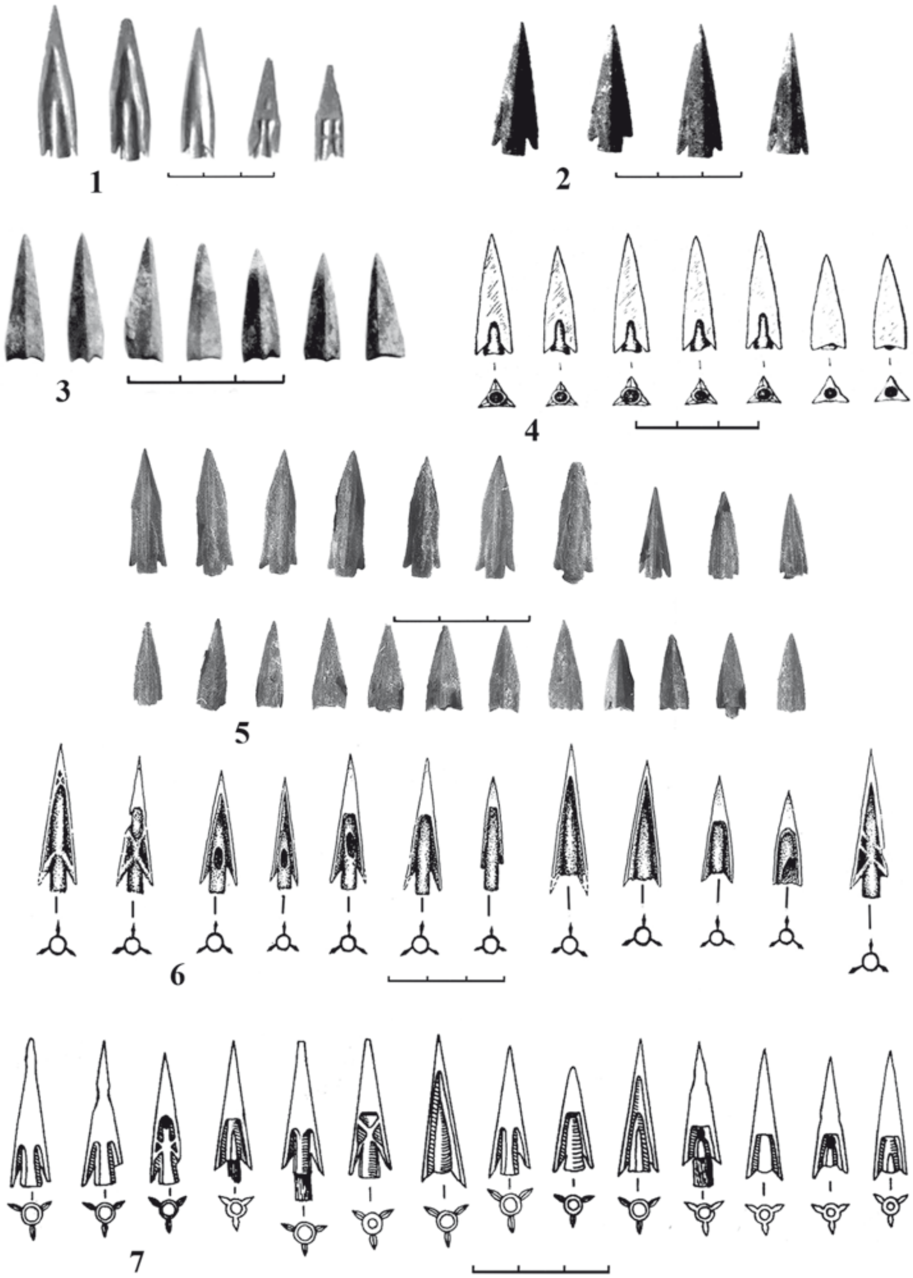


Fig. 6. The sets of arrows with bronze tips: 1 – burial 2, kurgan 6 near the village Maryivka; 2 – burial 2, kurgan 16 near the village Novopylypivka; 3 – burial 36 near the village Skelki; 4 – burial 1, kurgan V near the urban settlement Velykyi Rohachyk; 5 – burial 1, kurgan 5 near the village Shelyugi; 6 – burial 1, kurgan 1 near Horodyshche city; 7 – burial 1, kurgan 14 near the village Nikolske. Photo by O. Fialko

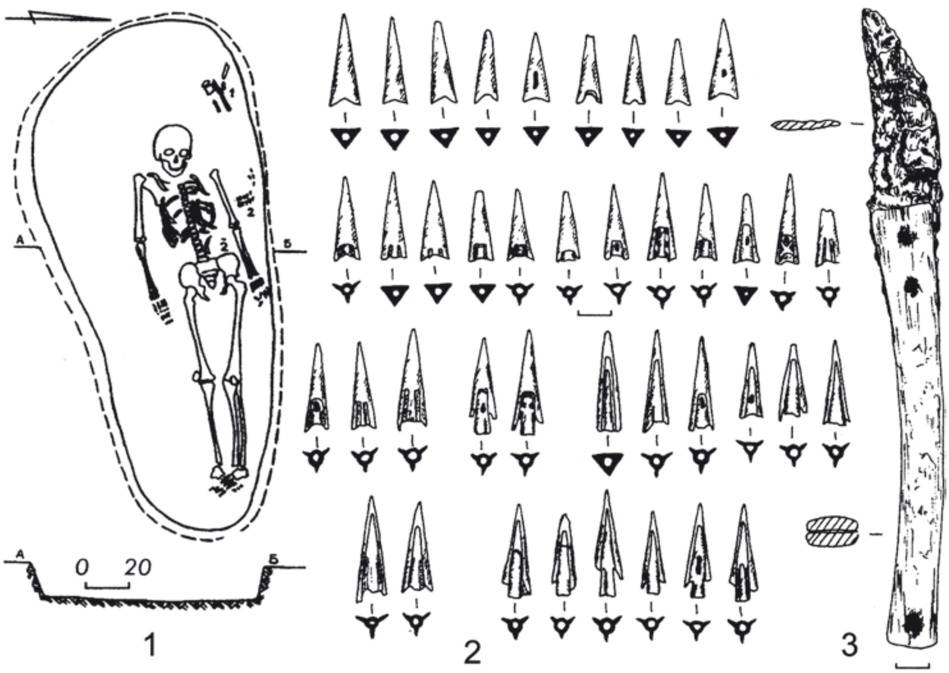


Fig. 7. The burial 44 from a burial ground near Skelki village: 1 – plan and section of the grave; 2-3 – the set of burial implements. After Popandopulo 2011, fig. 26

the poles had red and black belt-marks, in the latter – the same, but also in white and yellow colors. Sometimes short parts of the shafts remained in the socket near the arrowhead. It is possible that in some cases the arrow shafts were intentionally broken for ritual purposes.

The Scythians used arrows with tips made of bronze, iron, bone and wood. Generally, Amazons sets included arrows with *bronze* trihedral and trilobate tips (Fig. 6), typical for the sights of late 5th – early 3rd century B.C. (Melyukova 1964, 25-29). Quantitatively, trihedral points predominate (Fig. 6: 3, 4). Norms of the "ammunition" for arrows did not exist. This situation is observed for all Scythian quiver sets, regardless of the sex and social level of their owner (Hrytsiuk, 2009, 63). In the Amazons accompaniment sets different amounts of arrows were found: from a few units or several dozen to hundreds or more arrows (Fig. 7). The largest number was recorded, for example, in the burial 1, kurgan 45 near the village Lyubimivka – 98 specimens, in the burial 3, kurgan 2 near the village Zelene – 107 specimens, in the burial 2, kurgan 12 near Nosaky tract – 119 specimens, in the burial 1, kurgan 406 near the village of Zhuravka – 129 specimens, burial 1, kurgan 8 near Nove village – 130 specimens. The maximum number of arrows (135 specimens) was found in the burial 3, kurgan 38 near the village of Lyubimivka (Steppe group) and (150

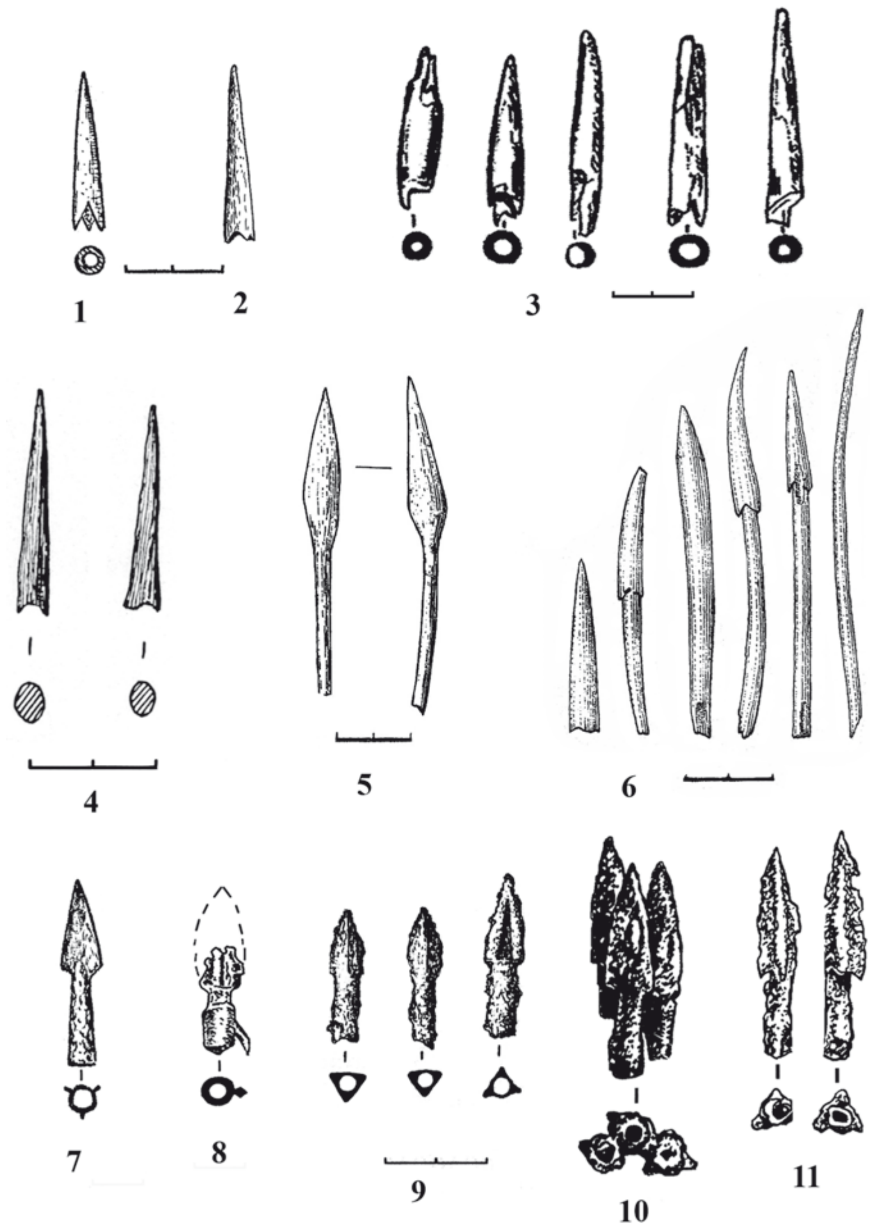


Fig. 8. The arrowheads made of other materials. Bone arrowheads: 1 – burial 1, kurgan 2 near Shiroke village; 2 – burial 2, kurgan 5 near Lvove village; 3 – burial 2, kurgan 1 near Volodymyrivka village; Wooden arrows: 4 – burial 1, kurgan 21 near Gyunivka village; 5 – burial 2, kurgan 13 of the BOF group; 6 – burial 3, kurgan 10 near Velyka Znamyanka village; Arrows with iron tips: 7 – burial 1, kurgan 2 near Shiroke village; 8 – burial 2, kurgan 1 near Kamkaly village; 9 – burial 50 near the village Skelki; 10 – burial 1, kurgan 12 near Glynoe village; 11 – burial 2, kurgan 12 near Glynoe village

specimens) in the burial 2, kurgan 6 near the village of Balabany (Transnistria) (Fialko 1987; 2011).

There are much fewer arrowheads made of other materials. *Bone arrowheads* (Fig. 8: 1-3) are recorded in sets, mostly with bronze once, in only 11 burials of all regional groups (in the Steppe in five graves, in Crimea in two, in Transnistria in two, and one grave in the Forest-Steppe and Don region each). There were from one to 18 items in one set. And in only one burial of the Crimean group (the village of Volodymyrivka, kurgan 1, burial 2), the set consisted of only five arrows with bone points. It is believed that bone points were intended for hunting.

Extremely rare are *wooden arrows* (Fig. 8: 4-6), recorded in nine burials of only two regional groups (five – in the Steppe and two – in Crimea) in combination with bronze tips arrows. And in only one burial (the village of Volodymyrivka, kurgan 1, burial 4) the set consisted of five wooden arrows. In the quiver from the burial 1, kurgan 5 near the village Nove, along with 82 bronze tips there were two wooden ones – round in cross section with small, pinned spikes (4.4 cm long). In a set of 24 bronze tips in the burial 2, of the kurgan 6 of the same burial mound, one wooden specimen was preserved. It was similar to the one described above, but slightly shorter (3.7 cm). Two integral arrows with two-bladed heads of rhombic shape come from the set of burial 2 of kurgan 13 of the BOF group (named after Bogdanovsk concentration plant). The length of their tip is about 5 cm, the total length is 8.5 and 9 cm. Such arrows are little known due to the poor preservation of wood.

Arrows with *iron tips* give a slightly different picture. These are usually three-bladed specimens with a long cylindrical socket (Fig. 8: 7-11). And usually, the sets here consisted of the same type of iron arrowheads. In the Steppe and Forest-Steppe groups they are found in rare complexes (six and two, respectively), in the Crimea they do not exist at all, and in Don and Transnistria regions they are much better represented. For example, in the Steppe group, three iron arrowheads were found in the burial 2 of kurgan 8 near the village of Ternivka; two specimens (together with five bronze ones) – in the burial 2 of kurgan 40 in Mamai-Hora burial mound; one specimen (among 16 bronze ones) is in the burial 6 of kurgan 10 in the Chortomlyk mound. In the Forest-Steppe – one iron tip (among 62 bronze ones) was found in the burial 2, kurgan 9 near the village Staryi Merchyk. The last one, which is the best preserved, is a three-bladed tip with a long cylindrical socket. Often the iron tips belong to an earlier time than the bronze arrows in the set. It is possible that such an archaic arrowhead was used here as a certain amulet.

In Don region such arrows are noted in 16 graves (out of 27), in eight exclusively with iron arrowheads, from one to 35 items, up to 84 in one of the cases (village Kolbino, kurgan 5, burial 1). Rates are even higher in Transnistria – here iron arrowheads are noted in 31 burials (out of 50), and in 18 of them arrows are exclusively with iron points. Moreover, all these graves were discovered in one necropolis near the village Glynoe. I should also note a few points regarding the sets of arrows from the last necropolis. Firstly, the dominance of iron arrowheads of the same type (in general, a tenfold increase in this burial

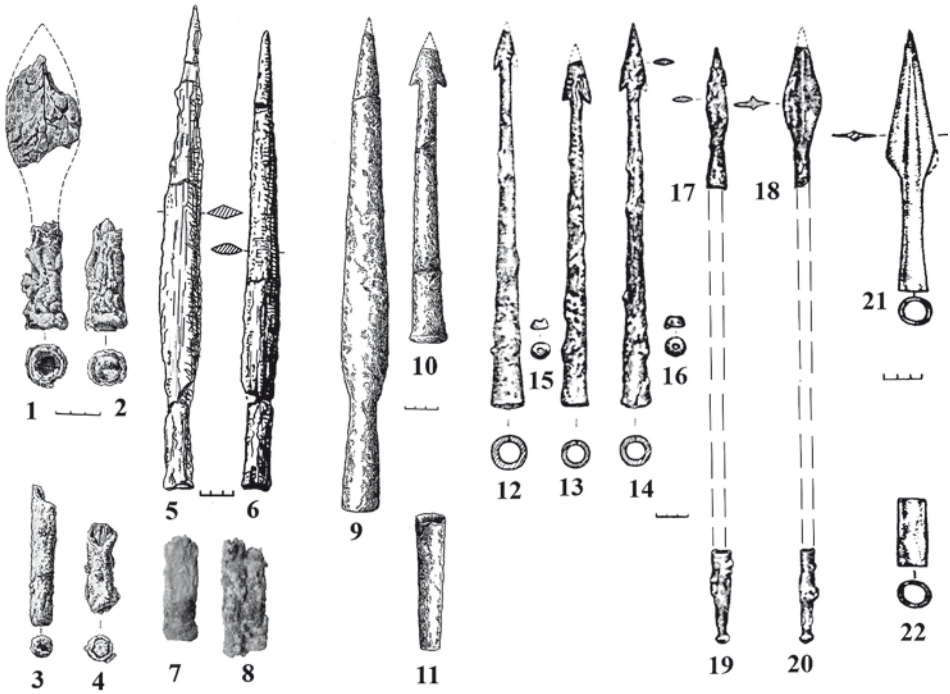


Fig. 9. Spears and darts from the graves of Scythian Amazons: 1-4 – burial 1, kurgan 10 near Velyka Znamyanka village; 5-8 – burial 2, kurgan 16 near the village Novopylypivka; 9-11 – burial 1, kurgan 1 near the village Kapulivka; 12-20 – - burial 1, kurgan 1 near the village Stebliv; 21-22 – the Dort-Oba kurgan

mound) (Telnov *et al.* 2016, 772). Secondly, such a small number of arrows in one set is surprising – from one to 11. Only in five graves this figure is slightly exceeded (in the kurgan 24 – 18 items, in the kurgan 103 – 19, in the kurgan 3 – 24, in the kurgan 45 – 28, in the kurgan 104 – 33 items). However, the number of arrows could be due to a certain social status of the deceased woman (Fialko 2015, 77). Thirdly, in the four female graves of this necropolis (kurgan 32; kurgan 38; kurgan 66 and kurgan 69), the arrows are clearly associated with injuries, as they are fixed in all cases in the chest area of the deceased. Besides no other weapons were found there. The interpretation of individual arrow finds could be quite ambiguous (Fialko 2019).

Regarding the arrows with iron tips, we can assume that their presence in the sights of two groups (in Don region and in Lower Dnipro territories) reflects the emergence of reinforced protective armor in the arms of the enemy.

The second position among the popular weapons belongs to **spears and darts**, with a quantitative predominance of the spears (3 to 1). Short spears with iron tips and end spikes or spear butt (weight fitted onto spear-shaft for balance) (Fig. 9: 1-9), with round in

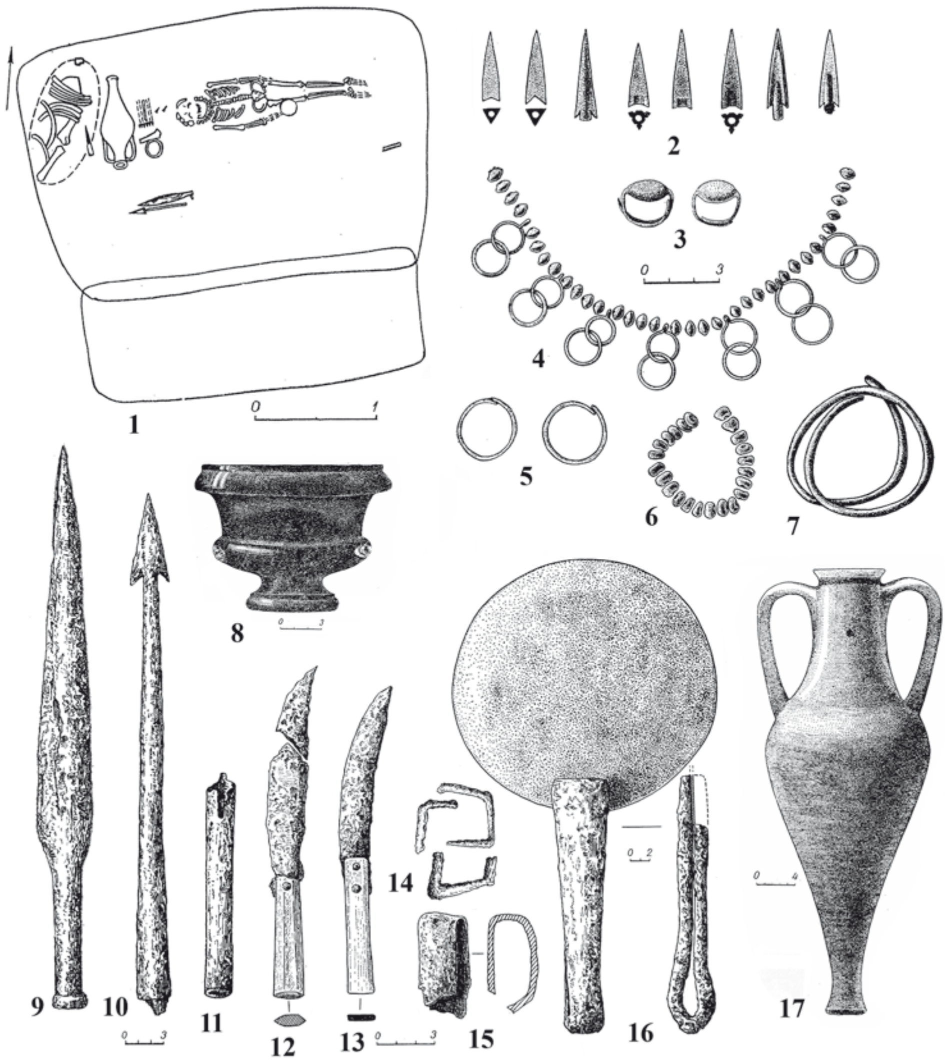


Fig. 10. The burial 1 of kurgan 13 near the village Kapulivka:
1 – the plan of the grave; 2-17 – the set of burial implements

section wooden shafts were used. The latter are rarely preserved in graves, mostly in fragments. At the same time, very often in robbed complexes the presence of a spear or a dart is evidenced by the cylindric caps (ends of the spears) left or lost by robbers (Fig. 9: 3-4; 7-8; 11). It is possible to determine the length of a spear or a dart due to the location of the tip and the end spike, found in situ in the grave. For example, the full length of the spear from the burial 1, kurgan 5 near the village Nove was 2.07 m (Fialko 1987, 174). Almost the

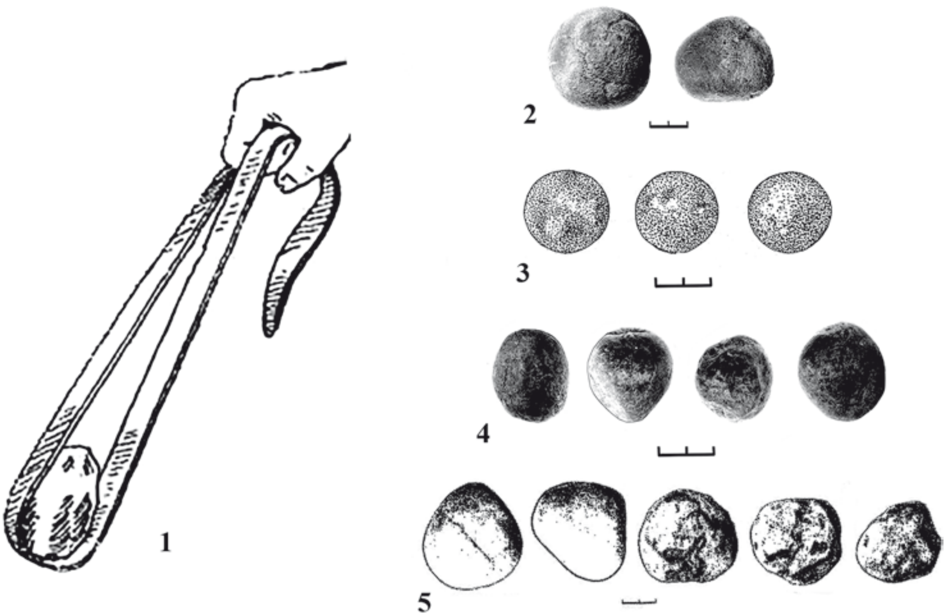


Fig. 11. The principle of slings functioning (1) and stone bullets from the graves of Scythian female warriors: 2 – burial 1, kurgan V near the urban settlement Velykyi Rohachyk; 3 – burial 3, kurgan 5 near the village Zelene; 4 – burial 12, kurgan 1 near the village Novomykolayivka; 5 – burial 7, kurgan 1 near the village Nove. Photo by O. Fialko

same length (2.1 m) were two spears from the burial of the kurgan 13 from the Stebliv burial mound (Skoryi 1997, 89). This fully corresponds to the size of ordinary Scythian spears and darts (Melyukova 1964, 43; Chernenko 1991, 133). Only one spear from the Dort-Oba kurgan (from Crimea) had a bronze tip (Fig. 9: 21), the rest had iron tips and butts. Most iron tips have sharp-leaved shape. They differ in the length of the socket, the edge of which is usually covered by a coupling (Fig. 9: 1-2). Spearheads were recorded in 83 (28%) Amazons burial complexes (including those where both, a spear and a dart were in the set). The cylindric ends by themselves (one or two) were found in 21 graves. According to the regional groups, the number of burials with spears is as follows: Steppe – 40, Crimea – 4, Transnistria – 5, Forest-Steppe – 7, Don region – 12. So almost every third female deceased was buried with a spear. The number of spears in one burial is one or two (in approximately equal proportions). In only two cases the woman had three spears (burial 2 of kurgan 6 near the village of Nove; burial 1, kurgan 22 near the village of Zolota Balka).

Darts – short spears with elongated tips of a stinger shape, were specially designed for throwing (Fig. 9: 10, 12-14). Quantitatively, they were much inferior to spears. This tendency is also characteristic for the Scythian weapons in general (Hrytsiuk 2009, 66). Darts

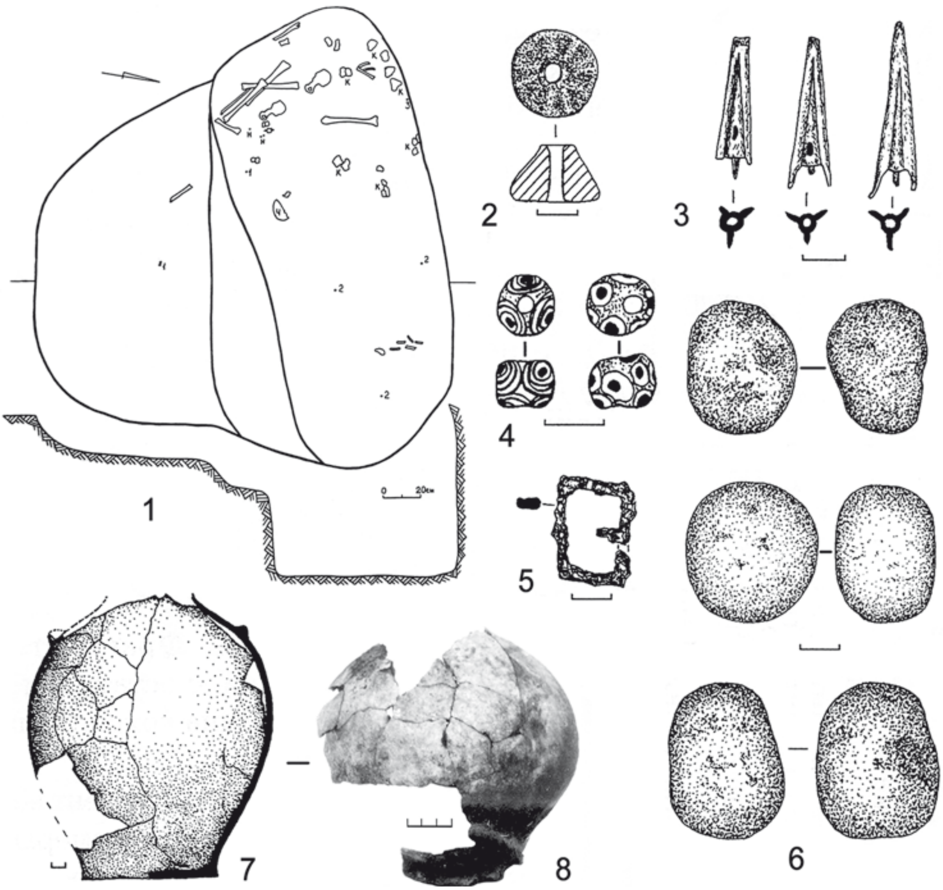


Fig. 12. The burial 14 from a burial ground near Skelki village:
1 – plan and section of the grave; 2-8 – the set of burial implements. After Popandopulo 2011, fig. 11

are noted only in 27 (9%) graves of Amazons. They were usually placed one by one in the grave. Exceptions are the burial 2 of kurgan 11 near the village Lvove, burial 1 of kurgan 15 near the village Zolota Balka and burial 1 of kurgan 16 near the village Durovka (two darts found in each burial) and kurgan 13 of the Stebliv burial mound, where three darts were found in a set with spears (Fig. 9: 12-20). Only in one burial there were three darts (burial 1 from kurgan 3 near the village of Dudchany). In almost half of the cases, the darts were paired with a spear (Fig. 10). The wooden handles of most spears and darts at the lower end had a cylindrical or conical end (Fig. 9: 11). However, this part of the weapon was optional. The design features as well as tactical and technical characteristics, submitted to the functional purpose of the weapon, indicate that the Amazons preferred metal spears and darts.

The tips of spears and darts were often kept in leather or cloth *covers*, tightened with a lace with a vorvorka (sort of a clasp, that usually looks like a pendant button). The remains of such a cover with a bone vorvorka-button are recorded, for example, in the burial 1, kurgan 5 near the village Nove; two iron vorvorkas on dart sockets – in the burial 1, kurgan 13 near the village Stebliv (Fig. 9: 15-16).

The Amazons also used a sling (or a slingshot), another type of projectile weapon designed for long-range combat. The principle of its functioning is that the soldier twisted the sling and, by releasing one of the belts, sent a stone bullet towards the enemy (Fig. 11: 1). The sling-bullets exclusively are kept in the burials (Fig. 11: 2-5). Only in one (burial 7, kurgan 11 near the village Lvove) there were the remains of a leather belt, which could correspond to a sling stone. “Bullets” of more or less round shape were made of different types of stone and differed in size. Scythian sights are known for such stones ranging in size from a walnut to a chicken egg, or even an apple (Melyukova 1964, 68). In women’s burials such stones were rather small – 5-6 cm in diameter. Stones were found in 31 (10%) burial complexes of the Amazons (13 in the Steppe, 3 in Transnistria, 9 in the Forest-Steppe, 6 in Don region, in Crimea they are absent). There were usually one to five stones in the set (Fig. 12). And only in one case (burial 1, kurgan 1 in Elizavetovsky burial mound) was a set of 17 stones. However, the separation of the slings from the general mass of stone finds is somewhat complicated, as they are similar to those that served as heating elements. Slingshots were used by both infantry and cavalry. The unpopularity of this type of weapon in the female environment may be due to its great weight.

The earliest graves of the Amazons date from the second half of the 7th – beginning of the 6th centuries B.C. Thus, burial complexes of the Scythian Amazons both in the territories of the nomadic dwellings at the beginning of the Iron Age, and in the areas controlled by the Scythians (or border areas), date from a wide range – from the second half of the 7th to the 2nd centuries B.C. However, the main group of these tombs is dated 4th century B.C.

CONCLUSIONS

The represented review of the weapon allowed to draw the following conclusions:

1. Scythian Amazons were armed with projectile weapons – first of all, bows and arrows, relatively short spears and darts, and slingshots.

2. Weapons of hand-to-hand combat (*i.e.* stabbing and slashing types of weapon) – swords and daggers, battle axes, polearms were used much less by women.

3. Bow, that was the most popular type of weapon for the Amazons, was used both on foot and on horseback. Shooting a rider in motion on a moving target required remarkable skills. Long-term training was necessary to achieve a long-distance targeting of the enemy, as well as the accuracy of shooting (Chernenko 1981, 115; Hrytsiuk 2009, 64).

4. In general, the weapons of the female warriors fully corresponded to those in the arsenal of the Scythian army. However, the Amazons clearly preferred weapons intended for contactless combat.

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FIELD SURVEY AND MATERIALS

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A NEW FIND OF A MESOLITHIC ANTLER AXE FROM WESTERN POLAND

ABSTRACT

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In 2017, a man fishing in the Oder River accidentally discovered an antler-base axe in the village of Domaszków, Lower Silesian Voievodship. In-depth study of the axe included analysis of the traces on its surface, radiocarbon dating and paleogenetic analysis, and concluded with the tool's conservation. Most of the traces casting light on the techniques used in its crafting had been eroded by intensive water action. The axe was made from the unshed red deer antler. Among the preserved marks we note pointed depressions made during the separation of the antler beam, traces where the brow and bay tines were cut off, and concentric rings from the drilling of the perforation. A small scar on the axe's blade was identified as resulting from the tool's use. Radiocarbon dating placed the origins of the axe in Boreal period. Such tools are known from western Poland and the north-western European Mesolithic as well as from the Neolithic and the Early Bronze Age.

Keywords: antler-base axe, Mesolithic, Boreal period, Lower Silesia, microscopic analysis
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INTRODUCTION

Knowledge of the Mesolithic in the lowland segment of south-west Poland comes chiefly from sites located on top of sandy deposits, formed during deglaciation and through dune-formation processes (Bagniewski 1987). Such sedimentation conditions only rarely allow for the preservation of items made of organic materials, hence our knowledge of the material culture of Mesolithic hunter-gatherers is based chiefly upon lithics. It is rare for sites with organogenic sediment to be explored (Pobiel, site 10, Góra district), these yielding well preserved Mesolithic artefacts from organic materials (Bagniewski 1990; 1992). Hence every new find of a Mesolithic artefact made from bone or antler in this area attracts understandable interest.

On 30 September 2017, Tomasz Piotrowski, resident of Krzydlina Wielka (Wołów district), was fishing in the Oder River. During this angling expedition he found an antler axe (Fig. 1) in shallow water next to the riverbank. The discovery was made within the limits of the village of Domaszków (Wołów district) in the Lower Silesian Voievodship (Fig. 2). After finding the artefact, he wrapped it in a damp cloth, thus protecting the find from rapid dehydration, a process which almost certainly would have led to serious damage, *i.e.* the antler cracking and the surface flaking. On 12 October 2017, Mr Piotrowski handed over the find to the Provincial Heritage Monuments Protection Office in Wrocław. The authors of this paper make use of this opportunity to express their gratitude to the finder for his quick thinking which protected the artefact from destruction.

METHODS

The type of artefacts discussed in this paper appear in the pertinent literature under various names, most commonly "axe" – for items where the blade is parallel or set at an oblique angle to the axis of the handle, or"mattocks" or "adzes" when the blade is perpendicular to the axis of the handle" (Smith 1989; Elliott 2015; Orłowska and Osipowicz 2017). This specific specimen fits the definition of "axe". The item was studied and analysed with an eye to the fullest discovery of its "life history", from the moment it had been made, through its use, discarding, up to post-deposition changes. Thus we strived to identify, during analysis, characteristic traces and microtraces made at various stages of the artefact's existence. The axe's surface was subject to both macroscopic and microscopic examination, the latter with an optical microscope Olympus SZX9 stereomicroscope (6.3-57×) and a Hirox 3D Digital Microscope RH-2000 at the Laboratory for Archaeometry and Archaeological Conservation of the University of Wrocław Institute of Archaeology. The next stage involved the taking of two samples from the part next to the burr – one for ^{14}C dating, the other for paleogenetic analysis. Radiocarbon dating was carried out at the Poznań Radiocarbon Laboratory, while paleogenetic analysis was done at the Laboratory

Fig. 1. Domaszków. Antler axe.
Photo T. Gąsior

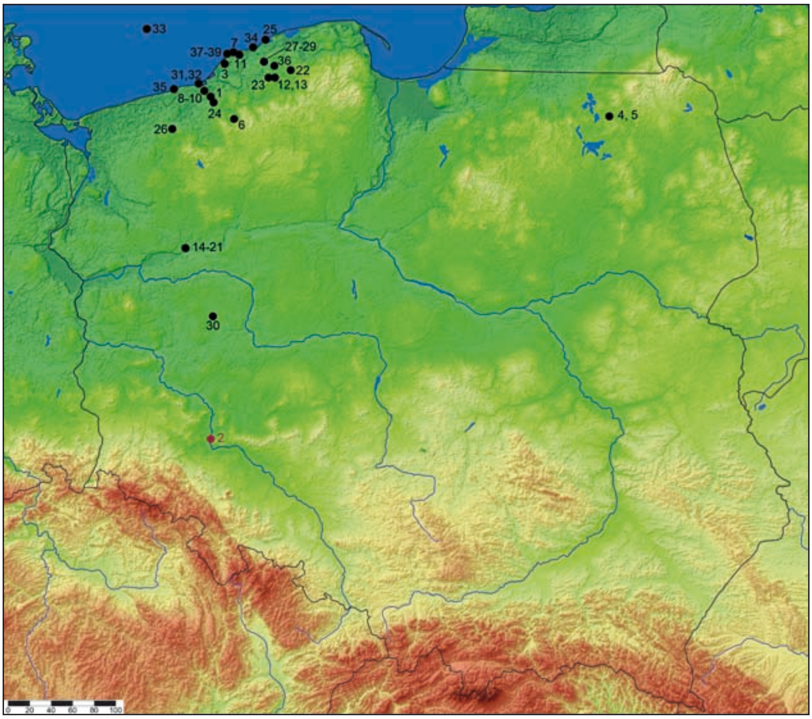

Fig. 2. Antler-base axes and adzes in western and northern Poland (numbering as per Table 1). Computer processing by N. Lenkow

of Paleogenetics and Conservation Genetics Centre of New Technologies of the University of Warsaw. Finally the axe underwent conservation treatment at the Laboratory for Archaeometry and Archaeological Conservaon of the University of Wrocław Institute of Archaeology.

Dimensions of antler axes from sites inside Poland's current borders are given partly as listed in source materials (Kabaciński *et al.* 2008; Ilkiewicz 2010) and partly from measuring drawings in said publications (Fiedorczuk 1995). Width was measured on the plane where the perforation is located; maximum width was used, this occasionally including stumps of removed tines.

DESCRIPTION

The axe was made from the right antler of a red deer *Cervus elaphus* Linnaeus, 1758. It is representative of the antler-base axe type (Fig. 1). Its length is 18.79 cm, width in the craniocaudal plane is 5.8 cm and in the medial-lateral plane 4.75 cm, and circumference –

17 cm. This size places the antlers used for the crafting of this artefact among the smallest specimens known from Quaternary sites (Fig. 3), including antlers from the Holocene (Stefaniak 2017). However, in this case the tool's dimensions might have been significantly decreased through abrasion during its depositing in water.

The axe was made from an antler of an animal killed on a hunt or dead from other causes – as evidenced by the preserved stem. During crafting the brow and bay tines were removed – leaving visible marks on the item's sides. A perforation was made in the medial and lateral sides of the beam, with internal diameter of 2.57-2.66 cm, with the external width of the opening being 3.32-3.55 cm. The distal section of the beam was used for the formation of a blade, set at an angle to the axis of the opening. The blade's length was 5.63 cm, while the width was 3.89 cm. The thickness of the compacta alongside the blade varies from 0.22 to 0.37 cm. Under the Smith (1989) classification such specimens are classified as Type B, described as "laterally perforated antler-base mattocks", versus Type A where the perforation is in the same plane as the tines.

The object is heavily eroded, with all surfaces and edges evidently polished as a result of natural processes. In the blade section – as well as where the brow and bay tines were cut off the spongiosa was partly removed by abrasion, leading to the formation of pits with smooth sides and bottom (Fig. 1). As the axe was found in the Oder River, it may be assumed that it owes this state of preservation to being intensively worked over by flowing water. However, this process does not extend to the scar on the blade where the scar's edges along the bottom are evidently uneven. Microscopic examination of the blade additionally revealed small, flat microchippings doubtlessly formed at the end of the item's depositing in the river. These traces are fresh and stand out versus the surrounding surface of the item, which in turn show significant polishing. The blade and antler beam sections show significant cracks, that are the result of partial dehydration after the artefact's discovery.

Traces made during the manufacture of the item and its subsequent usage are preserved to a minimal degree, this being due to the general condition of the artefact. The first stage of manufacture involved the removal of the antler from the animal's skull, this leaving scars in the proximal section of the artefact, where a fragment of a pedicle is still preserved, and pointed depressions in its base (Fig. 4: 1). It should be assumed that at this stage the surface of the antler was not subjected to modifications. Microscopic examination revealed the existence of the original surface of the antler, subjected to polishing by water. Only the burr might have been modified by the craftsman, yet no traces of cutting or of pearling were found. The abraded traces of removed tines (irregular depressions on the edges) point to the compacta being probably sawed and then the tines broken off (Fig. 4: 2). The perforation was drilled from both sides.This activity left characteristic concentric traces (Fig. 4: 3). The perforation's perimeter and part of its internal section are smoothed and polished through use and water action. On one side the perforation widens towards the base (Fig. 1), this probably being due to damage later smoothed over during the item's depositing in an aquatic environment.

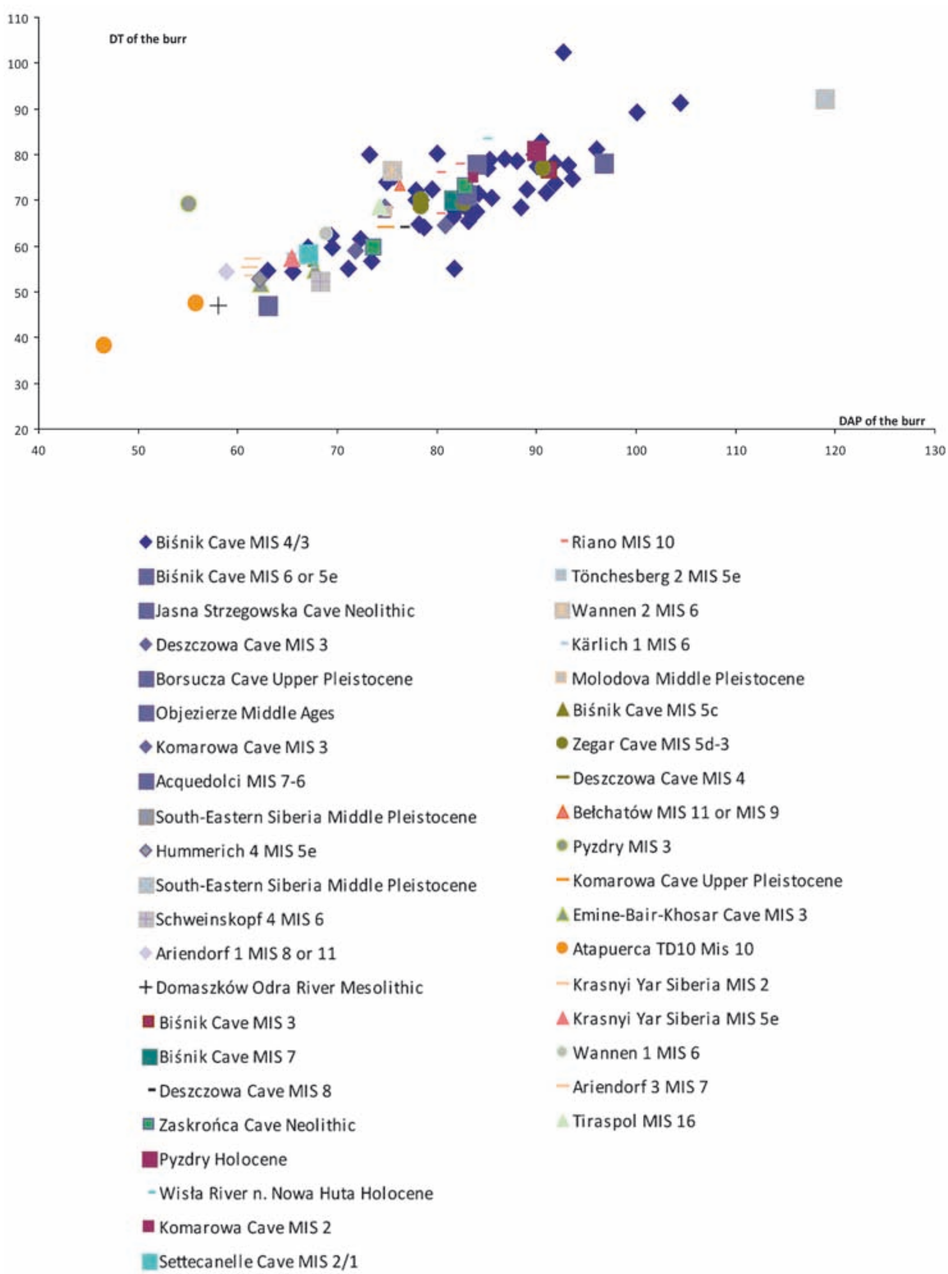

Fig. 3. Comparison of measurements of the burr in *Cervus elaphus* Linnaeus, 1758 from Quaternary localities of Eurasia. Domaszków – black cross. Prepared by K. Stefaniak

Fig. 4. Domaszków. Traces on axe surface:
1 – pointed traces on stem; 2 – remnants of brow tine; 3 – concentric marks in perforation; 4 – nick on axe blade. Photo T. Gąsior (1-3), M. Diakowski (4), computer processing by N. Lenkow

The blade was formed obliquely to the antler's shaft. No traces of the action are visible, having been removed due to the deposition. However, despite post-depositional polish, a small depression is preserved in part of the blade (Fig. 4: 4), possibly a fragment of the use scar (see below).

The sample taken from the axe was dated to 8510 ± 50 BP (Poz-101613), a date almost identical to ones of the axes from Krzyż Wielkopolski, site 7 (Czarnków-Trzcianka district) (Kabaciński *et al.* 2008). Hence it may be said that the antler from which the artefact had been crafted comes from 7600-7500 cal BC, *i.e.* the younger phase of the Boreal period.

DNA analysis was used in an effort to establish paleogenetic information. DNA was extracted from the bone powder and transformed into two independent double-stranded and double-indexed sequencing libraries. Target enrichment of the mitochondrial DNA was performed using hybridization in solution with the bait consisted of modern DNA of red deer (*Cervus elaphus*) and elk (*Alces alces*). High-throughput sequencing was performed on the NextSeq Illumina platform. The two sequencing approach showed that the DNA is very poorly preserved and not suitable for analysis.

CONSERVATION OF THE FIND

Evaluation of the state of preservation of the find at the point of its handover established that it was wet, waterlogged, with visible cracking of its surface (Fig. 5). Preservation efforts were preceded by the taking of samples for specialist archaeometric analysis (*e.g.* cutting out a fragment for radiocarbon dating) and paleogenetic analysis.

The programme of preservation tasks developed for the axe included a dehydration process combined with structural reinforcement to prevent uncontrolled shrinking. As a result the surface of the artefact should be hard and with a light gloss (due to use of resin).

Specific conservation tasks included washing off dirt with tap water and a soft brush, and then drying the artefact with an acetone solution. The axe was immersed several times in a water-acetone wash, with increasing concentrations of acetone. Structural impregnation was effected using a Paraloid B72 acetone solution with gradually increased concentration. Impregnation with resin began with a 1% solution, the concentration being increased on a weekly basis. Impregnation was concluded when the Paraloid concentration reached 30%. The reason behind use of such a highly concentrated solution were the visibly growing cracks that were observed from the onset of the impregnation process. Here, the artefact was protected with hydraulic steel clasps, clamped on top of protective covers made from a soft polymer material. The clasps remained clamped around the artefact throughout the slow-dry process, yet failed to protect it from the deepening of the cracks. The surface of the axe, glossy from the use of Paraloid, was matted using mechanical means as well as with the use of non-acidic wax Cosmoloid H80 (Fig. 1).

Fig. 5. Domaszków. The axe before preservation (cracks identified with arrows; marked area – source of samples). Photo B. Miazga, computer processing by N. Lenkow

CULTURAL AND CHRONOLOGICAL CONTEXT

Deer antler axes are rare finds at sites located in Poland (Fig. 2, Table 1). Specimens manufactured from the sections next to the antler stem have been found at only two excavated sites: at Krzyż Wielkopolski, site 7 (Kabaciński *et al.* 2008; Kabaciński 2009) and Dudka (Giżycko district), site 1 (Fiedorczuk 1995). A common feature of these finds is the material from which they are made, the existence of a perforation and one-side bevelled blade (Table 1). The axes from Krzyż Wielkopolski are more or less of equal age to the Domaszków axe, whereas one of those from Dudka is unquestionably younger, dating to the 2nd half of the 7th millennium cal BC.

Forms of similar type are commonly found in a Mesolithic context across north-western Europe (Mathiassen 1948; Clark 1975; Smith 1989; Elliott 2015). In Germany, besides the well documented finds yielded by excavations at Hohen Viecheln (Mecklenburg) and Friesack (Brandenburg), site 4 (Schuldt 1961; Gramsch 1973; Pratsch 1994), also numerous stray finds exist (Gramsch 1973, 40-41; Heidelk-Schacht 1984; Cziesla and Pettitt 2003). The well stratified finds from Friesack, site 4 point to such axes being encountered

Table 1. Antler-base axes and adzes from western Poland

No.	Site	District	Length [cm]	Breadth [cm]	Thickness [cm]	Diameter of perforation [cm]	Angle (blade vs. axis of perforation)	Cast off	Radiocarbon date BP	Calibration (2σ) BC	Remarks	Reference
1	Bonin	Koszalin	13.5	?	?	?	almost parallel	+	-	-	stray find	Ilkiewicz 2010, 24, Fig. 4: 1
2	Domaszków	Wołów	18.8	6.0	4.8	2.6-2.7	acute	-	8510±50 (Poz-101613)	7599-7500	stray find	-
3	Drozdowo	Sławno	17.0	7.1	5.8	2.5-2.8	paralel	+	-	-	stray find	Ilkiewicz 2010, 21, Fig. 5: 1
4	Dudka, site 1, layer B5	Giżycko	14.1	5.7	4.6	2.3	acute	?	-	-	in a small pit; next to a Wieliszew point	Fiedorczuk 1995, 51, Fig. 4: e
5	Dudka, site 1, cut III	Giżycko	14.6	6.1	5.4	2.3	*ca* 90°	?	7420±80 (Gd-5575)	6435-6097	date from burnt pine next to the axe; an X-shaped mark	Fiedorczuk 1995, 51, Fig. 4: f
6	Gołogóra	Koszalin	?	?	?	?	90° ?	?	-	-	stray find	Ilkiewicz 2010, 24
7	Jarosławiec	Sławno	14.0	5.7	4.2	2.5	acute	+	-	-	stray find	Ilkiewicz 2010, 24, Fig. 6: 1
8	Koszalin	Koszalin	14.5	6.6	?	?	*ca* 90°	+	-	-	stray find	Ilkiewicz 2010, 25, Fig. 4: 4
9	Koszalin	Koszalin	21.0	6.7	4.1	?	90°	+	-	-	stray find	Ilkiewicz 2010, 25, Fig. 4: 6
10	Koszalin District	Koszalin	?	?	?	?	90° ?	?	-	-	stray find	Ilkiewicz 2010, 25
11	Królewice	Slawno	15.3	7.4	4.7	2.3-2.5	acute	+	-	-	stray find	Ilkiewicz 2010, 22, Fig. 5: 2
12	Krzynia	Słupsk	16.0	9.0	6.0	2.4-2.5	acute	+	-	-	stray find	Ilkiewicz 2010, 25, Fig. 6: 3
13	Krzynia	Słupsk	?	?	?	?	90° ?	?	-	-	stray find	Ilkiewicz 2010, 25
14	Krzyż Wielkopolski, site 7	Czarnków-Trzcianka	11.3	7.9	5.8	2.7-2.9	*ca* 90°	-	-	-	-	Kabaciński *et al.* 2008, Tab. 1, Fig. 4

15	Krzyż Wielkopolski, site 7	Czarnków-Trzcianka	11.9	9.5	6.6	2.6	*ca* 90°	-	-	-	-	Kabaciński *et al.* 2008, Tab. 1, Fig. 5
16	Krzyż Wielkopolski, site 7	Czarnków-Trzcianka	15.5	9.7	5.3	3.0-3.6	acute	+ (?)	-	-	-	Kabaciński *et al.* 2008, Tab. 1, Fig. 6
17	Krzyż Wielkopolski, site 7	Czarnków-Trzcianka	18.7	7.4	5.3	2.6-3.3	*ca* 90°	-	-	-	-	Kabaciński *et al.* 2008, Tab. 1, Fig. 7
18	Krzyż Wielkopolski, site 7	Czarnków-Trzcianka	21.6	7.2	6.3	2.4-2.8	*ca* 90°	+	-	-	-	Kabaciński *et al.* 2008, Tab. 1, Fig. 8
19	Krzyż Wielkopolski, site 7	Czarnków-Trzcianka	12.1	7.3	6.4	2.9-3.3	acute	- (?)	-	-	-	Kabaciński *et al.* 2008, Tab. 1, Fig. 9
20	Krzyż Wielkopolski, site 7	Czarnków-Trzcianka	13.8	7.8	4.9	2.8-3.1	acute	- (?)	-	-	-	Kabaciński *et al.* 2008, Tab. 1, Fig. 10
21	Krzyż Wielkopolski, site 7	Czarnków-Trzcianka	15.2	7.5	4.7	2.8	acute	+	1. 8520±50 (Poz-12336) 2. 8530±50 (Poz-12593) 3. 8760±50 (Poz-12337)	1. 7602-7505 2. 7608-7505 3. 7974-7606[a]	axe; fragment of wooden shaft (the third date)	Kabaciński *et al.* 2008, Tab. 1, Fig. 12
22	Łupawa	Słupsk	23.0	6.0	5.5	2.3	acute	-	-	-	stray find	Ilkiewicz 2010, 22, Fig. 3
23	Łysomiczki	Słupsk	15.9	8.5	5.3	2.8	*ca* 90°	+	-	-	stray find	Ilkiewicz 2010, 24-25, Fig. 6: 2
24	Manowo	Koszalin	17.0	?	?	?	?	?	-	-	stray find	Ilkiewicz 2010, 21
25	Rowy, site 1	Słupsk	13.0	8.0	?	2.6-2.9	acute	+	-	-	stray find	Ilkiewicz 2010, 26, Fig. 4: 2
26	Sławoborze	Świdwin	18.7	3.1 ?	?	3.1 ?	90° ?	?	-	-	stray find	Ilkiewicz 2010, 26
27	Słupsk	Słupsk	22.5	8.3	6.4	2.1-2.4	acute	+	-	-	stray find	Ilkiewicz 2010, 22, Fig. 5: 3
28	Słupsk, site 29 **(30)**	Słupsk	12.5	7.3	4.3	3.0	almost parallel	+	-	-	stray find	Ilkiewicz 2010, 22, Fig. 5: 4
29	Słupsk, vicinity	Słupsk	22.3	6.8	9.0	2.5-3.5	acute	+	-	-	stray find	Ilkiewicz 2010, 23, Fig. 5: 5

Table 1.

No.	Site	District	Length [cm]	Breadth [cm]	Thickness [cm]	Diameter of perforation [cm]	Angle (blade vs. axis of perforation)	Cast off	Radiocarbon date BP	Calibration (2σ) BC	Remarks	Reference
30	Troszczyn	Nowy Tomyśl	15.6	8.6	6.1	2.8	90°	-	6610±40 (Poz-15119)	5619-5488	stray find	Goslar *et al.* 2006, 8-9, Figs 5, 6
31	Unieście	Koszalin	10.5	5.2	3.8	2.2	90°	+	-	-	stray find	Ilkiewicz 2010, 26, Fig. 6: 4
32	Unieście	Koszalin	?	?	?	?	?	?	-	-	stray find	Ilkiewicz 2010, 23
33	unknown site	-	?	6,7	5,9	?	*ca* 90°	+	-	-	stray find	Orłowska and Osipowicz 2017, Fig. 7
34	Ustka, site 2	Słupsk	11.5	ca. 8.0	?	?	90°	+	-	-	stray find	Ilkiewicz 2010, 26
35	Ustronie Morskie	Kołobrzeg	16.0	5.6	3.5	?	90° ?	?	-	-	stray find	Ilkiewicz 2010, 26
36	Warblewo	Słupsk	12.9	6.4	5.5	2.6	acute ?	+	-	-	stray find; repaired	Ilkiewicz 2010, 23, Fig. 5: 6
37	Wicie, site 1	Sławno	14.8	5.4	4.1	2.2-2.5	parallel	?	-	-	stray find	Ilkiewicz 2010, 23, Fig. 5: 7
38	Wicie, site 1	Sławno	19.1	6.4	4.9	1.9	acute	+	-	-	stray find	Ilkiewicz 2010, 24, Fig. 5: 8
39	Wicie, site 1	Sławno	13.9	6.8	5.1	3.0-3.3	parallel	+	-	-	stray find	Ilkiewicz 2010, 24, Fig. 5: 9

[a] 93.2% probablity

in layers of that site, starting from the late Preboreal/Early Boreal (*ca* 9400-9200 radiocarbon years BP) up to the final Boreal and early Atlantic period (*ca* 8200-7000 radiocarbon years BP) (Pratsch 1994, 33-34, Fig. 14).

Finds from different regions of Europe show that axes crafted from the base segment of deer antlers are also present at sites dated to the late Mesolithic and later, to the Neolithic, in spite of the growing popularity of T-shaped axes (Smith 1989). The specimens from Altfriesack-Bützsee (Ostprignitz-Ruppin) were radiocarbon dated to 6910 ± 50 BP (OxA-8746) and 6855 ± 50 BP (OxA-8745) (Cziesla and Pettitt 2003, 26, Fig. 2: 1, 3). Hence it may be assumed that such axes were in use around 5900-5650 cal BC, *i.e.* in the late Mesolithic, during the older phase of the Atlantic period. Such dates are in line with radiocarbon dating results for the youngest layer with an antler-base axe at Friesack, site 4 (*Zeitstufe IV*) (Pratsch 1994, 26). Both examples, one larger, over 22 cm long (broken blade), the other shorter – 17.3 cm do not have the pearling removed and areas where the tines had been removed were less attentively worked. The adze from Troszczyn (Nowy Tomyśl district), held in the collection of the Archaeological Museum in Poznań is even younger, being dated to 6610 ± 40 (Poz-15119) (Goslar *et al.* 2006). Hence it may be placed in the 5600-5500 cal BC period. It is worth mentioning that none of the pearling has been removed – besides from the area around the blade; also, locations of where the brow and bay tines had been removed are very clearly discernable. Nevertheless, the degree of attention given to working the surface or eliminating the marks of removed tines are not characterising features of older axes from the Boreal period – here one may point to the series of artefacts of thus type from the site 7 at Krzyż Wielkopolski (Kabaciński *et al.* 2008).

Other axes from western Poland are stray finds, lacking in broader context and precise dating; these finds may be connected with either the Mesolithic or Neolithic (Ilkiewicz 2010). In central and south-east Poland forms of this type, at times differing in shape of head (button-shaped) or perforation (square) are occasionally found in a Middle Neolithic context (Kempisty 1958; Gajewski 1969; Gumiński 1989; Grygiel 2008).

Examination of marks on the surface of the axes from Krzyż Wielkopolski, site 7 and traces from their crafting provides an insight into the details of how they were made (Kabaciński *et al.* 2008, 251-266). Both shed and unshed antlers were used. The tines were removed by first making a groove in the antler and breaking it off. The groove itself was made in one of two manners: a. sawing (two axes from sheds); b. faceting with a flint tool (six axes from kills). The faceting technique was universally known across the north-west European Mesolithic, yet the axes from Krzyż Wielkopolski, site 7 stand out by having the groove not going all around, but being made only on the two opposite sides of the tine. The perforations (*ca* 2.5-2.8 cm diameter, wider in axes made from sheds) were made with a bow drill more or less at the height of the brow tine. The blade was formed by scraping with a stone tool. In the specimens from Friesack, the tines had been removed in similar manner (Pratsch 1994, 21). Two methods of preparing the surface before the holes were made were noted: removal of part of the compacta through strikes or by grinding. Then the entrance to the opening was formed, at both ends, and the spongiosa removed, either by chiselling or drilling (Pratsch 1994).

FUNCTION

Implements made from the proximal portion of a red deer antler and with a perforation belong to one of two main types: i. with a blade parallel to the handle (axes); ii. with a blade perpendicular to the handle (adzes/mattocks) (Smith 1989; Riedel *et al.* 2004). The specimen described herein belongs to the widely encountered intermediary group – the blade is at an angle to the handle; it seems that this variety is closer in functionality to axes.

Axes and adzes found in western Poland are 10.5-23.1 cm long (Table 1, Figs 2, 6). Analogous Neolithic and Bronze Age finds from the Leine river valley, near Hannover, also come in varied sizes – 10-23.35 cm length and 3.75 or 4.75 cm diameter at the base (Riedel *et al.* 2004, 201). Here one should point out that finds from those two collections are in the same length range – this being dictated by deer antler morphology and the implement's functionality. The maximum length is limited by the need to form the blade below the antler's trez tine. Minimal length in turn is determined by the distance between the perforation used to attach the handle from the antler's base on one hand, and from the blade on the other – these dimensions dictating the item's functionality. This gives rise to the question – what were the drivers for these different dimensions? Do these differences stem from implements of different size being crafted for different tasks? Or is the difference in size a result not of their intended use, but of the dimensions of available raw materials? It

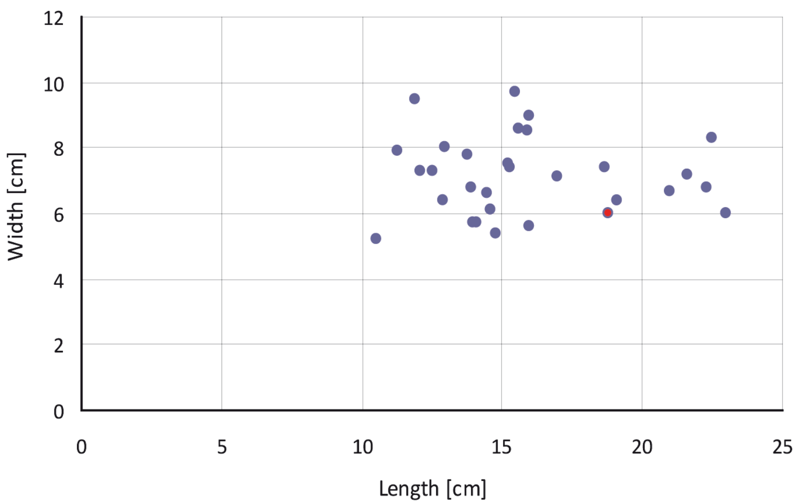

Fig. 6. Length and width diagram of axes and adzes from western and northern Poland (see Table 1, Domaszków axe as a red circle). Prepared by T. Płonka

also is possible that the shorter axe lengths are the result of longer usage – *i.e.* of being shortened at every repair of the blade. The aforementioned diameters are probably the outcome of conscious selection of material with parameters meeting some criteria used by the craftsmen.

In older literature – and going by macroscopic examination results, antler axes were considered as being principally earth digging tools, although capable of serving other roles as well (Smith 1989, 281-283). The results of analysis of the working surfaces of the axes, combined with experimental archaeology and examination of its effects, allow us to shed more light on the use of such a type of axe (Jensen 1991; Pratsch 1994, 26, 27; Orłowska and Osipowicz 2017). We may now affirm that these were indeed multitask implements. The axes could be used for many tasks: working wood, working leather, digging, possibly also for hewing ice holes. The use of such axes for working wood was proven by results of analysis of microscopic fragments preserved in the spongiosa, in the axes' blades (Riedel *et al.* 2004). These fragments were identified as coming from a deciduous tree subjected to being worked with the axe. Not much more was identified, as antler is quite resistant to being struck against wood. Additionally, different tasks occasionally produce very similar traces on tools. In the case of the Domaszków axe, the entire surface of the find was transformed by the conditions of its depositing – *i.e.* being transported by water had polished its surface. The sole trace of use seems to be a small scar on the blade, probably made before the artefact was deposited in the river, as it is polished to same degree as other sections of the axe (Fig. 4: 4). This only trace of use makes it difficult to draw any conclusions as to what activity had caused this scar. It could just as well have been the side effect of working soft wood, or digging in not very stony soil, or when hewing an ice hole (Orłowska and Osipowicz 2017, 107-109, Fig. 3).

CONCLUSION

The antler axe discovered in the Oder River proves that tools of this type were used in south-west Poland during the early Mesolithic. Similar tools are associated with the north-western circle of the Mesolithic, in Polish literature known as the Komornica culture (complex) or Komornica-Duvensee complex. The Domaszków artefact is related to the axes excavated at Krzyż Wielkopolski, site 7, and also is chronologically co-extant. The Domaszków axe, similarly to other artefacts of this type, was most likely extensively used for everyday activities such as working wood or digging. Unfortunately, not many traces of use have been preserved on the working edge. The circumstances of its deposition are not clear – it might have been eroded out from the layers of a Mesolithic site somewhere upriver and brought by the river current to the shoals where it was noticed by the angler.

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ENEOLITHIC FLAT AXE FROM RACIBOROWICE, SITE NO. 7, BIAŁOPOLE COMMUNE, CHEŁM DISTRICT

ABSTRACT

Bronicki A. 2022. Eneolithic flat axe from Raciborowice, Site No. 7, Białopole commune, Chełm district. *Sprawozdania Archeologiczne* 74/2, 111-138.

This study is a contribution to research on copper metallurgy in the early Eneolithic (= Chalcolithic). The axe was discovered as a "single" artefact. It represents the category of flat axes with a convex cutting edge. The metallurgical mass consist of "pure" copper, or it may contain a small admixture of silver. The Raciborowice specimen corresponds well to the Szakálhát type, the Sárazsadány variant, and specifically to the two Budapest-Békásmegyer tools. According to Albert Schmitz's classification, the tool from Raciborowice belongs to category 5 or to its variant marked as 6 (Beilform 5, 6). Categories 5 and 6 are dated to the early Eneolithic: from the transition of phase Ib to IIa, the entire phase II, up to phase IIIa. Their concentration occurs in Hungary and Slovakia, where are recorded in the Bodrogkeresztúr culture graves. The analysed artefact, should probably be related to the Lublin-Volhynian culture.

Keywords: early Eneolithic, coper flat axe, import, Lublin-Volhynian culture, eastern Lublin region
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At the beginning of 2010, the collection of the Chełm Land Museum increased by the addition of seven archaeological artefacts, donated as the result of an administrative decision of the Lublin Voievodship Conservator of Monuments. Among them was a massive flat axe with a convex cutting edge. In the appendix to the conservation decision, it was aptly called a „copper axe (?), possibly Eneolithic". The place of its discovery, as well as other artefacts, has not been determined. It was suspected that they originate from ar-

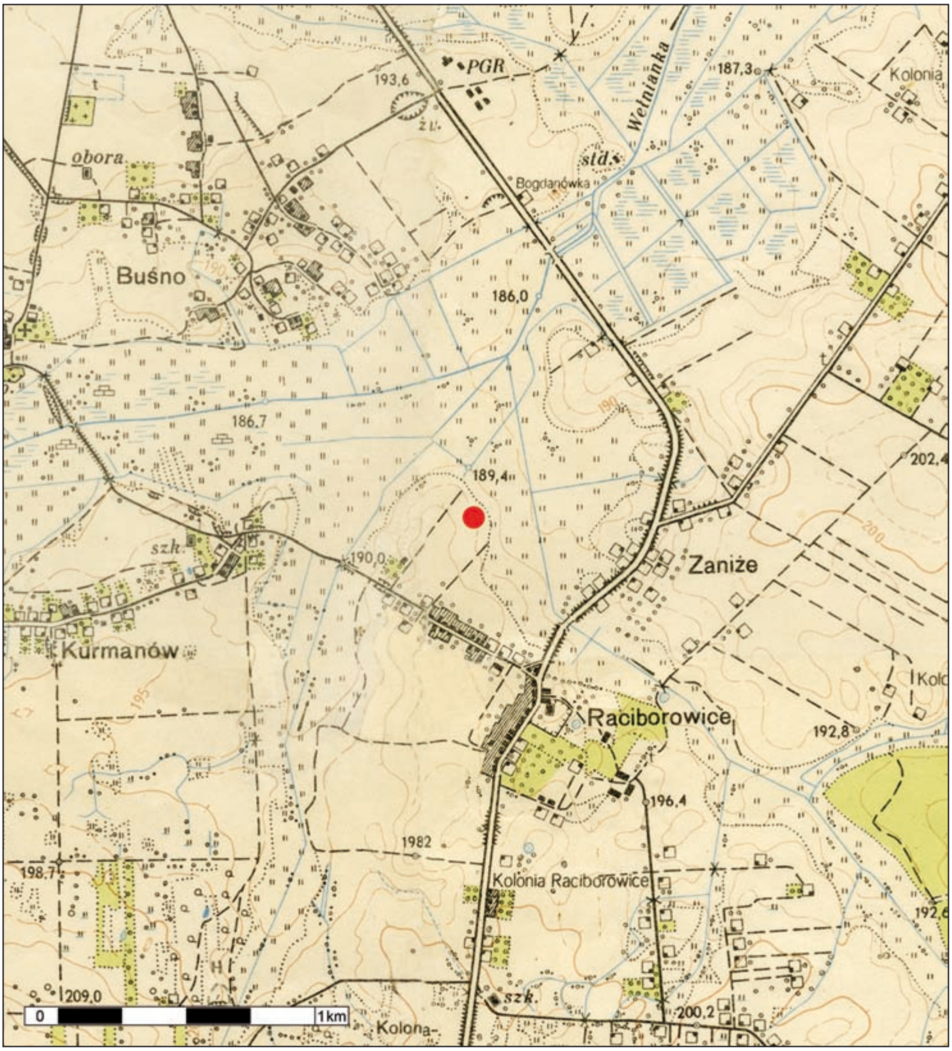


Fig. 1. Raciborowice, Site 7. Place of the copper axe discovery – red dot
(map fragment 1: 25,000; Hrubieszów district. Lublin Voivodeship. Publisher: Topographic Board of the Polish General Staff, Warsaw 1963)

chaeological sites in the area of the police station in Żmudź, *loco* comm., *i.e.* from the area of the southern municipalities of the Chełm district. The interview with the discoverer – Roman Pawełczuk from Hrubieszów, who gladly indicated on maps the places of discovery of several artefacts donated to our Museum, including this Eneolithic axe, turned out to be very useful.

LOCATION OF DISCOVERY

Pawełczuk discovered the metal axe in the arable layer of a field, accompanied by a bifacial, slightly asymmetrical flint axe. The place of discovery is located on fairly extensive, slightly undulating headland, indenting into the southern part of the Wełnianka river valley – a tributary of the Bug (Fig. 1). The slope descends to the east and northeast. In autumn 1983 a trace of settlement had been recorded approx. 80 m west of the place of discovery during surface-surveys carried out by Sławomir Jastrzębski and Andrzej Kokowski in the Archaeological Map of Poland program (AZP). It consisted of an uncharacteristic flint flake and a fragment of prehistoric ceramics of undefined cultural affiliation (inventory number in the archaeological collection of the Chełm Land Museum: MCH/A/877). Observation conditions were difficult at that time, which influenced the number of finds. It seems, however, that both: the archaeological material discovered in 1983, as well as both axes, occurred on the same site, the area of which probably exceeds two hectares. Following the presented considerations, it was decided that the trace site No. 7 in Raciborowice (known from AZP) should be enlarged to include the places where both axes were found and to avoid the need to assign a new number. The site is at least of bi-cultural nature (the flint bifacial axe is dated back to the early Bronze Age). It is located in the AZP area No. 83-93 (number 22), which is part of the Dubienka Depression – part of the Volhynian Polesia. The headland is covered by a light, dusty, sandy soil formed on the loess layer (Męczyński ante 1939). It is a quite fertile soil, easy to cultivate, well-drained, so it is not threatened with excessive dampness. According to Doc. Stanisław Gołub, a few years ago, a "hoard of copper or bronze objects" was found less than a kilometre to the southwest, on the western side of the valley of the nameless tributary of the Wełnianka, within the land of Kurmanów, Białopole commune. The hoard was scattered by the finders. Unfortunately, nothing more is known on this subject.

DESCRIPTION OF THE AXE

The massive, symmetrical axe from Raciborowice was assigned to the group of flat specimens (with non-raised edges). Its slender body in the shape of tall trapezoid change into separate, symmetrical, convex cutting edge. The faces (side walls) are wide, slightly concave, in the form of an elongated leaf. The symmetrically arched cutting edge is in shape of

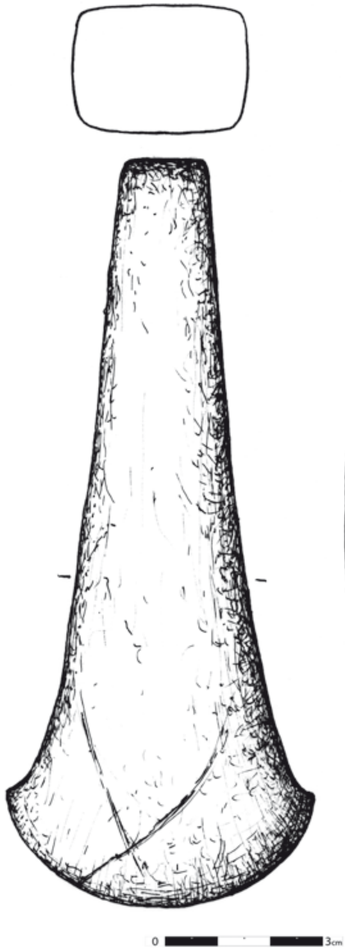


Fig. 2. Raciborowice, Site 7. Copper axe.
Drawing by E. Hander

a half of an ellipse. The butt is flat, almost square. The cross-section of the tool is in shape a fairly tall, horizontal rectangle with slightly convex sides and rounded corners. The longitudinal cross-section is wedge-shaped. The largest thickness occur slightly lower than half of the axe length (closer to the butt then to the cutting edge). All surfaces are covered by the green patina with grey and brown spots. Both faces, one edge and butt are covered by modern scars caused by farming machinery (Figs 2, 3). The tool hasn't been subjected to conservation treatment. Its weight – 698 g. Dimensions: height: 14.5 cm, cutting edge: major axis length (=cutting edge width): 5.9 cm, minor axis length: 4.3 cm, cutting edge high: 2.25 cm, butt: 1.6 × 1.5 cm, maximal body thickness: 2.5 cm.

Fig. 3. Raciborowice, Site 7. Copper axe. Photo by G. Zabłocki

LABORATORY RESEARCH

The studies on elemental composition was conducted with the use of two independent research methods. In the first case – in the laboratory of the Department of Geology, Soil Science and Geoinformation in the Institute of Earth and Environmental Sciences of the Maria Curie-Skłodowska University in Lublin. In the second case – in the Laboratory of Construction Engineering in Civil Engineering Centre of the State Academy of Applied Sciences in Chełm. In both cases they have a non-invasive nature due to aspiration to keep the artefact in intact condition. Therefore, the surface layer covered with patina and dirt, caused by long-term exposure to the soil, was examined. These circumstances, as well as chemicals used in agriculture (natural and artificial fertilizers, plant protection products,

Table 1. Results of the studies on elemental composition obtained with use of the electron microscope and electron gun in percentage by weight

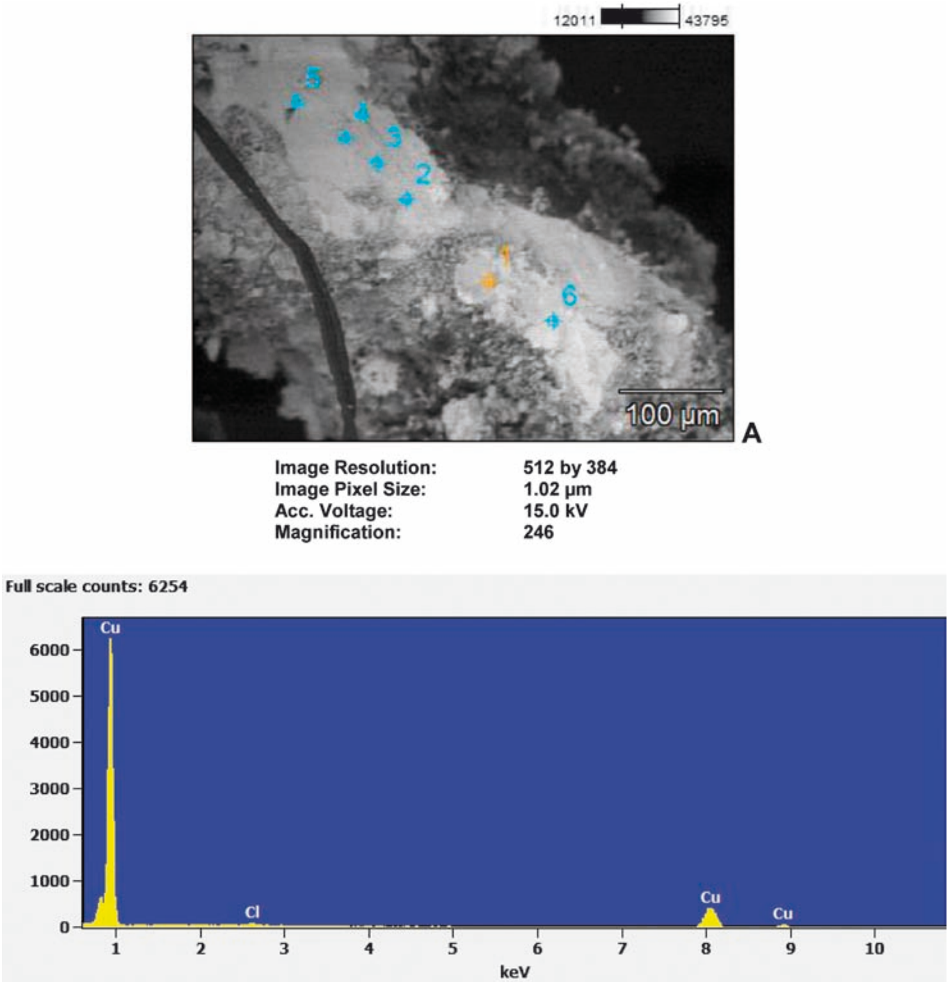
Element	Value	
	minimal	maximal
C	3,38	35,54
Fe	-	32,01
O	1,75	30,06
Ca	-	20,45
N	-	14,14
P	-	7,12
Cl	0,28	5,93
K	-	5,70
Si	-	4,19
S	-	3,25
Al	-	2,48
Br	-	2,33
Ar	**-**	**1,31**
Cu	**17,21**	**91,09**

lime) have probably left their mark on the chemical (elemental) composition of the axe coating.

During the Lublin research, Doc. Miłosz Huber used the Hitachi SU6600 scanning electron microscope with an EDS attachment. The samples were placed in the microscope without sputtering, in the conditions of so-called low vacuum. Subsequently they were tested with a 15 keV electron gun. The standard research procedure time at one sample was 90 seconds. The presence of elements was established as a result of 37 readings of 25 samples. It was possible to record: carbon, nitrogen, oxygen, aluminium, silicon, phosphorus, chlorine, potassium, calcium, iron, bromine, sulphur and – above all – copper, and a trace of silver (Table 1; Figs 4-7).

Most likely the elements that create silicates and phosphates cannot be considered as an addition to the metallurgical mass (except for silver). They should rather be interpreted as a surface contamination resulted from the artefact being depsited in the soil that since then was periodically or continuously cultivated.

The lack of arsenic and antimony (and, of course, tin) is noteworthy, as well as significant quantitative fluctuations of particular elements in various samples, which indicates the heterogeneous nature of the surface layer. Copper is the absolutely dominant element by weight (and percentage). Most probably the casting was made of almost “pure” copper, perhaps with a small, natural admixture of silver.

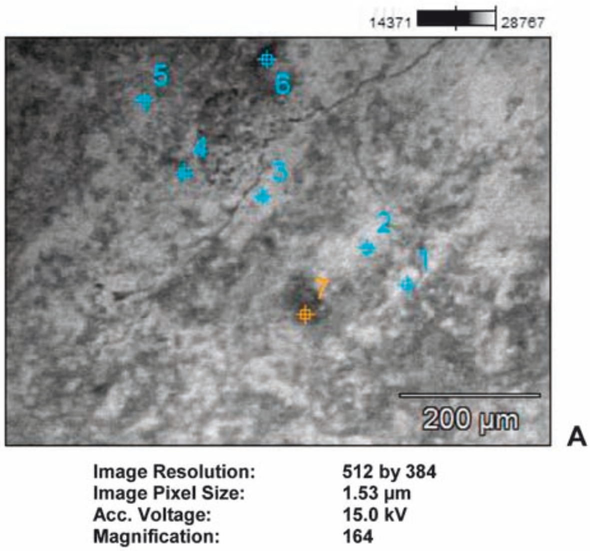


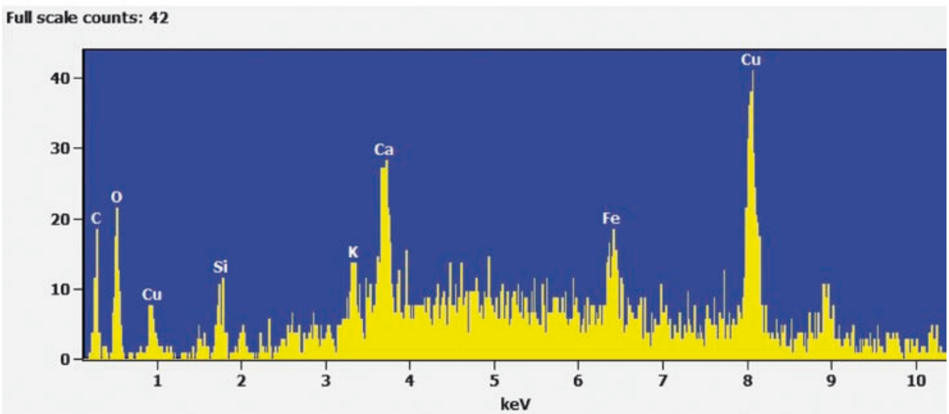
Weight %

	C	O	Cl	Cu
Point 1	11.31	13.51	0.53	74.65

B

Fig. 4. Measurement 1. A – microphotograph of backscattered electrons and measurement points; B – elemental composition at the measuring point 1. Prepared by G. Zabłocki and the author on the basis of illustration by M. Huber



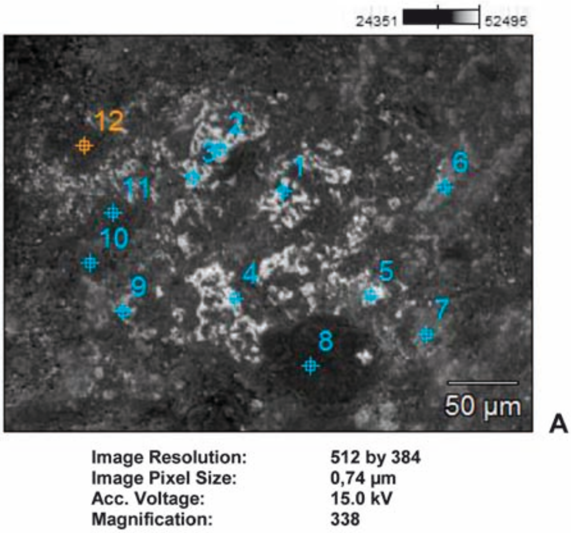


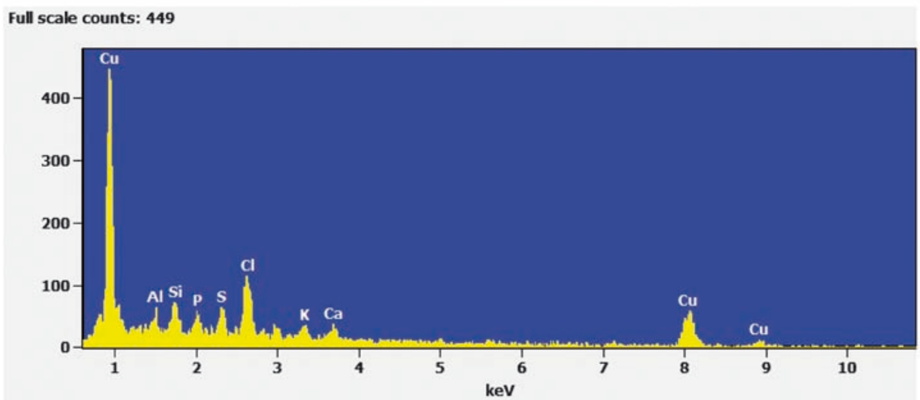
Weight %

	C	O	Si	K	Ca	Fe	Cu
Point 7	4.68	6.43	1.90	1.71	6.95	11.71	66.62

B

Fig. 5. Measurement 2. A – microphotograph of backscattered electrons and measurement points; B – elemental composition at the measuring point 7. Prepared by G. Zabłocki and the author on the basis of illustration by M. Huber



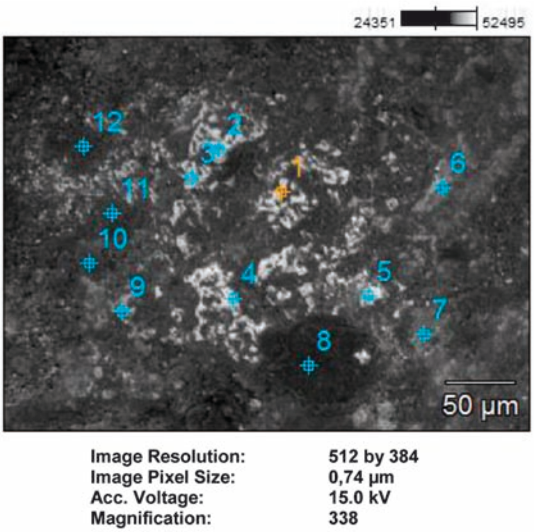


Weight %

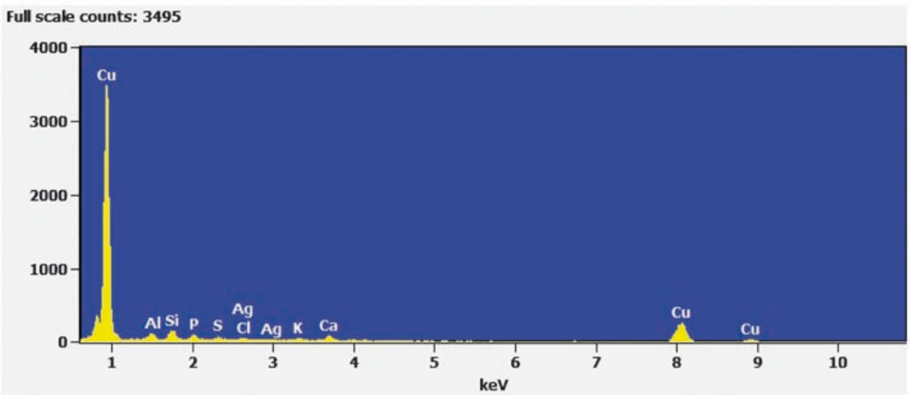
	C	N	O	Al	Si	P	S	Cl	K	Ca	Cu
Point 12	33.48	11.48	29.83	0.39	0.95	0.65	0.77	2.64	0.67	0.57	18.55

B

Fig. 6. Measurement 5a. A – microphotograph of backscattered electrons and measurement points; B – elemental composition at the measuring point 12. Prepared by G. Zabłocki and the author on the basis of illustration by M. Huber



A



Weight %

	C	O	Al	Si	P	S	Cl	K	Ca	Cu	Ag
Point 1	28.57	21.73	0.88	1.30	0.65	0.39	0.49	0.50	1.33	43.85	0.31

B

Fig. 7. Measurement 5b. A – microphotograph of backscattered electrons and measurement points; B – elemental composition at the measuring point 1. Prepared by G. Zabłocki and the author on the basis of illustration by M. Huber

Table 2. Results of the studies on elemental composition obtained with use of the X-ray fluorescence spectrometer in percentage by weight

Element	Value
Si	25,626
P	5,362
Al	4,388
Ca	3,275
Fe	3,095
K	2,946
Ti	0,823
S	0,308
Mn	0,111
Sr	0,050
Zr	0,031
V	0,031
Cu	**53,955**

The research in the Chełm laboratory was carried out by Natalia Iwanicka, MSc, using the Shimadzu EDX-7000 X-ray fluorescence spectrometer. Reading was conducted in the air atmosphere. The collimator was 10 mm in diameter. The test time was 30 seconds. One reading was recorded (Table 2).

The presence of silicon, phosphorus, aluminium, calcium, iron, potassium, sulphur – known from previous studies – was recorded with use of this method as well. The contents of titanium, manganese, strontium, zirconium and vanadium were also detected – they were not recorded by the electron microscope due to their low concentrations. The presence of silicon, phosphorus, aluminium, calcium and potassium draws attention. They probably form silicates and phosphates. In the examined part of the artefact, silicon was present in a much higher concentrations than in the case of analyses carried out in the Lublin laboratory.

Also in this case studies of the tool's surface layer did not provide an unambiguous answer about the elemental composition of the metallurgical mass. It is impossible to clearly decide whether titanium, manganese, strontium, zirconium and vanadium are a natural component of the ore, or they got there like other inclusions present in the patina, while the axe was corroding in the ground for several thousand years. Of course, copper dominates by percentage and weight also in the case of Chełm tests. At the same time, the lack of arsenic, antimony and silver (and tin) was found.

Thus, there are many indications that the Raciborowice axe was made of "pure" copper.

ARCHAEOLOGICAL ANALYSIS

The Raciborowice axe is classified into the group of flat axes (with non-raised edges), trapezoidal in cross-section, with slightly concave faces, widened, convex cutting edge, flat butt and both sections symmetrical. Jiři Říhovský described these types of artefacts as group V, type 3c, Bb variant (1992, No. 101) of copper axes discovered in Moravia. Miroslav Dobeš found that identical and similar specimens in the Czech Republic, Moravia, Poland and Eastern Germany (former GDR) form group I, Boljun type, Szakálhát variant (1989, 44), in his more recent work (2013) he placed the most similar specimens among the axes of the first group, the Osik type (38, Pl. 6: 7) and the Jordanów type (39-40, Pl. 7: 10, 8: 1). Moreover, in the study on Central Germany and the Czech Republic the authors: Dobeš, Lutz Klassen and Pierre Pétrequin included the most similar axe – a specimen of the Steinbach type (2011, 10, pl. 6: 2) into the group of 3 triangular flat axes (2011, 12, 13). Henrieta Todorova placed similarly shaped Bulgarian specimens among the flat axes of the Sălcuţa (1981, Nos 49-64), Kamenar (1981, Nos 67-76) and Dolčevo (1981, Nos 65, 66) variants, while Alexandru Vulpe included Romanian specimens among flat axes of the 1st group (narrow) of the Cucuteni (1975, No. 268) and Sălcuţa (1975, No. 271) variants. Viktor Klochko and Anatoliy Kozymenko, in the catalogue of metal artefacts from Ukraine (2017), present three similar specimens from Turiysk (8, Fig. 12), – a field between the villages of Nosivtsi, Kunka (16, Fig. 25) and Novovolynsk (18, Fig. 32). In the western part of the Balkan Peninsula (in Dalmatia, Croatia, Montenegro, Bosnia and Herzegovina) Zdenko Žeravica classified axes similar to Raciborowice specimen as the Stollhof-Pločnik type (1993, No. 131), possibly Stollhof-Pločnik, Hartberg variant (1993, Nos 132-134), while others as Spitz type (1993, No. 135), Gurnitz type (1993, Nos 136-152A), Szakálhát type, Sălace variant (1993, Nos 153-157). For the territory of the former Yugoslavia Martin Kuna identified also the types of Dugo Selo and Buljun (1981, 17-19) – also quite similar to our specimen. Among the Slovak copper artefacts that Mária Novotna classified into the very broad (“multi-threaded”) category of “narrow axes” (1970), there are specimens that fully resemble the Raciborowice one. These are the discoveries from Bešeňová (No. 35) and Handlová (No. 36). Pál Patay gathered (1984) similar Hungarian specimens in a collection called the Szakálhát type, divided into seven variants and two additional single special forms (Nos. 16-75). The closest analogy to the Raciborowice specimen is the Sárazsadány variant, namely two tools from Budapest-Békásmegyer (Nos. 44, 45). Among the Austrian artefacts collected by Eugen Fridrich Mayer (1977), quite similar axes also occur. They represent the Stollhof type: the Hartberg variant (No. 97), the Gurnitz variant (No. 103) and the Szakálhát type (Nos. 109, 112). In Western Germany, Kurt Kibber placed similar axes among flat triangular tools (Grundform 2; 1980, Nos 18, 19, 25, 26) as well as small, massive axes: Nieder-Ramstadt (Grundform 7a; Nos 27-30), Rűnthe (Grundform 7b; Nos. 31-34). J. Jacobs classified copper flat axes from Eastern Germany into four basic types: I, II, IIIa and IIIb (1989). Type II is identical with Nieder-Ramstadt, type IIIa with basic form 2 (Grundform 2) of Kibber, and IIIb with type Boljun, variant Hartberg and also type Szakálhát, variant Sălacea. The Raciborowice specimen also should be included into that group.

The above considerations indicate, that in the literature, local typologies have been developed covering national (*e.g.* Hungary, Slovakia) or regional (*e.g.* Moravia) territories, which in various extent correspond to closer or slightly further areas. The nomenclature of each type (and variant) varies, depending on the geographic location of the discoveries (Table 3).

Albert Schmitz (2004) tried to overcome this methodological difficulty by studying Early Eneolithic copper flat axes all over Europe. His analysis covered 1137 specimens (Tabelle/Diagramm Nr 74), *i.e.* almost all of the published ones. Using complicated methods of statistics, as well as special computer software to compare particular discoveries, it was possible to classify eight basic forms (Beilform), with form 8 – that covers chisels, and form 7 – gouges (chisel-shaped axes). The Raciborowice specimen has no features of either form. Moreover, it is also different from forms 1-4. It represents category 5 (Pl. No. 135) or possibly 6 (the latter is described by the author as "variant of the form 5"; Pl. 136; collective definition of form 5: Schmitz 2004, 371, 372; and form 6: 372-374). In Plate 94 Schmitz included transitional forms with features of both categories. It is interesting that the same types identified by different researchers can be placed by Schmitz in different typological categories, *e.g.* the Gurnitz-Boljun axes from Bosnia can be classified in categories 5, 5/6 or 6 (Table 3). Whereas the "Polish" axes described by Andrzej Szpunar (1987) as type Dąbrówka Dolna – also correspond to three Schmitz categories: 5, 5/6 and 6; Strzelin, variant A – 5 and 5/6; Strzelin, variant B – 5; Bytyń, variant A – also 5, and the same find from Jarosław, considered to be a "single and indefinite specimen" (Table 4).

At this point, it is worth taking a closer look at the axes from Poland, classified into one of the above-mentioned categories (Table 4; Fig. 8), in the context of the similarity with the Raciborowice specimen. Schmitz qualified seven axes into category 5, three into the transitional 5/6 and one into the 6. None of them seem to be identical to our specimen. The overall outline proportions resemble the Trzebuska axe (Szpunar 1987, Pl. 1: 11), but it is not as massive (thick) and does not have such a distinct convex blade. A specimen from Dobkowice (Szpunar 1987, Pl. 1: 11B) has a distinctively shaped cutting edge (maybe a little less convex) and a matching thickness (proportionally). It is, however, much less slender. It can be assumed that two more specimens should be included in this list: from Wożuczyn (Gurba 1992) – not included by Schmitz, and from Książnice, site. 2 (Zakościelna 2010, 149) – discovered after the completion of work on early Neolithic axes and chisels in Europe. However, including them in one of the distinct categories is not possible without applying the methodology used by the German researcher. In Table 4, they were recorded without specifying the typological position of Schmitz. It appears that the specimen from Wożuczyn is quite similar in shape to the Raciborowice one. It has a similar slenderness and a widened blade (Gurba 1992, 72, Fig. 1) but slightly different shape, its cross-section

Table 3. Types and variants of flat axes corresponding to categories 5, transitional 5/6 and 6 (according to Schmitz 2004; Tabelle 94)

Type of Schmitz 2004	Switzerland	Germany		Denmark	Romania		Dalmatia
	Type	Type	Variant	Type	Type	Variant	Type
5	Thayngen,	Small massive	Rűnthe	Vantore ?	narrow	Cucuteni	Gurnitz / Boljum
			Nider-Ramstadt			Sălcuța	
		Nider-Ramstadt / Jacobs-II	-	Valdkilde 1 / Bygholm	wide	Ostrovul-Corbului	
		Bygholm / Jacobs-IIIa	-				
		triangular, flat / Jacobs-IIIa	Grundform 2	Valdkilde A1			
		triangular, flat / Jacobs-II	Grundform 2				
	Bevaix / Altheim	Boljun / Jacobs- IIIb	Hartberg	Valdkilde 4	-	-	
5/6	-	triangular, flat	Grundform 2	-	-	-	Miniature flat axe
		triangular, flat / Jacobs-II	Grundform 2				
		Szakálhát / Jacobs-IIIa	-				
6	-	-	-	-	-	-	-

Type of Schmitz 2004	Hungary		Croatia		Bosnia		Est France
	Type	Variant	Type	Variant	Type	Variant	Type
5	Szakálhát	Vasmegyer	Buljun	-	Spitz / Boljun	-	Nider-Ramstadt
		Sárazsadány					
		Sălacea					
		Sălacea, with central ridge					
	stocky	Ravazd	Stollhof / Pločnik / Dugo selo	-	Gurnitz / Boljun	-	Rűnthe
	Boljun	-	Stollhof / Pločnik / Dugo selo	Hartberg			
	Felsögalla	-			Stollhof / Pločnik / Dugo selo	Hartberg	
		Szendrö					
	flat	krępy					
5/6	Hungarian form	-	Buljun / jak Szakálhát	-	Gurnitz / Boljun	-	-
	Szakálhát	Sárazsadány					
		Sălacea, with central ridge			Szakálhát / Boljun	-	
6	Szakálhát	Keszthely	-	-	Gurnitz / Boljun	-	-

Type of Schmitz 2004	Bulgaria		Slovakia		Moravia		
	Type	Variant	Type	Variant	Group	Type	Variant
5	flat	Kamenar	Sălacea	-	V	2a	Ab
			Salcuța	-			
	flat	Sălcuța	płaski	Gumelnița	VI	2a	Bb
			Coteana	-			
5/6	flat	Kamenar	Cucuteni / Handlová	-	-	-	-
			Cucuteni	-			
			Boljun / Szakálhát / Cucuteni / Gurnitz	-			
6	flat	Delčevo	-	-	V	3c	Bb
	flat	Salcuța / Pločnik					

Type of Schmitz 2004	Austria		Former Yugoslavia		Ukraine		Serbia
	Type	Variant	Type	Variant	Type	Variant	Type
5	Salzburg-Rainberg	-	Szakálhát	Sălacea	Boljun / Stollhof	Hartberg	-
	Szakálhát	-					
	Stollhof	Hartberg					
	Stollhof / Boljun	Hartberg					
5/6	Split	-	-	-	-	-	as Alba Julia
6	-	-	-	-	-	-	-

Table 4. Flat axes of Shmitz (2004) categories 5, transitional 5/6 and 6 (*Beilform* 5, 5/6, 6) from the area of Poland

No.	Place	Schmitz ax category (2004, Tabelle 76)	According to Szpunar 1987			According to Dobeš 1989			According to Patay 1984
			Type	Variant	Catalogue number, figure	Group	Type	Variant	Type
1	Dąbrówka Dolna	6	Dąbrówka Dolna	-	7	-	-	-	-
2	Dobkowice	5	Strzelin	A	11B	-	-	-	-
3	Gołostowice	5/6	Strzelin	A	12	-	-	-	-
4	Jarosław	5	znaleziska pojedyncze i formy nieokreślone	-	66	-	-	-	-
5	Książki	5	Strzelin	B	15	-	-	-	-
6	Książnice**, stan. 2	?	-	-	-	-	-	-	between Hajdúszoboszló and Fesögalla
7	Lubycza Królewska	5	Dąbrówka Dolna	-	11A	-	-	-	-
8	Strzelin	5	Strzelin	A	14	-	-		-
9	Trzebuska	5/6	Dąbrówka Dolna	-	11	-	-	-	-
10	Tyniec Mały	5/6	-	-	-	I	Boljun	Szakálhát	-
11	Wożuczyn*	?	-	-	-	I	Boljun	Jordanów	-
12	Nieznana	5	Strzelin	B	17	-	-	-	-
13	Nieznana	5	Bytyń	A	57	-	-	-	-

* According to typological classification of Jan Gurba (1992, s. 72).

** According to typological classification of Anna Zakościelna (2010, s. 149).

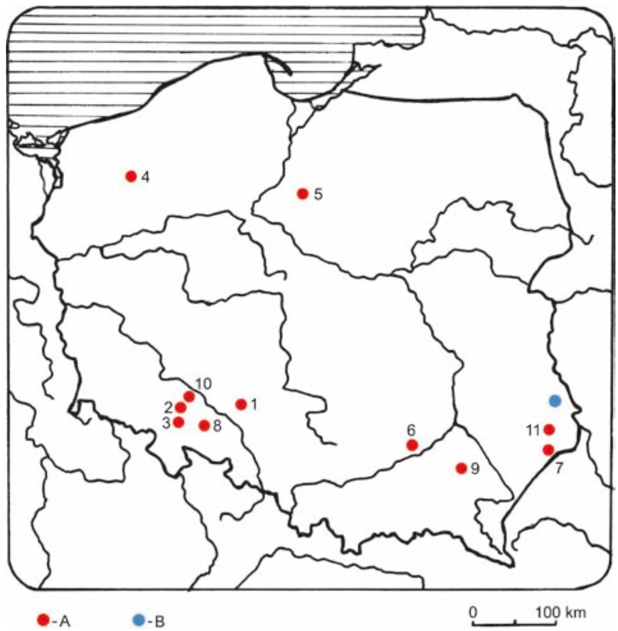


Fig. 8. Spread of the Schmitz category 5, 6 and transitional 5/6 (Beilform 5, 6, 5/6) flat axes in Poland. According to A. Schmitz 2004, 1075-1081, Tab. 76; 1321, 1322, Karte 158; with supplements by J. Gurba (1992), A. Zakościelna (2010) and the author. Finds known from literature (A), Raciborowice, site No. 7 (B) 1 – Dąbrówka Dolna, 2 – Dobkowice, 3 – Gołostowice, 4 – Jarosław, 5 – Książki, 6 – Książnice, site 2, 7 – Lubycza Królewska, 8 – Strzelin, 9 – Trzebuska, 10 – Tyniec Mały, 11 – Wożuczyn. By G. Zabłocki on the basis of drawing by the author and E. Hander

is rather flat than rectangular. The axe from grave No. 5 in Książnice has a similar separate blade (Zakościelna 2010, Pl. 37: 4). Nevertheless, it is a specimen of much smaller size, more stocky, with a flat-convex cross-section, which differs significantly from the Raciborowice one. The remaining "Polish" tools of Schmitz categories 5, 5/6 and 6 cannot be treated as exact analogies. It seems that the features are quite similar: a specimen from Jordanów Śląski is characterized by appropriate slenderness and thickness, and the discrete cutting edge (Szpunar 1987, Pl. 1: 5). Schmitz, however, included him in category 7 (2004, 1166, Pl. 94).

A CHRONOLOGY OF AXES CORRESPONDING TO SCHMITZ 5, 5/6 AND 6 CATEGORIES

Todorova ascribes Bulgarian discoveries of Sălcuţa variant flat axes to the younger phase of the Varna culture, Krivodol-Sălcuţa culture and the Kadžadermen-Gumelniţa-Koranowo VI complex, functioning in the late phase of the local Eneolithic and during the

Bulgarian Transitional Period (Schmitz 2004, 48; Todorowa 1981, 2, 3, Abb. 1). She connects the Dolčevo variant with the second phase of the Kadžadermen-Gumelniţa-Koranowo VI complex (*ibid.*), while Kamenar with the final section of the Varna culture and the beginning of the Bulgarian Transitional Period (*ibid.*).

Vulpe dates Romanian narrow axes of the Cucuteni and Sălcuţa variant, to phase A1 of the Gumelniţa culture, with the possibility of their production and use in the Bodrogkeresztúr culture, *i.e.* it would be the older (early) Eneolithic period, phase I/II and II in Schmitz's periodization (Schmitz 2004, 53). The wide axes of the Ostrovul-Corbului variant, on the other hand, are placed by the same author at the turn of the Copper Age and Bronze Age, *i.e.* the third phase of the older (early) Eneolithic and the first phase of the middle Eneolithic (*ibid.*).

Ukrainian tools were ascribed by Kłoczko and Kozymienko to the Trypillia culture. Specimens most similar to the Raciborowice one were dated to the A-BI1 phase (2017, 8), while the other two – BII-CI (2017, 10). In the light of other well-dated axes of this type, such an early chronology of the Turiysk single find is unjustified. The oldest specimens from Ukraine could originate at the earliest from the turn of phase Ib to IIa of the Schmitz early Eneolithic, as this is the date of the Tiszavalk-Tetes cemetery (documenting the transition from Tiszapolgár to the Bodrogkeresztúr culture; Patay 1984, 32).

In the countries of former Yugoslavia, Kuna related the Pločnik type axes with the Kadžadermen-Gumelniţa-Koranowo VI-B complex, Vinča-Pločnik II and the Tiszapolgár culture, with the possibility of their existence also in the Baden culture (Schmitz 2004, 57). The Dugo Selo type is related to the late stage of the Bodrogkeresztúr culture, which indicates the IIb phase of the older Eneolithic according to Schmitz (*ibid.*). The Boljun type is synchronized with the B phase of the Bodrogkeresztúr culture, B2 of the Trypillia culture and the Sălcuţa III-IV culture, thus placing it in phase II of the older Eneolithic (*ibid.*).

In the Adriatic countries of the western Balkans, Žeravica classified axes of the Stollhof/Pločnik type, some of them identifying with the Hartburg variant. He attributes them to the Vinča-Pločnik culture, phase B of the Cucuteni culture, as well as the Baden and Michelsberg cultures (Schmitz 2004, 61). The Spitz type is a product also used by the Vinča-Pločnik culture, just like Gurnitz, however the last one – in its younger phase (*ibid.*). The Szakálhát type was connected with the Bodrogkeresztúr culture (*ibid.*).

Novotna ascribes narrow Slovak axes, to the Bodrogkeresztúr culture, synchronizing them with the B phase of the Cucuteni culture, however in specimens No. 35 and 36 (1970) she sees relatively late forms parallel to the Remadello culture from northern Italy (Schmitz 2004, 70).

Patay assigned Hungarian axes of the Szakálhát type, Vasmegyer, Sălacea, Sárazsadány variants to the younger phase of the Bodrogkeresztúr culture (Schmitz 2004, 73), the Keszthely variant – the Baden culture, while the Gurnitz type from Austria, which – according to him – is a variant of Szakálhát, to the Balaton culture (*ibid.*). According to Patay, the Felsögall type, including the Szendrö variant, was used in the Bodrogkeresztúr culture (*ibid.*), as well as stocky axes of the Ravazd variant, and additionally in the Baden culture (*ibid.*).

Říhovskýis ascribes Moravian axes classified to group V, type 3c, variant Bb to the Bodrogkeresztúr, Sălcuţa III-IV, Cucuteni B, possibly Baden culture (Schmitz 2004, 83).

Czech axes of the Dobeš 1st group, Pločnik type, Stollhof, Split and Dugo Selo variants (1989) may be dated to the second phase of the early Eneolithic (Schmitz 2004, 90). Split, by resemblance to Szakálhát, is related to the late Bodrogkeresztúr culture (phase IIb of the early Eneolithic in Schmitz's periodization; *ibid.*). The same author in a later study synchronizes the Stollhof type with Cucuteni A-Gumelniţa A2, which equates to the late phase of the Lendziel culture in the Czech Republic (Dobeš 2013, 38). The Hartberg type is simultaneous with the Jordanów culture (group) and the chronologically corresponding Lower Austrian group of Bisemberg-Oberpullendorf (*ibid.*). The Osik type originate from the Jordanów horizon (*ibid.*), as well as the Jordanów type (Dobeš 2013, 39, 40).

Szpunar classified Polish axes of the Dąbrówka Dolna type as the products of the Funnel Beaker culture (Schmitz 2004, 96), the Strzelce type (both variants) - of the Jordanów culture (group; *ibid.*), and Bytyń to the late phase of the Funnel Beaker Culture (Schmitz 2004, 97). The axe from Wożuczyn, probably an import from the Tisza River area, could have been used by the population of the Lublin-Volhynian culture (Gurba 1992, 73, 74). Undoubtedly, the specimen from Grave 5 in Książnice, Site 2 should be related to this cultural unit (Zakościelna 2010, Pl. 37: 4).

Flat axes of the Stollhof (including the Hartberg variant) and Spitz types from Austria were ascribed by Mayer to the horizon Baden culture: / "Commercial" / Trypillia culture A / Vinča-Pločnik / Cucuteni B / Michelsberg (Schmitz 2004, 99). Szakálhát ascribes Type Gurnitz – generally dated to the younger stage of the Eneolithic (*ibid.*), to the culture of Michelsberg (Schmitz 2004, 99) of the Early Eneolithic stage II (*ibid.*), Split – also to the Bodrogkeresztúr and Michelsberg cultures (Schmitz 2004, 100).

Swiss Thayngen type axes occurred in the older and middle phases of the Pfyn culture, in phase IIb of the Early Eneolithic in Schmitz periodization (2004, 107). It is the horizon of Cortaillod – Pfyn – Althaim – Mondsee – Ludanice-Lažňany-Balaton II – Bodrogkeresztúr – Trypillia culture C (Schmitz 2004, 109).

Western Germany tools – triangular, flat (Grundform 2) were classified by Kibbert as products used in the Michelsberg culture (Schmitz 2004, 115), similar to the small triangular axes (Form 7a and 7b): Nieder-Ramstadt and Rűnte (the latter in its the younger phase; *ibid.*).

According to Schmitz, on the basis of the uniform collections analysis (Table 5 and 6), category 5 axes appear at the time of transition from Early the Eneolithic phase Ib to phase IIa, they last through the entire phase II (a and b) up to phase IIIa, when they disappear (*e.g.* Schmitz 2004, Diagramm No. 130). Specimens of category 6 appear in Early Eneolithic phase IIa and occur in phase IIb to phase IIIa (*ibid.*). Axes with transitional features – probably have the same chronology.

Table 5. Cultural situation in the central part of Europe, in countries where flat axes of categories 5, transitional 5/6 and 6 occurred (according to Schmitz (2004; Tabelle 94)

Dating: Early Eneolithic		Place	Country
Phase	**Culture / Time horizon**		
Treasures			
Ib	-	Luica	Romania
II	-	Boljun	Croatia
	-	Bosanska Krupa	Bosnia
IIa	-	Kolubara river mouth	Serbia
IIab	-	Novest	Croatia
	-	Orašje	Bosnia
	-	Surčin	Croatia
IIb	-	Horodnica	Ukraine
	-	Kladari-Karavid	Bosnia
II / III	-	Conțești	Romania
	-	Handlová	Slovakia
IIb / transition to IIIa	-	Stollfof	Austria
	-	Veliki Gaj	Serbia
Graves			
Ib / IIa	Transition from Tiszapolgár to Bodrogkeresztúr	Tiszavalk-Tetes	Hungary
IIa	Bodrogkeresztúr	Ciumesti	Romania
IIab	Bodrogkeresztúr	Hódmezövásárhely-Szakálhát	Hungary
	Gumelnița B	Sava	Romania
IIb	Jordanów	Dobkowice	Poland
	Bodrogkeresztúr – earlier phase	Fényslitke	Hungary
	Jordanów	Tyniec Mały	Poland
Settlements			
IIb	Trypillia BII	Brynzeny III	Ukraine
		Michurin Sovchoz	
IIb or transition to IIIa	Pfyn	Thayngen	Switzerland

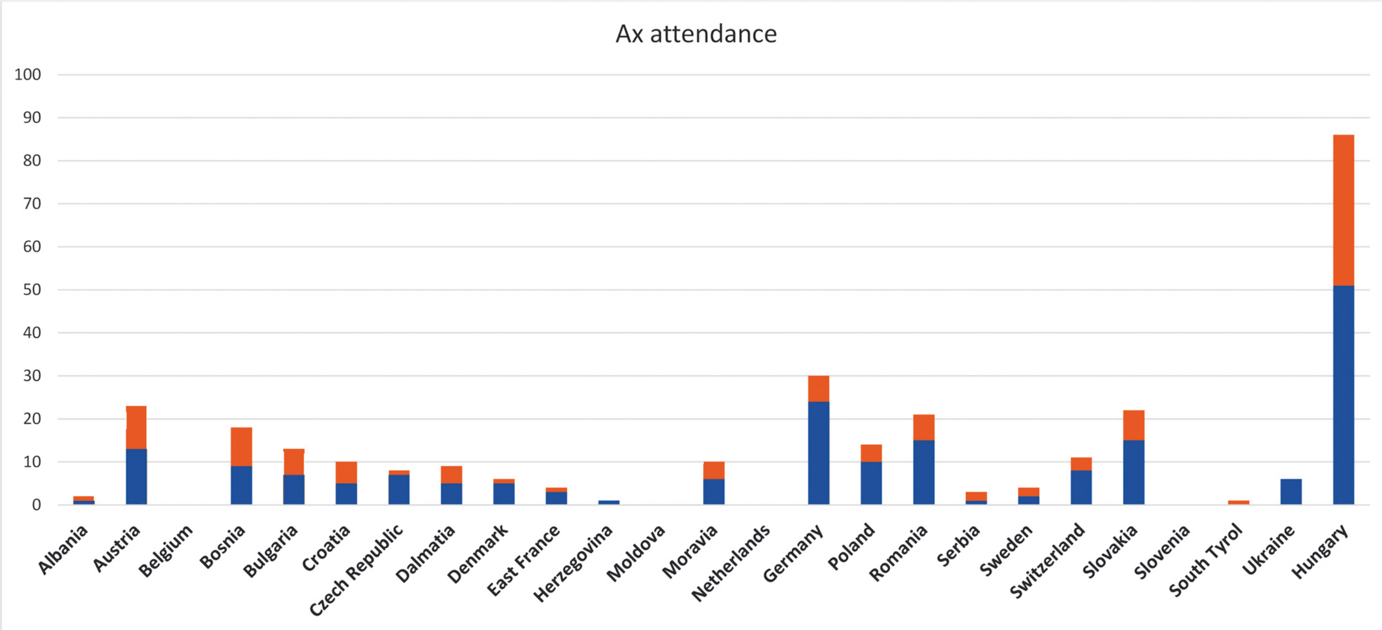
The cultural situation in the countries where the axes of Schmitz categories 5, 5/6 and 6 were discovered is presented in Table 7. The quantitative summary is presented in Fig. 9. The range of category 5 axes (Beilform 5) covers the area from Alsace and Lorraine in eastern France in the West to western Ukraine in the East and from the southern Balkans (Albania, Bulgaria) in the South to southern Scandinavia in the North. Category 6 axes (Beilform 6), roughly repeats this range (except western Ukraine, where they have not been recorded; Schmitz 2004, Karte 144, 145). At first glance it can be recorded that the greatest density

Table 6. Chronology of Schmitz category 5 axes (Beilforme 5) – uniform groups (Schmitz 2004, 573, 574)

Dating: Early Eneolithic		Place	Country
Phase	**Culture / Time horizon**		
Treasures			
IIa	-	Kolubary river mouth	Serbia
	-	Surčin	Croatia
IIab	-	Boljun	Croatia
	-	Bosanska Krupa	Bosnia
	-	Dorog	Hungary
	-	Kladari-Karavid	Croatia
IIb	Ludanice	Hradec	Slovakia
	-	Orašje	Bosnia
	Treasure corresponds to Bodrogkeresztúr B	Split-Gripe	Croatia
	Bodrogkeresztúr – earlier phase	Szeged-Szillér	Hungary
IIb / IIIa	Transition to Bajč-Retz	Handlová	Slovakia
Graves			
Ib / IIa	Kadžadermen-Gumelnița-Koranowo VI	Reka Devnja	Bulgaria
	-	Tiszavalk	Hungary
IIa	Bodrogkeresztúr A	Magyarhomorog	Hungary
IIab	Bodrogkeresztúr	Hódmezövásárhely-Szakálhát	Hungary
		Srárazsadány	
Settlements			
IIa	Karanovo VI, phase IIb	Goljamo Dolcevo	Bulgaria
IIab	Karanovo VI, phase III	Russe	Bulgaria
II	Sălcuța-III	Cerat	Romania
		Sălcuța	

occur in today's Hungary and in neighbouring Slovakia, definitely exceeding all other areas in terms of quantity. The area of these two countries appears to be the centre of production and spreading of these products to the entire central part of Europe, but – of course – the existence of secondary centres of regional production, following the Hungarian-Slovak models, must be taken into account. Such kind of assumption of the potential exploitation of copper ore deposits and metallurgical production in the Jordanów culture (group) was recently formulated by Beata Miazga and Marta Mozgała-Swacha (2018, 41). Klochko and Kozymenko expressed their opinions in a similar way in relation to the Trypillia culture in Ukraine (2017, 287, 288).

The Raciborowice axe was probably made of "pure" copper, but it is also possible that the small amount of silver was a natural admixture of the ore (Table 1). The presence of arsenic was not recorded in the analysed samples, which may have some chronological



Schmitz ax category (*Beilform*)	Albania	Austria	Belgium	Bosnia	Bulgaria	Croatia	Czech Republic	Dalmatia	Denmark	East France	Hertzegovina	Moldova	Morawia	Netherlands	Germany	Poland	Romania	Serbia	Sweden	Switzerland	Slovakia	Slovenia	South Tyrol	Ukraine	Hungary	Total
5	1	13	-	9	7	5	7	5	5	3	1	-	6	-	24	10	15	1	2	8	15	-	-	6	51	**194**
6	1	10	-	9	6	5	1	4	1	1	-	-	4	-	6	4	6	2	2	3	7	-	1	-	35	**108**
Total	**2**	**23**	**-**	**18**	**13**	**10**	**8**	**9**	**6**	**4**	**1**	**-**	**10**	**-**	**30**	**14**	**21**	**3**	**4**	**11**	**22**	**-**	**1**	**6**	**86**	**302**

Fig. 9. Spread of the Schmitz category 5 and 6 (Beilform 5, 6) flat axes in Europe. According to Schmitz 2004, 1015, Tab. 74

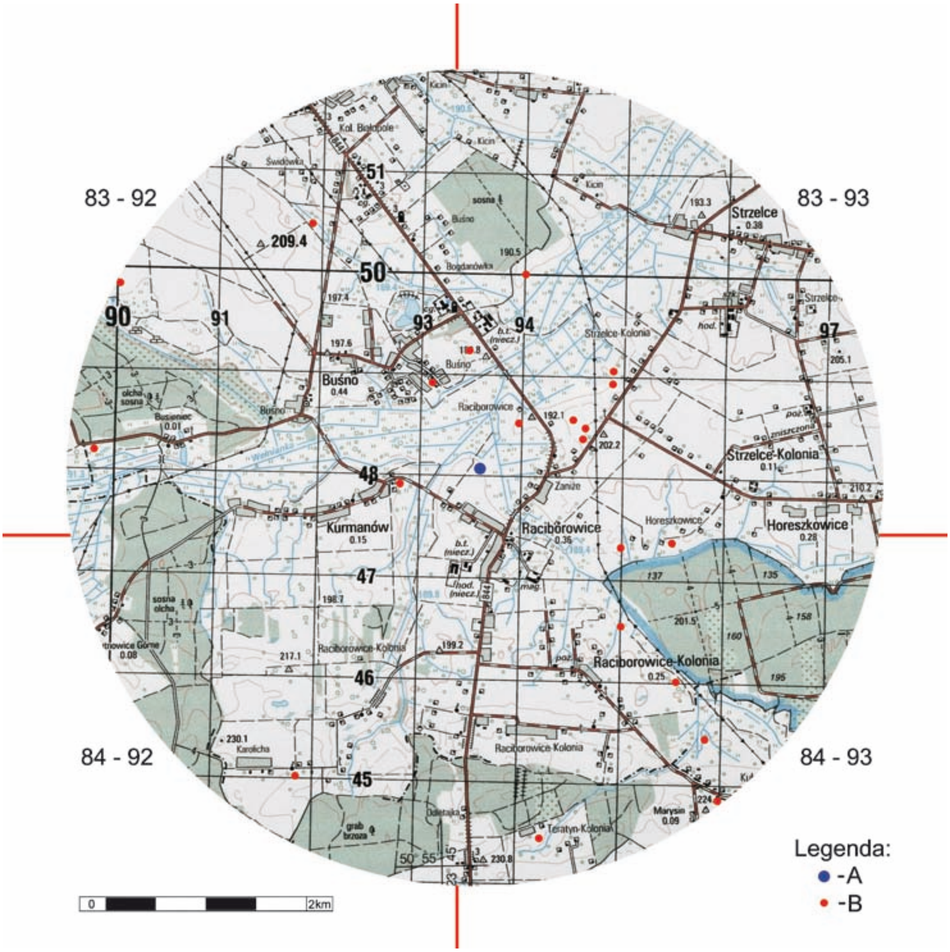


Fig. 10. Raciborowice, Site 7. The place of the copper axe discovery (A) in the context of the Lublin-Volhynian culture sites known from the AZP and excavations (B). According to: Kokowski and Jastrzębski 1983; Bronicki and Hander 2008 (map fragment 1: 50,000; M-34-048-A, B Wojsławice. Publisher: Chief of Military Geography, Warsaw 2013). Illustration by G. Zabłocki and the author

importance. The elemental composition analysis of the Schmitz category 5 and 6 axes indicates, that throughout the second phase of the early Eneolithic, both: completely "pure" copper, as well as copper with the addition of antimony, silver and a small amount of bismuth were used for their production. The latter one is called Nógrádmarcal type copper. Its ore was found in the area of the North Hungarian Mountains (Schmitz 2004, 580). Traces of copper ore exploitation and processing have also been recorded in Slovakia – in the Low Tatras, near Banska Bystrica. They are related to the Ludanice taxonomic unit (Łęczycki 2010, 276, 277). Arsenic copper was widely used only in Early Eneolithic phase

Table 7. Chronology of Schmitz category 6 axes (Beilforme 6) – uniform groups (Schmitz 2004, 574, 575)

Country	Early Eneolithic	
	Phase II	**Phase III**
Austria	Epi-Lengyel	Retz
Upper Austria	Műnchshöfen / Michelsberg III/IV ?	Montsee I
Bavaria	Wallerfing	Altheim I
Bulgaria	Karanovo VI	
Tisza river basin	Bodrogkeresztúr A i B	Hunyadihalom
Czech Republic	Jordanov	Baalberge
Moravia / Lower Austria	Lengyel V	Lengyel VI
Central Germany	Baalberge A	Baalberge B
West Germany	Michelsberg II/III	Michelsberg IV/V
Poland	FBC – Pikutkowo	FBC – early Wiórek
Northeast Romania	Cucuteni A/B	Cucuteni B
South Romania	Gumelniţa A2-B1	Gumelniţa B2
Serbia	Bubanj-hum	
South Scandinavia	FBC A/B	FBC C
Slovakia	Lengyel V: Ludanice A i B	Lengyel VI: Bajč-Retz
Switzerland	Pfyn	
Silesia	Jordanów A-B	FBC C
Ukraine	Trypillia BI	Trypillia BII

III, especially in IIIb (Schmitz 2004, 581). Arsenic next to antimony, silver and bismuth characterizes the so-called Handlová type copper from the upper Nitra in Slovakia. Due to the strong evidence that the Raciborowice specimen was made of arsenic-free metallurgical mass, it should be dated to the second phase of early Eneolithic, eventually stage IIIa, *i.e.* before the widespread use of arsenic copper.

The Bodrogkeresztúr A culture corresponds to Schmitz's early Eneolithic phase IIa, period B – phase IIb. According to the recent radiocarbon dates analyses Tomasz Chmielewski suggests that this culture period A should be dated to 4290/4270-4250/4220 BC, and period B to 4250/4220-3950/3850 BC. On the other hand, the Hunyadi-Halom culture could have developed at the end of the 40th and the beginning of the 39th centuries BC (partly in parallel with the latest stage of the Bodrogkeresztúr culture) and would last until *ca.* 3800 BC (2019, 29) – in stage III of the Schmitz Early Eneolithic. The cut-off dates of taxonomic units quoted by Sławomir Kadrow are slightly different: The Tiszapolgar culture: 4420-4240 BC (Schmitz's Eneolithic phase I); Bodrogkeresztúr: 4250-4070 BC (2nd phase) and Hunyadi-Halom: 4020-3780 BC (3rd phase; 2016, 70; 77; see also Brummack and Diaconescu 2014; Raczky and Siklósi 2013). The BII phase of the Trypillia culture was quite similarly dated by Soviet scholars, corresponding to Cucuteni AB: 4250-4000 BC (Masson and Merpert eds 1982, 175, Pl. 10).

Klassen, Dobeš and Pétrequin dated the Steinbach type axe (very similar to the specimen from Raciborowice) from 3900-3700 BC (2011, 19), which corresponds to the transition from Schmitz's IIb to IIIa stage.

As a result of these considerations, it follows that the Raciborowice discovery probably dates back to the end of the 5th or rather the beginning of the 4th millennium BC.

One issue still remains to be resolved – an attempt to answer the question with what cultural environment in the Lublin region should be the imported axe related. It seems it was the Lublin-Volhynian community – the last Eneolithic taxonomic unit with strong relations with the Carpathian Basin, which clearly marked its presence in south-eastern Poland (and, of course, in Volhynia). The discovery of a copper axe in the deposit of the Lublin-Volhynian Grave 5 in Książnice (Zakościelna 2010, 393, Pl. 37: 4), dated back to the third phase of this culture (Zakościelna 2010, 28, Pl. 5), also is important. The classic phase (II: 4000-3800 BC) of the Lublin-Volhynian culture is synchronized with the Trypillia BII culture, and the older part of the late phase (IIIa: 3800-3600 BC) with the Trypillia CI (Zakościelna 2006, 90). At that time, the communities of the Funnel Beaker Culture only incidentally visited the loess highlands of south-eastern Poland, and mainly in peripheral zones, beyond the compact range of settlements of the "southern" competitors (Włodarczak 2006, 57).

Around the site where the "single" copper axe was discovered, within a 4 km radius, traces of 21 relics of the Lublin-Volhynian culture were discovered (Fig. 10). They were recorded primarily during surface surveys (Kokowski and Jastrzębski 1983). Further ones (Raciborowice-Kolonia, Site 3) were discovered after their completion. The latter is located almost 3 km southeast from the place of discovery of the copper artefact. They were archaeologically excavated (Bronicki and Hander 2008). The ceramic material dates a small (?) settlement to the classical phase, with the possibility of its continuation also in the late phase (*ibid.*, 23).

The period of the "Funnel Beaker" domination in the loesses areas of western Lesser Poland, the Lublin region and western Volhynia falls a bit later, when the Lublin-Volhynian culture communities have already lost their identity. This happened around 3650-3400/3300 BC (phases II-IIIA – classic – Funnel Beaker culture; Włodarczak 2006, 58). This fact rather excludes the possibility of linking our axe with this taxonomic unit.

Acknowledgements

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FIRST EARTHEN LONG BARROWS IN CENTRAL GREATER POLAND. RESULTS OF TEST EXCAVATIONS IN FBC CEMETERY, SOBOTA, SITE 52

ABSTRACT

Żurkiewicz D., Niebieszczański J., Romaniszyn J. and Teska S. 2022. First earthen long barrows in central Greater Poland. Results of test excavations in FBC cemetery, Sobota, Site 52. *Sprawozdania Archeologiczne* 74/2, 139-164.

The article presents the results of test excavations on one of the first Funnel Beaker culture long barrow cemeteries explored in the middle Warta River catchment, Greater Poland. The excavations at Sobota Site 52 near Poznań covered 80 sq. m and cut across the heads of two (M4 and M5) out of five barrows. Neolithic and Roman period materials were recovered. Burnt animal bones found in excavated barrow mounds were radiocarbon dated, indicating the interval of 36335-3520 BC (at the probability level of 95.4%). As far as can be deduced from the narrow strip explored, the side enclosure of the barrows consisted of ditches dug into the undisturbed soil and filled with boulders of various sizes. A stone envelope/pavement could have also once covered the mounds of these barrows. The Sobota barrows seem to find no analogy in the structures of this type in the Funnel Beaker culture eastern group.

Keywords: Greater Poland, Funnel Beaker culture, earthen long barrows
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INTRODUCTION

Until 2018, the area of central Greater Poland was devoid of discoveries related to classic long earth barrows of the Funnel Beaker culture (FBC) (Żurkiewicz 2021). The forms identified here were classified into tombs of other types, also much younger, dating back to the first half of the fourth millennium BC (Wierzbicki 2013, 234-237).

New research indicates that the discoveries from Sobota may not be the only discoveries of this type for the Greater Poland region. Research is currently underway on the verification of further individual tombs and complex cemeteries. Verifying their existence will significantly change the current image of the community inhabiting the area of the central Warta River basin (Żurkiewicz 2022).

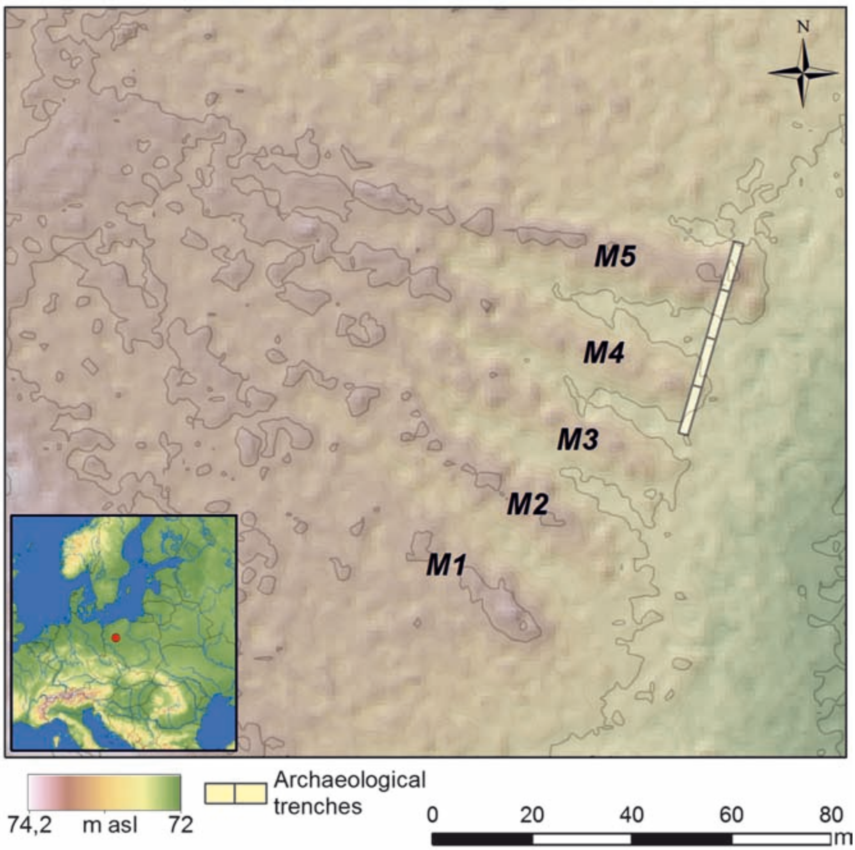

Fig. 1. Sobota, Site 52, Greater Poland. Elevation model of a section of the site, giving the location of the test trenches

Sobota, Site 52 (Rokietnica Commune, Poznań District, Greater Poland province) was discovered in 2018 while reviewing ALS (Airborne Lidar Scanning) images. The discovery was made by Tomasz Wiktorzak (Society of Friends of Łupawa – Valley of Łupawa Megaliths), who informed the authors about the presence of probable long barrows. The information was first verified by a preliminary identification of suspected structures in the field as well as by magnetometry surveys and test boreholes limited to a small section of the site. The results indicated the occurrence of stone boulders within the barrows, thus pointing to the artificial origins of structures (Żurkiewicz *et al.* 2020). The initial work therefore pointed to the possible existence of the first known unchambered long barrows of the FBC in Greater Poland.

The cemetery at Sobota, Site 52 comprises five long barrows (M1-M5), oriented along the NWW-SEE axis (Fig. 1). The structures are not parallel – they fan out from their tails to heads radially. Their state of preservation allows estimation of their original lengths as between 132-145.5 m. The current height of the barrows is below 1.55 m. The discussed structures are located within an area that has been forested since at least the middle of the 19th century AD and therefore they have avoided the agricultural denudation witnessed heavily in Greater Poland for the last 150 years (Jaeger *et al.* 2015; Żurkiewicz *et al.* 2020).

The test excavations reported in this article, were carried in out in 2022, because of the need to define the chronology of these structures and to possibly relate them with the FBC funeral pattern.

EXCAVATION

The conducted fieldwork was financed by the County Office for the Protection of Heritage in Poznań and, importantly, comprised rescue excavations. For this reason, four narrow trenches were established at the head area of two barrows (M5 and M4) on the basis of the magnetometry and drilling results which had provided brief insight into the stratigraphy. The trenches, measuring 10 × 2 m each, were arranged along a NNE-SSW axis. An additional factor determining the layout of the trenches was the distribution of forest undergrowth and a desire to stay clear of the 90-year-old pine trees.

Inside the explored area of 80 sq. m, seven stratigraphical features were revealed and a section of the cultural layer was documented which yielded altogether 56 potsherds of the Przeworsk culture (PC) as well as seven potsherds of the FBC, 22 clusters of small burnt (animal?) bones, seven flints and two metal artefacts (Tab. 1). The site was explored manually, using a system of arbitrary horizontal levels, 0.25 m thick (AL), beginning with the highest point inside the excavation grid located at the top of Barrow M5 (app. 72.75 m. a.s.l. in Trench 1). Each find was located three-dimensionally and the explored sediments were sieved. Geodetic tools including a total station Leica TCR407 and the RTK antenna Leica CS15 with receiver were used during the excavations. All inventoried artifacts were

Table 1. Sobota, Site 52, Greater Poland.
Features recovered in test excavations divided into exploration units

Feature	Layer	Material	Chronology	Amount	Comments
Mound of Barrow M5	AL I	ceramics	PC	8	
	AL II	ceramics	PC	3	
	AL III	ceramic	PC	1	
	AL III	metal	PC	1	
	AL IV	ceramic	PC	1	
	AL VI	flint	FBC?	1	erratic material, retouched flake/ perforator Fig. 6:1
	DUMP	ceramics	PC	6	
	DUMP	bone		1	
M5 Feature 1	AL I	ceramics	PC	17	
	AL II	ceramics	PC	8	
	AL IV	flint	FBC?	1	erratic material, single-platform core Fig. 6:2
M5 Feature 2	AL II	ceramics	PC	5	
M5 Feature 5	AL V	ceramic	FBC	1	Fig. 5:1
M4 subsoil horizon	AL III	ceramic	PC	1	
	AL IV	flint	FBC?	1	burnt retouched blade Fig. 6:3
	AL VI	ceramic	PC	1	
Mound of Barrow M4	AL IV	charcoal		1	
	AL V	ceramic	FBC	1	Fig. 5:2
Barrow M4	DUMP	ceramic	FBC	1	Fig. 5:3
M4 Feature 3	AL V	ceramics	FBC	2	Fig. 5:5
M4 Feature 6	AL VI	flint	FBC?	2	erratic material, retouched blade; burnt flake Fig. 6:4
		ceramics	FBC	2	Fig. 5:4, 5:6
M4 Cultural layer	AL IV	ceramics	PC	2	
		bones		7	
		metal	PC	1	
	AL V	ceramic	FBC	1	Fig. 5:7
		ceramic	PC	1	
		flint	FBC?	1	erratic material, flake
		bones		8	dated sample (3640-3518 BC, 95.4% probability)
	AL VI	ceramic	PC	1	
		flint	FBC?	1	burnt, splintered piece flake
		bones		6	dated sample (3636-3379 BC, 95.4% probability)

recorded within the coordinate system, which allowed for the creation of planigraphy plans.

The stratigraphy is considered as a uniform pattern along the excavated trench. The natural layer recorded at the base of each of the trenches is the Pleistocene glacifluvial sand of fine sorting and yellowish-grey colour. Additionally in the section of the trench passing through Barrow M5, a palaeosoil level with high organic material and iron oxide content was recorded, indicating the surface level on which the long barrow was erected. Above the natural strata, a layer of uniform mound material was documented, consisting of dark yellow sandy-silt with considerable amount of organic material. Its thickness varied from 0.75 m on the slope of Barrow M5 to 0.45 m in the case of M4. Over the lithological unit of the mound proper, a continuous layer of illuvial yellow sandy silts was encountered of app. 0.47-0.35 m thickness (respectively: W profile at the head of Barrow M5, and E profile at the head of Barrow M4). This layer should probably be regarded the same as original mound structure below, however changed by ongoing soil processes within the woodland. Within the unit, a considerable amount of larger stone boulders were documented, which testify to the presence of specific funeral architecture. Aside of repeatable stratigraphical units witnessed in both of the barrows, between them a feature resembling the backfill of a ditch was recorded, which might be the remnant of an original stone enclosure. The fill consisted of brownish sand layer with considerable amount of organic material, and coarser yellowish sands with presence of larger stones.

To compare the stratigraphy with the natural soil development in the area a test drilling provided the following sequence. At shallow depths (0.4 m b.g.l.) the yellowish sands of glacifluvial origins were overlaid by a subsoil horizon consisting of sandy silts of darker colours. The latter continued to approximately 0.07 m b.g.l. where the topsoil of pine forest occurred.

EXCAVATION RESULTS

The archaeological features and artefacts documented during the excavations are linked to different cultural provenances: the FBC discussed below and the PC (see Tab. 1), which will be the subject of another paper.

FBC archaeological features

The two earthen long barrows investigated in Sobota should be treated as belonging to the FBC funeral rite. Apart from them, in the close proximity, just south-east of the M4 structure, a single feature was also assigned to this cultural unit. Due to the narrow extent of excavation, all of discussed below features were revealed only partially (Fig. 2):

Long Barrow M5

This monument is the tallest, and also the northernmost of the whole cluster of barrows. Its relative height may be estimated to approx. 1 m and is about 145 m long and positioned along the WSW-ENE axis. The maximum width of the barrow is approx. 15.5 m (Fig. 1). The test excavation trench was set in the area of widest section of the head-part. The relative height of this section is approximately 1.55 m.

The central part of the barrow was destroyed by a large PC feature (Feature 1). Observation of the stratigraphy confirmed that this structure was dug into the original object. The same situation was documented in the northern slope of the barrow, where another PC feature was identified (Feature 2) and whose lithological markers were less clear. Nevertheless, it contained chronologically consistent material.

The structural elements of Barrow M5 included ditches dug into the undisturbed soil, which formed the foundations for a lateral stone enclosure positioned within the ditch (Feature 4 – northern enclosure, Feature 5 – southern enclosure), a mound and presumable elements of a stone pavement, or an envelope (Figs 2; 3).

Feature 4 – northern enclosure of Barrow M5

The location of Trench 1 didn't allow the complete exploration of the structural elements that are found outside the mound delineated on the plan. Indirectly, the existence of such a structure may be presumed by analysing the W profile of Barrow M5 (Figs 3; 4:1). Its outline is visible also on the horizontal plan of Arbitrary Level (AL) VI. What can be clearly seen there is a trough-like hollow whose fill consists of brown sand with a high organic content. Its documented width is 1.66 m and it visibly juts onto the N trench wall. The base of the visible feature extends at least 0.43 m below the undisturbed soil level in the central portion of the profile. In the feature, no finds have been recorded.

Feature 5 – southern enclosure of Barrow M5

The feature was documented in the W and E profiles of Barrow M5 and on the plans of AL V and VI. This was an extensive structure of a maximum width of 5.76 m (Figs 2; 3; 4:2). Its floor consisted of boulders of various sizes and extended 0.87 m below the undisturbed soil level in the central part of the barrow. The feature fill was yellow medium-grained sand with the subsoil stratum in the upper part of the feature. Perhaps this is somehow related to the degradation of the barrow mound when the original empty or boulder-filled ditch was filled with subsoil horizon and the original layer of the barrow mound. The feature yielded only one artefact: an uncharacteristic FBC potsherds (Fig. 5: 1) recovered from a depth corresponding to where the boulder layer began to be recorded.

Mound of Barrow M5

The best preserved stratigraphy of Barrow M5 was documented in the west section of the Trench, where the mound's surviving deposits were estimated to be 0.67 m thick. They comprise dark yellow silty sands with a considerable admixture of organic matter. Much of the stratigraphy within the excavated section was interrupted by a PC feature dug into the central part and visible mostly in the eastern section. Along the opposite one, the outline

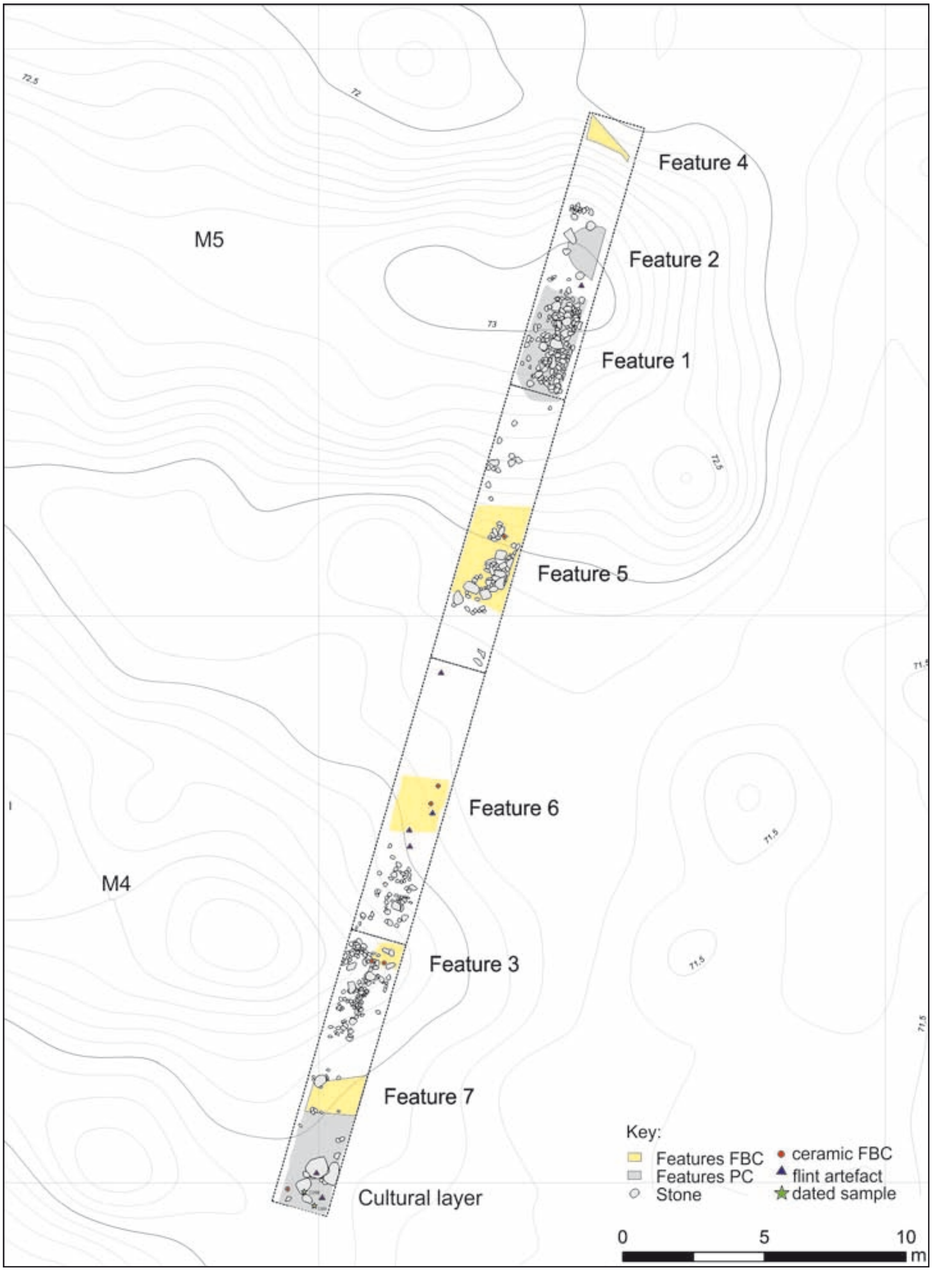

Fig. 2. Sobota, Site 52, Greater Poland.
Features and layers on all exploration levels

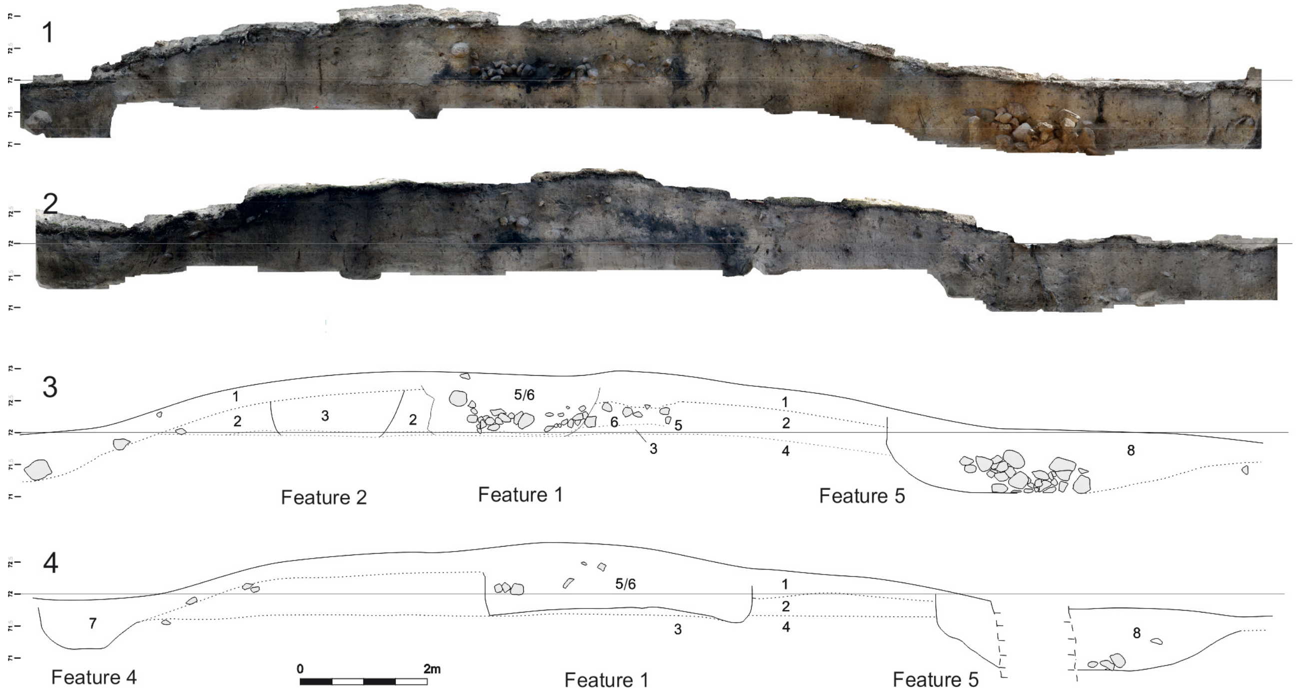

Fig. 3. Sobota, Site 52, Greater Poland. Barrow M5. 1, 3 – E profile; 2, 4 – W profile. Legend: 1 – subsoil horizon, yellow sandy silt, 2 – mound – dark yellow sandy dust with boulders, 3 – hardpan and original soil layer, 4 – undisturbed soil, yellow fine-grained sand – upper surface of glaciofluvial sand layer, 5 – dark grey sandy silt with organic content, 6 – light yellow silty sand, 7 – dark yellow sandy silt with an organic content; 8 – yellow medium-grained sand

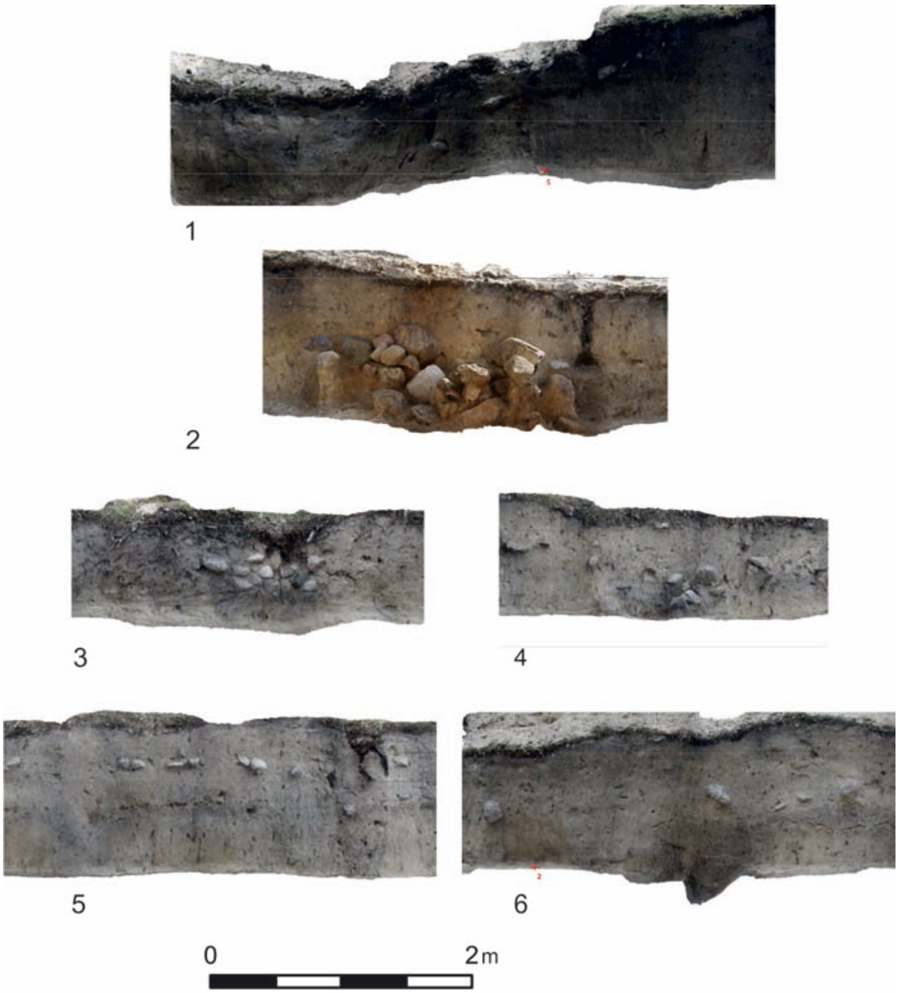

Fig. 4. Sobota, Site 52, Greater Poland. Views documenting selected portions of profiles of Barrows M5 and M4. 1 – Feature 4, E profile, stone envelope elements; 2 – Feature 5, E profile – southern enclosure of Barrow M5; 3 – Feature 6, E profile – northern enclosure of Barrow M4; 4 – Feature 6, W profile, side enclosure of Barrow M4; 5 – mound of Barrow M4, W profile; 6 – Feature 3, profile

of Barrow M5 could be discerned with a distinct border between the natural deposits and the mound's main unit. Within the extent of the excavated part of the barrow, 19 PC pottery fragments were collected, one bone fragment and a piece of metal object. On the last exploration level (AL VI), a retouched flake was found, which could have been a perforator (Fig. 6: 1). In addition, the PC feature fill yielded (in AL IV) one more flint artefact (single-platform core, Fig. 6: 2).

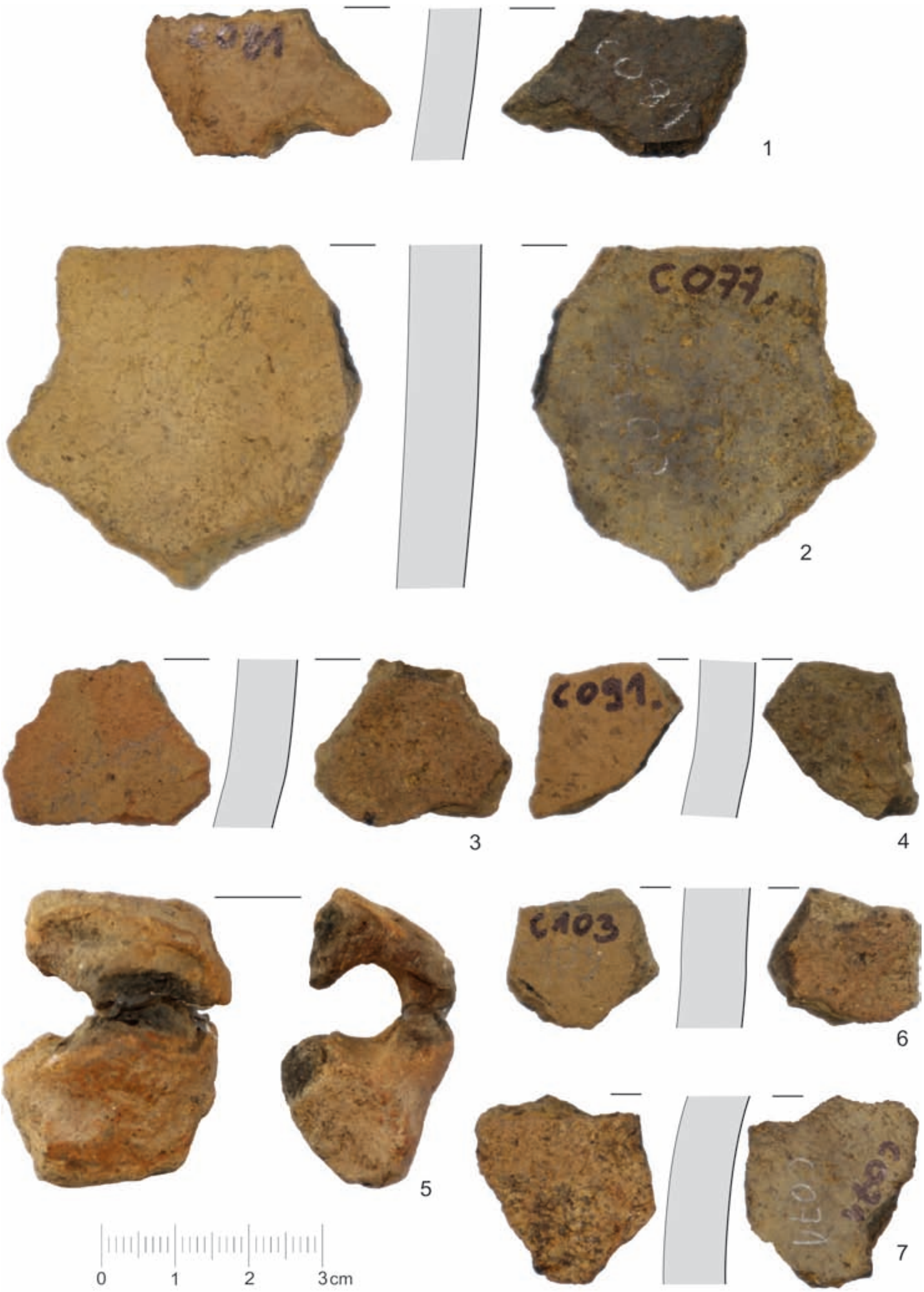

Fig. 5. Sobota, Site 52, Greater Poland. FBC pottery recovered in test excavations: 1 – Feature 5; 2 – Mound of Barrow M4; 3 – Barrow M4 Dump; 4 – Feature 6 ; 5 – Feature 3; 6 – Feature 6; 7 – Cultural layer

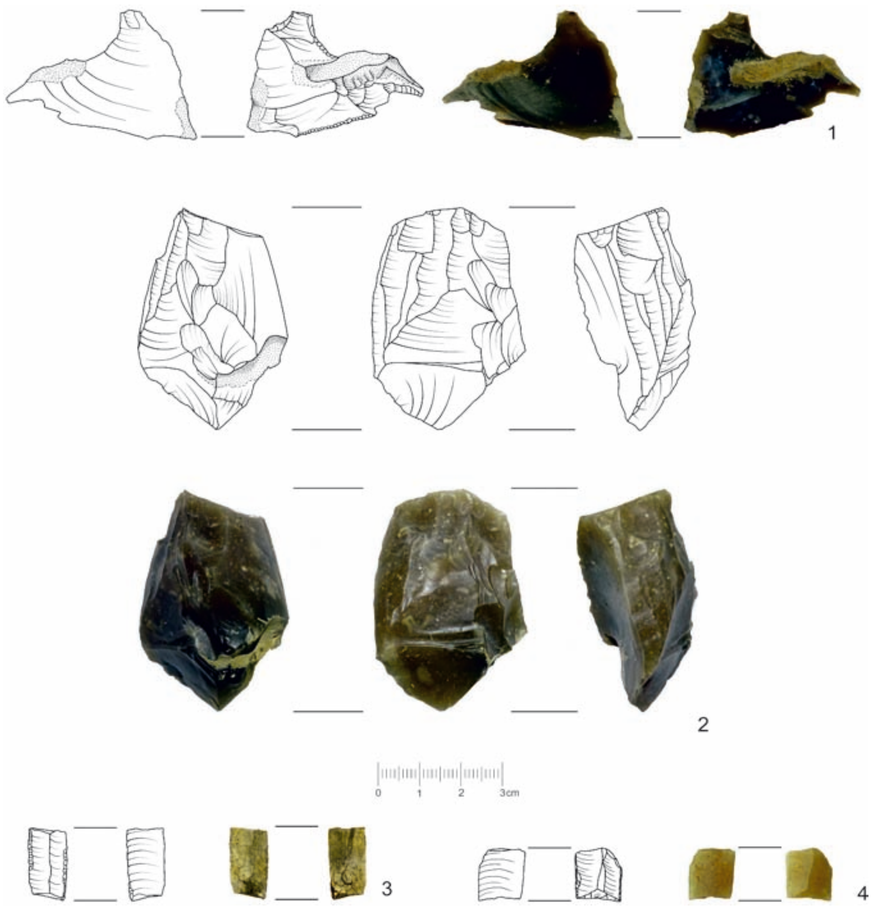

Fig. 6. Sobota, Site 52, Greater Poland. Flint artefacts recovered in test excavations: 1 – Mound of Barrow M5; 2 – Feature 1; 3 – M4 subsoil horizon; 4 – Feature 6

Pavement – stone envelope

This structural element of the mound is the least preserved due to its destruction by the activities of the PC community around the barrow. The evidence for the existence of stone pavement lies in its presence in the undisturbed sections of excavation trench. The compactly arranged stones were positioned within the current subsoil, especially in the northernmost margin of Barrow M5 and documented in both sections (W and E: Figs 3; 4: 1).

If this interpretation is correct, the width of the base of the original barrow mound, measured between the edges of the foundation ditches, may be estimated at approx. 12.2 m (relying on the measurement of the W profile). The present-day mound width, following from the contour-line plan of the feature and oscillating around 15.5 m, is the effect of the degradation of the original mound that, once the foundation ditches had been filled, expanded to reach today's dimensions.

Long Barrow M4

The feature's total length is approx. 140 m while its axis deviates NE by about 23.5 degrees from the W-E line and coincides with the axis of Barrow M5 in the tail portion. Barrow M4, within the grid, was covered by Trench 3 and Trench 4, which run 2.6 m from its head at a maximum. At the northern and southern extremities, within the E section of the test excavation, both trenches cut across the barrow head (Figs 1; 2).

The particular structural elements of Barrow M4 resemble those of Barrow M5. These are foundation ditches (Features 6 and 7), the mound layer and portions of a stone pavement (Fig. 7). In addition, a single FBC feature was recorded underneath the mound, the function of which is difficult to interpret (Feature 3). The mound width, measured between the inner edges of the foundation ditches, is 9.6 m while the mound height, as it is determinable in the profile, reaches approx. 0.71 m (from the undisturbed soil/hardpan stratum to the top of the humus). It seems that in all likelihood a so-called 'cultural layer' is connected to Barrow M4. This is a cluster of boulders, single PC and FBC pottery sherds, flints and numerous small burnt (animal?) bones (Łukasik 2020).

Feature 6 – northern enclosure of Barrow M4

Its maximum width is 1.22 m while its depth measured from the level of subsoil is about 1.63 m. The feature was documented in the W and E profiles of the barrow and in AL V-VI (Figs 8; 4: 3). The feature backfill varies within the 2-m-wide investigated space. In its W part, it consists of brown silty sand with an intensive layer of small boulders, while in the E portion, the feature is filled with similar brown sand with a high organic content. The feature yielded two FBC pottery sherds (Figs 5: 4; 5: 6) and a single fragment of a flint blade (Fig. 6: 4). The bottom of Feature 6 is dug approximately 0.27 m into the undisturbed soil level.

Feature 7 – southern enclosure of Barrow M4

The feature resembles Feature 6 in many respects. However, the distribution of boulders in the E profile of Trench 4 is much less compacted, making it necessary to mark a slightly wider, measuring 1.43 m, section of the feature (Figs 2; 4: 4; 7). Its fill resembles that of Feature 6 as well: in the W profile: light grey silty sand with boulders; while closer to the E profile —brown silty sand with a higher organic content. The feature's base extends 0.28 m below the level of undisturbed soil. At the southern edge of the feature, several fragments of burnt, probably animal, bones were documented. They were found also in a higher arbitrary level (AL IV) where the limit of the feature was not yet noticeable.

The difficulties in the interpretation of the course of ditches and their construction arise from the rather less favourable location of trenches vis-à-vis the identifiable outlines of Barrow M4. While the W profile of Trench 3 and Trench 4 probably still cuts across the structures of a side stone enclosure, the E profile should rather expose the layers of the barrow head.

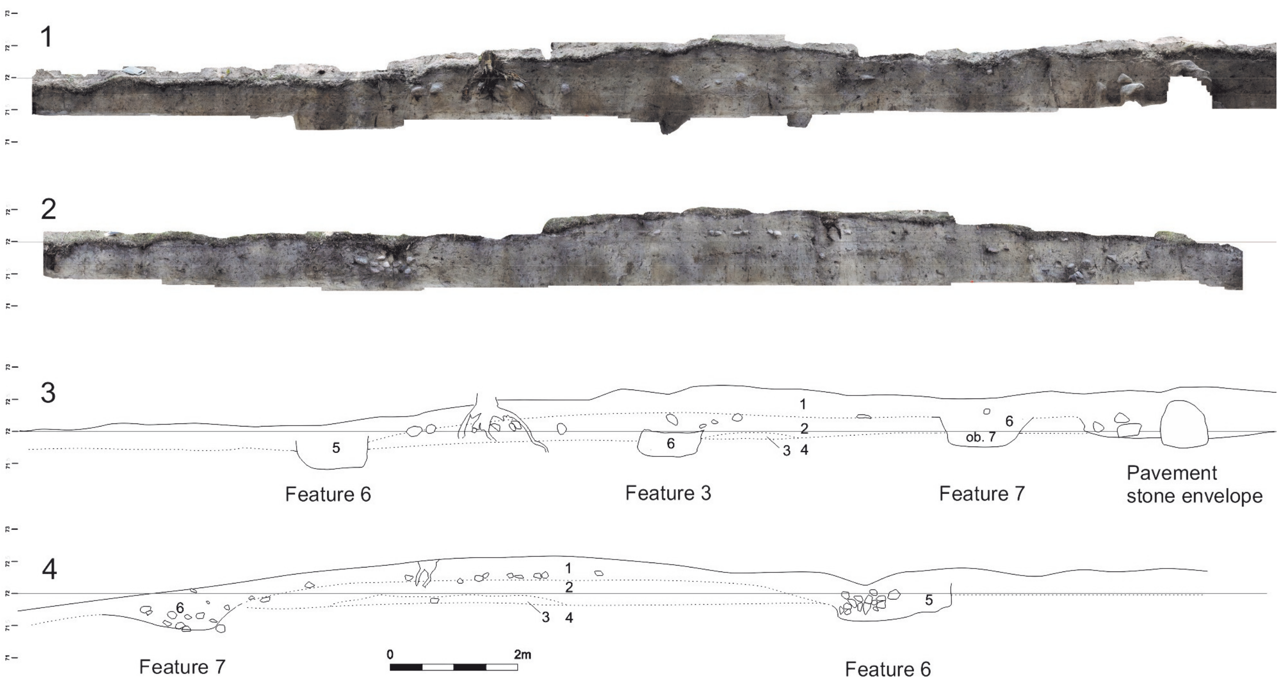

Fig. 7. Sobota, Site 52, Greater Poland. Barrow M4. 1, 3 – E profile; 2, 4 – W profile. Legend: 1 – subsoil horizon, yellow sandy silt, 2 – mound – dark yellow sandy silt with boulders, 3 – hardpan and original soil layer, 4 – undisturbed soil, yellow fine-grained sand —upper surface of glaciofluvial sand layer, 5 – dark grey sandy silt with organic content, 6 – light yellow silty sand, 7 – dark yellow sandy silt with organic content; 8 – yellow medium-grained sand

Mound of Barrow M4

The barrow mound is built of dark yellow silty sand with boulders. It is thickest at the barrow's top, where it can be estimated at approx. 0.38 m (Figs 2; 4: 5; 7). From the level of the undisturbed soil – the top of the glacifluviall sand – it is separated, as in Barrow M5, by a hardpan stratum, recordable at a length of approx. 3.36 m in the central sector of

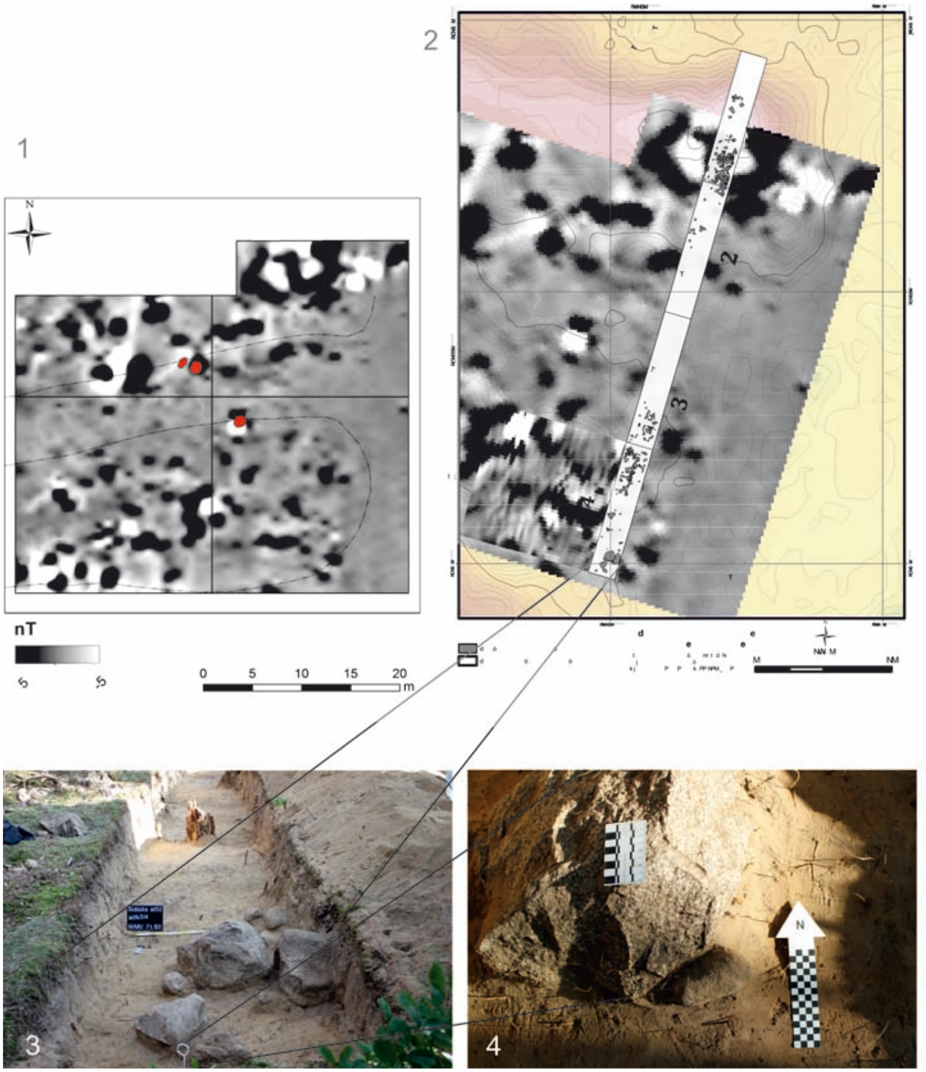

Fig. 8. Sobota, Site 52, Greater Poland. Results of magnetometry survey of Barrows M5 and M4 and their excavation verification. 1 – Narrow value range (5/–5 nT) of magnetometry survey result image prior to test excavations; 2 – verification of magnetometry survey by test excavations; 3 – Trench 4, stone structure in the head of Barrow M4; 4 – traces of a tool use on a boulder

Barrow M4 profile. From all the levels of exploration of the mound the following artefacts were recovered: two FBC potsherds (Fig. 5: 2, 3), two PC potsherds, a single burnt retouched blade (Fig. 6:3) and charcoal.

Pavement – stone envelope encasing Barrow M4

Within Barrow M4, a stone pavement is recordable (a) in the feature sections, (b) within the planigraphy of AL III and IV and (c) on results of the magnetometry survey.

(a) In the sections of Trenches 3 and 4, less compact, horizontal arrangements allow to draw the limit of the mound's top, separating it from the subsoil stratum (Fig. 4: 5).

(b) Rock fragments, visible in the planigraphy of Barrow M4, were recorded already during the removal of the turf. Their considerable concentration was recorded in the first arbitrary level explored in this feature (AL III), covering the subsoil. Another major accumulation was found within the mound, however boulders were clearly concentrated in its higher portions.

(c) The magnetometer survey preceding the excavation showed that the line of Trenches 3 and 4 did not cover anomalies of a particularly high intensity (Żurkiewicz *et al.* 2020). Nevertheless, in the exact spots of registered anomalies, the excavations exposed boulders (Fig. 8); and vice-versa, where no anomalies were recorded within the magnetic image, there were no boulders recorded in the course of excavations (area between M5 and M4). The verification of non-invasive investigation justifies the hypothesis about the connection between all recorded anomalies and horizontal accumulation of stone fragments at small depths (distal, western portion of Barrow M4).

Feature 3

The feature was recorded in AL V. Its fill was made up of light grey sand with a high organic content. In terms of lithology, the fill strongly resembled a layer in Feature 6 – in the northern ditch of Barrow M4, identifiable in the same section (Fig. 4: 6). The feature was documented in the horizontal plane and in the E section of Trench 4 (Figs 2; 8). Its fill was dug approximately 0.25 m below the level of undisturbed soil and yielded two FBC potsherds.

Cultural layer 1

Due to the limited field of observation in the southernmost section of Trench 4 and the presence of numerous archaeological artefacts, it was decided to distinguish a cultural layer at this spot. Lithologically the layer was a mixed subsoil horizon, consisting of yellow sandy silt. Its distinct limits coincide with the mound's edge; one level down —with the southern line of the foundation ditch (Feature 7) of Barrow M4. South of this feature, in AL IV-VI, the following artefacts were discovered: a cluster of burnt bones, most likely animal ones, four PC potsherds, one FBC potsherd, one uncharacteristic iron object and two flints (splintered piece flake). Their distribution across the arbitrary levels is shown in Table 1. Additionally, many large stones were also recorded within the layer.

Data gathered from Trench 4 (the outline of the largest boulders protruding into the E profiles of Trench 4) can be compared to the results of magnetometer survey (Fig. 8). The latter suggest that a structure, taking the form of a cist, or stone-lining, continues outside the excavated area. The structure may have been more complex and perhaps a neighbouring magnetic anomaly is its prolongation towards W (the authors would like to thank Cezary Bahyrycz for support in carrying out magnetometr survey). The feature backfill was non-homogeneous as it contained both FBC and PC materials. Its cultural attribution was defined by two radiocarbon dates obtained from burnt animal bones (see below). However, materials were linked also to the PC and there were characteristic traces shaped like very distinct flutes on a large boulder (Fig. 8).

FBC pottery from the Site

The assemblage of FBC pottery comprises eight finds of a total weight of 59 g. Most (7 sherds) are connected to Barrow M4 and were found within features: two sherds in Feature 3, two sherds in Feature 6 and one sherd in the barrow's mound. In addition, a single sherd was recovered from a stone concentration in the southern section of Trench 4 (Feature 8). A single sherd was also retrieved from a dump unequivocally linked to the exploration of Barrow M4 (Fig. 2; Table 1). Only one sherd was connected to Barrow M5 and was recorded in its southern stone enclosure ditch. Such a small collection should be associated with the rescue character of the excavations.

The seven sherds are uncharacteristic and unornamented parts of bellies of various vessels. Moreover, the assemblage comprises one handle (in two pieces), probably representing a lumpish type, horizontally perforated (Fig. 5: 5). They were assessed technologically and stylistically (based on Czebreszuk *et al.* 2006).

The thickness of walls was predominantly 8 mm (4 pieces), with single specimens being 9 mm or 6 mm thick. The sherds were made using the technology known as A or possibly AB, which means that their body was tempered with fine sand and fine and medium grog. There are doubts, however, if the sand was intentionally used. Their inner and outer surfaces are smooth and even, in one case (C071), the outer surface may bear the traces of rough-casting. This is the only sherd whose fracture is distinctly two-coloured. The fractures of the others are either navy blue or black.

The claim about the homogeneity of this assemblage, if any, may be based solely on technological evidence. The domination of type A or AB technologies in it assigns this assemblage to the technologies of classical FBC.

Flints from the Site

Excavation produced 26 potential flint objects. However, only seven were classified as bearing traces of knapping or being flint waste left after producing a proper tool.

Two flints were recorded within the Barrow M5: in a secondary context, one in the last arbitrary level of Feature 1 and the other in the barrow mound. Two flints were found in the cultural layer distinguished next to Barrow M4 while another two – in Feature 6 (northern foundation ditch of Barrow M4). A single blade was recovered from the subsoil horizon, covering the mound of Barrow M4 (Table 1, Figs 2; 6).

These are mostly small uncharacteristic artefacts that bear traces of burning in three cases. Despite lack of distinguishing attributes, all flint artefacts fall within the ambit of FBC knapping tradition in terms of production technology, typology and raw material selection. They also correspond with other FBC assemblages from the Polish Lowlands (Domańska 1995; Dmochowski 2005; Jankowska and Pyżewicz 2006; Domańska 2016). Therefore, in the absence of any other chronological references at the site, the artefacts might be assigned to the FBC. The only questionable artefact is a single-platform core which technologically corresponds with Mesolithic knapping tradition (Dmochowski 2019, 83, 86, figs 2, 3). Nevertheless, it shall be stressed that there are similar finds of single-platform cores from FBC context in Greater Poland (Kabaciński and Sobkowiak-Tabaka 2019, 46, fig. 13: 1, 3) and Kuyavia (Domańska 2013, 26, fig. 6: 1). Moreover, described core was found in a PC feature, therefore it must have occurred there with redeposited soil.

Chronology

Three samples derived from excavations were dated: two fragments of burnt bones from the cultural layer from two levels (Sobota 52_C069 and Sobota 52_C098): one corresponding to the floor of the northern foundation ditch (Feature 7), the other lying 0.18 m higher, and a soil sample (palaeosoil) from the central sector of the W profile of Barrow M5 (Sobota 52_T022). The following dates were obtained:

Sobota 52_C069	Poz-141328 0.0%N 0.3%C carbonate 4780±30 BP
Sobota 52_C098	Poz-141332 0.0%N 0.3%C carbonate 4750±35 BP
Sobota 52_T022	Poz-141104 0.7mg C 4120±35 BP

The dates set two distinct time horizons. The two obtained for the burnt bones from the cultural layer jointly set an interval of 115 years from 3635 to 3520 with a 95.4% probability (Fig. 9). Meanwhile, the third date, obtained for the original humus (palaeosoil) found underneath the mound of Barrow M5, is much younger. Its extreme values related to a probability of 95.4% set a time range between 2871-2576 BC, which might be the result of charcoal migration along the soil profile of the mound.

The last-cited date, obtained for a sample of palaeosoil, extends beyond the age of barrow-raising. The excavations did not produce any evidence that could culturally justify the placement of the dated material at that time. Hence, it may be assumed that post-depositional factors of soild processes must have produced this inversion. In turn, the dates obtained for the burnt bones may be considered satisfying, but it must be stressed they came from a feature extensively disturbed by later PC population actions. This is evidenced, for instance, in PC pottery found on the floor of the dated layer (Table 1), which alas prevents an analysis of the stratigraphic context of the samples with respect to the barrow.

Sequence of barrow raising

The descriptions of particular structural elements of the barrows provided so far are sufficient to draw conclusions as to their size and appearance. Although they differ slightly in size, both structures were erected using similar techniques.

Barrow M5, its head being approx. 12.2 m wide, is slightly larger than Barrow M4. The width of the latter, measured at its excavated head portion is almost 9.6 m (the excavation trench did not cut across the barrow head where it was the widest). The overall lengths of the barrows are mere estimates, based on available contour plans and were not verified during the excavations. A similar limitation applies to conclusions as to the design of the barrows. What is being said about their design and manner of construction refers solely to the investigated portions of side stone enclosures and does not rule out different construction techniques in other portions.

A reconstruction of the barrow building scenario suggests that at an initial phase, perhaps on an original ground level from which humus had not been removed (traces of soil in the W profile of Barrow M5), the entire cemetery was laid out. The space could have been originally used by FBC communities (Feature 3, underneath the mound of Barrow M4). The arrangement of the barrows argues for the opinion that the entire cemetery was laid out and built over a short time. Namely, the symmetry axes of all barrows intersect in a manner far from being accidental. This strongly suggests that the cemetery was the effect of a carefully thought-out, planned or even designed action.

Next, at least in the head sectors, side foundation ditches were dug, with the excavated earth partially also used to build mounds. The lithology of the mound layers does not vary in any significant manner, hence it can be presumed that the earth necessary to bring mounds to the desired height was taken from the immediate surroundings of the site.

At a further construction stage, the side foundation ditches were filled with boulders of various sizes, forming thus a kind of trim, or a foundation supporting pavement — a stone envelope that must have covered the mounds that were originally not very high. In theory, such a design had many technical advantages. It isolated rather loose mound layers of silty sand and sandy silt from excessive precipitation and water penetration. Furthermore, it safeguarded the mounds in the event of a periodical water-table rise (the barrows lie on the bottom of a river valley in the immediate vicinity of an area that is water-logged today). Finally, the stone facing of the mound surface had an undeniable symbolic effect – it showed off this material. If this design was followed in other parts of the Sobota barrows, it would explain why no distinct side stone enclosure (large boulders) was recorded along the walls of all the barrows.

Advancing with time, the destruction of such barrows would start nowhere else but with the stone envelope. It would first lose its compactness due to various natural causes (burrowing animals, plant roots, *etc.*) and anthropogenic ones (PC features), letting water into the mound layer. As a result, the mounds would gradually spill and cover foundation ditches with time, slowly adopting the barrow outlines we see today.

What evidence was gathered shows that this structural design cannot be assumed to have been used with all barrow parts. Relying on the observations concerning Barrow M4 related earlier, where the line of trenches cuts across a part of its head, it can be tentatively presumed that this part of the barrow was differently designed. The difference may lie in not only construction traits, but also in the material from which the head wall was built. Its design could have employed a characteristic break in the wall outline, known from other long barrows. Alternatively, it could have been built of wooden elements, concluding from the accumulation of organic matter in foundation ditches, which are recordable here (E profile, Barrow M4). This concept needs however, further research. The results of excavations do not support any claims either concerning burials in these imposing structures. Nor do the results rule out the possibility that both barrows originally had megalithic side stone enclosures that were completely removed later. The present-day state of preservation of the entire cemetery prevents archaeologists from recording any larger pieces of rock inside the outlines of the barrows. After some 3500 years, the top of the mound of Barrow M5 and the southern slope of Barrow M4 again attracted human interest, this time by a PC community.

ANALOGIES AND REFERENCES

The Sobota dates may be referred to a set of about 30 determinations obtained for 11 sites with unchambered long barrows, belonging to the FBC Eastern group (Król 2021, 99 fig. 33; Papiernik *et al.* 2018). In the interval set by the extreme values of the Sobota determinations (3640-3379 BC at the probability of 95.4%), it is very likely that phenomena dated at the following sites could have taken place as well: Jastrzębiec 4 (Poz-25823 4840±50 BP; Poz-25550 4790±40 BP; Rzepecki 2011, 23-36) and Sławsko Dolne 34 (Ki-5071 4790±80 BP; Kośko 2006, 23). Whereas, features dated in Zbierzyn, Site 3A (Lod-159 4720±110; Gorczyca 1989) and Gaj, Site 1 (Poz-83418 4700±50 BP; Poz-83419 4700±50BP; Papiernik *et al.* 2018) could have been contemporaneous or slightly younger. Most of these determinations (except for Zbierzyn) were made for short-lived material (animal and human bones) and direct our attention to three main types of unchambered long barrow design (Fig. 9).

The Sobota Barrows compared with FBC Eastern group of unchambered long barrows. In the area covered by the FBC Eastern group, unchambered long barrows are found in several distinct clusters that are not co-extensive with the territorial range of this cultural unit. They are the most numerous in Kujawy where the largest number of their types were distinguished as well (Chmielewski 1952; Jażdżewski 1970; Kośko 2000). The second-

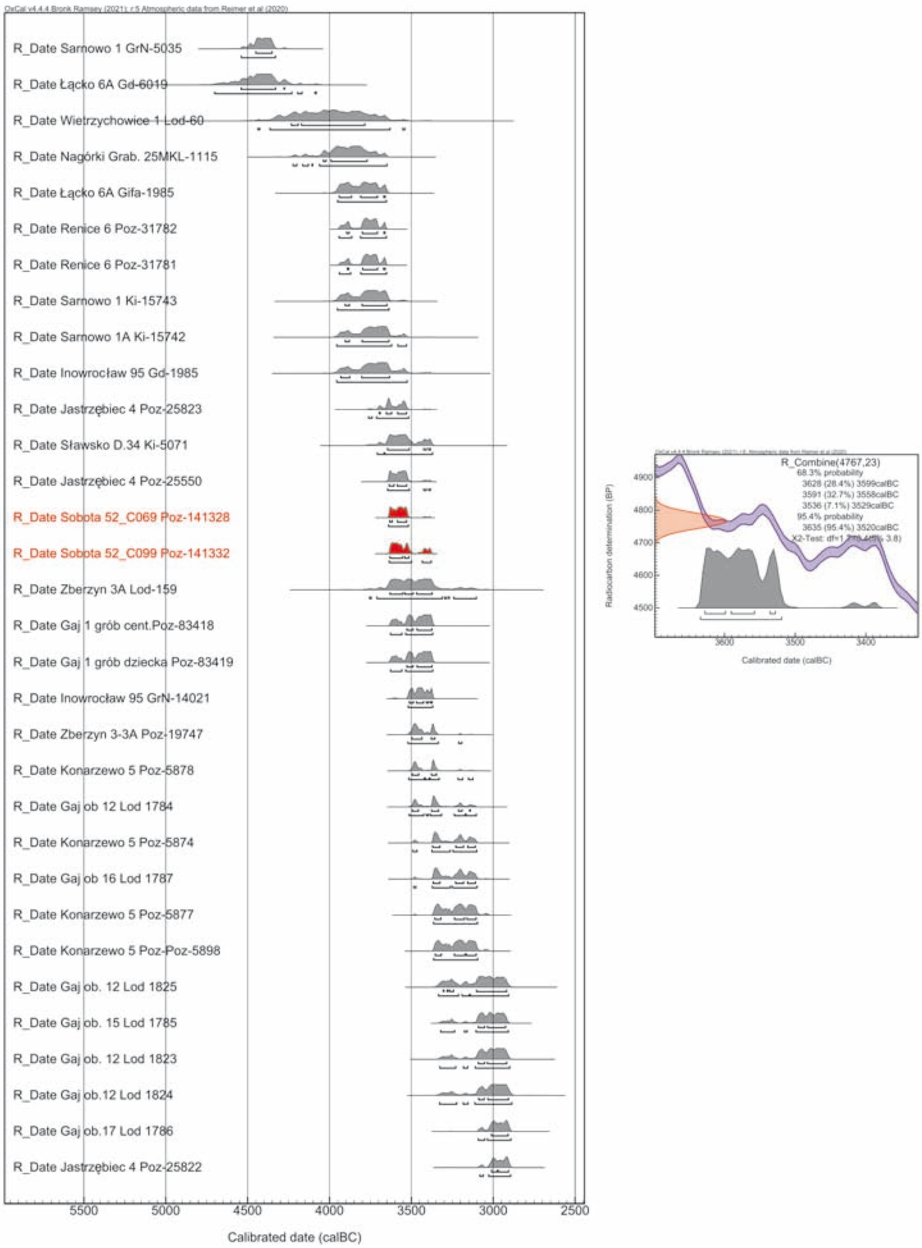

Fig. 9. ^{14}C determinations made for the cultural layer in Sobota Site 52 compared to other available ^{14}C determinations of the earthen long barrows in the FBC Eastern group

largest cluster is found on the middle and lower Oder River and in West Pomerania (Chłodnicki 1997; Rzepecki 2011; Matuszewska and Szydłowski 2011), while the Central Pomerania cluster is smallest (Siuchniński 1969; 1972; Czarnecki 1971; Jankowska 1980; Weber 1983; Wierzbicki 1999). Single sites are known from Mazovia (Jażdżewski 1936, 191, 192, 294, 295), Silesia (Wojciechowski *et al.* 2002, 177–186) and Greater Poland (the discovery described in this article, Żurkiewicz *et al.* 2020).

The unchambered long barrow clusters are dominated by the Kujawy type (Jażdżewski 1970, 15–16). This groups trapezoidal barrows with stone enclosures made of large pieces of rock; rectangular, round and oval ones, although very rare, do occur too. It is possible to include the structures from Zberzyn and Gaj (Gorczyca 1989; 2005; Papiernik *et al.* 2018) in this type. In the FBC Eastern group, they account for more than 80 percent of the structures so far discovered. In the regions where unchambered long barrows were fewer (Silesia, Mazovia), this was the only barrow type recorded (Król 2021).

In Western Pomerania and Kujawy, rare discoveries of barrows with a foundation ditch and wooden enclosure have been made (about 10% and 6% of barrows, respectively) (Rzepecki 2011). To this type should be assigned the discovery from Jastrzębiec, Site 4 (Rzepecki 2011, 23-36), mentioned earlier in the context of an absolute age determination similar to that for the Sobota barrows.

Other barrow types are only encountered in Kujawy, within the Eastern group, and in Central Greater Poland. They include barrows with stone enclosures built of small boulders supplemented with a pavement/stone envelope or having only the last-mentioned element (Kośko 2006). A barrow from Sławsko Dolne that is dated similarly to the Sobota barrows may also be assigned to this type.

Much fewer in number, barrows with mixed stone-wooden enclosures are either trapezoidal or rectangular (Łącko, Site 6-6A; Domańska and Rzepecki 2004, 419-433; Domańska 2006, 289-299); Nagórkach Grabowskich, Site 25 (Kittel *et al.* 2012; Król *et al.* 2012, 167-182).

A major parameter characterizing long barrows, making for their imposing appearance, is their length. The longest, discovered in the Eastern group, attain as many as 170 m (Kujawy, Rzeszynek, Site 1, Łebiński 1888, 36; Chmielewski 1952, 95). They always represent the Kujawy type and concentrate in the eponymous region. There, the average length of barrows with a large-boulder enclosure is 74.5 m. The average length of such barrows in other regions where they occur in the FBC Eastern group is 64.3 m in the Chełmno Land (max. length: 68 m, Narva-Plebanka, no site no., Chmielewski 1952, 97), 29.9 m in Central Pomerania (barrow in Łupawa, Site 18, was the longest in this region – 56 m; Weber 1983: 7), 42.3 m in West Pomerania (barrow in Kurcewo, Site1, was the longest in this region – 157 m; Dorka 1939, 154), 27.5 m in Lower Silesia (Barrow II in Muszkowice, Site 18, was the longest in this region – 36 m; Wojciechowski and Cholewa 2006, 227). From Mazovia, a single long barrow is known – Rybno, Site 1 – which is 50 m long (Chmielewski 1952, 97).

For the other barrow types, dimensions are available only for barrows from Kujawy and West Pomerania. The type of a barrow with a wooden enclosure placed in a foundation ditch is not more than 80 m long in Kujawy (Redecz Krukowy, Site 20; Król 2021, 59; Table 1), with the average length being 24 m. West Pomeranian barrows are considerably smaller. The longest one, exposed in Renice, Site 6, was 34 m long (Rzepecki 2011, 75). The average length for this region is 10 m. Among the mixed, stone-wooden structure barrows, known only from Kujawy, the longest one was discovered in Nagórki Grabowskie, Site 25. It was 30 m in length (Król *et al.* 2012).

CONCLUSIONS

The comparison of the Sobota barrows with similar structures in their nearest vicinity in the FBC Eastern group in terms of construction, size and chronology allows their preliminary classification. A review of available chronometric data shows that barrows of various types could have been built in a relatively short span of time. As regards their design, within the explored space, the Sobota barrows are distinguished by rather deep foundation ditches, partially filled with stones. Formally, this characteristic makes them resemble barrows with a foundation ditch and a wooden enclosure, for instance, Jastrzębiec, Site 4. However, in Sobota, the ditches appear to have been much deeper and wider; in addition, they were filled in part with compact rock arrangements. However, no clear traces of wooden structures were noticed within them, possibly due to the porous sandy material in which the organic remains were dissolved. Barrows combining wood and stones in their design are known only from two sites in the Polish Lowland. In Nagórki Grabowskie, Site 25, in identifiable ditch sections, only single stones and postholes were recorded (Kittel *et al.* 2012). In Łącko, Site 6-6A, in turn, a foundation ditch could not be discerned; only single postholes were found in the stone enclosure of Barrow 2 (Domańska and Rzepecki 2004, 419-433; Domańska 2006, 289-299).

Furthermore, it transpires that an important design characteristic of the Sobota barrows is a stone envelope/pavement, covering the earthen mound. In barrows known from the FBC Eastern group, this element is noticeable best in these whose enclosure/edging was built of smaller rock fragments or these whose stone envelope/pavement was all that had been left of them. These characteristics are shared by a barrow from Sławsko Dolne, Site 34, but it is not certain if it was covered by an earthen mound protected by a stone envelope. Other locations where it can be presumed that such an envelope existed include: Inowrocław 95, Barrow I (Feature 482), Kijowiec 4 and Łupawa, Site 2 (Czerniak and Kośko 1993, 5-50; Gorczyca 2005, 117-132; Wierzbicki 1992; 1999). The closest to the Sobota barrows in terms of distance, the structure at Konarzewo, Site 5 (Feature 2242) yielded burnt human bones from within the stone envelope (Wierzbicki 2008, 25-55; 2013, 234-236). A stone pavement/envelope is a characteristic shared by many single graves dug into barrow mounds.

The dimensions of particular barrow types, when compared with the size of the Sobota barrows, show that the latter fit best into the size category typical of megalithic (Kujawy) barrows. However, it must be remembered that the overall lengths of other, less numerous barrow types, are not known and are currently impossible to determine for various reasons.

SUMMARY

The dimensional and morphological uniformity of the Sobota barrows makes them classifiable, with a measure of caution, to the Kujawy type. An argument in favour of this is supplied by the recording of rather large boulders in the foundation ditches (*e.g*. Feature 5 – the southern enclosure of Barrow M5). The uniqueness of the Sobota barrows lies in the very fact of recording ditches filled with boulders. This is a characteristic that simply cannot be found in any other excavated long barrow in the FBC Eastern group. Only barrows that have a foundation ditch are always connected to a wooden enclosure and their maximum length stays below 100 m (Słonowice, Site 5, FBC Southeastern group; Tunia 2006, 336). In terms of dimensions, the Sobota cemetery is consistent with the suggested type of unchambered barrows whose average length, verified in excavations, is 74.5 m in Kujawy. If in field investigations, the estimated lengths (145 m and 140 m) are going to be confirmed, these would be the third-longest barrows, among published ones, in the FBC Eastern group and the only ones located outside Kujawy (Rzeszynek, Site 1 – 170 m in length and Ziemięcin, site no. unknown – 160 m (Łebiński 1888; Chmielewski 1952, 51).

An unequivocal interpretation of the Sobota field discoveries is made harder by the limited space that could be excavated. A research project that is currently underway attempts to verify whether the design and chronological characteristics revealed in Sobota have analogies in other unchambered long barrows in the middle Warta River basin.

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THE SETTLEMENT OF THE BADEN CULTURE AT GRODKOWICE SITE 4, WIELICZKA DISTRICT, IN THE LIGHT OF THE RESULTS OF EXCAVATION FROM 1959, 1962-163 AND NEW ANALYSES

ABSTRACT

Borowska A. The settlement of the Baden culture at Grodkowice Site 4, Wieliczka district, in the light of the results of excavation from 1959, 1962-163 and new analyses. *Sprawozdania Archeologiczne* 74/2, 165-188.

This paper presents results of excavations conducted by Zdzisław Sochacki at Grodkowice Site 4 in 1959, 1962-1963. An area of 1.15 hectares was explored during these three seasons and 50 features of the Baden culture were unearthed. The recovered materials have never been published completely. The storerooms of the Faculty of Archaeology of the University of Warsaw accommodate a collection of pottery vessels from this site, and these vessels were subjected to a number of analyses. As a result of multi-proxy approach in the analysis of the pottery, mainly examination focussing on plant macro-remains, it was possible to establish the type of the economy of the Baden culture society at the site. Mineral and petrographic analyses indicated the composition and details of vessel production. Another important aspect of the study is an attempt at establishing the chronology of the settlement in relation to the pottery style. Radiocarbon dating contributed to clarification of this issue.

Keywords: Baden culture, settlement, ceramics, radiocarbon dating, petrographic analysis
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INTRODUCTION

The objective of this article is to provide a general presentation of pottery materials recovered in the course of excavations conducted at Grodkowice Site 4, Kłaj municipality, Wieliczka district, Małopolskie Voivodeship (Polish Archaeological Record 104-59/58). The work was directed by Zdzisław Sochacki (1927-2011), who explored a part of a Baden culture settlement during three field campaigns (1959, 1962, and 1963; Sochacki 1963; 1964; 1971). Apart from lithic material, pottery was the main type of artefacts recovered from the site. Except for a few fragments, the pottery can be regarded as homogeneous in terms of the cultural affiliation. However, the analyses have never been finished and results of that work have never been fully published. Therefore, this is a good reason to present at least brief general information regarding selected aspects of the pottery discovered at the settlement. It must also be added that some of the artefacts were examined by multi-proxy approach, which is a perfect extension of the research done in the site.

HISTORY OF THE RESEARCH AND THE AVAILABLE SOURCES

The interwar period was a critical one in the history of the site, when a Baden culture amphora was found by accident in 1937. Many researchers must have realized the significance of this discovery since soon after the War, Kazimierz Bielenin decided to organize a surface survey in the area. He found more fragments of Baden culture vessels and flint tools, which confirmed earlier speculations. However, research was conducted on thi site with greatest intensity in the late 1950s.

Adam Krauss explored a Baden culture settlement-pit in the course of rescue excavations in 1957 (Sochacki 1964, 35). This discovery was definitely a stimulus to launch systematic excavations, which were conducted by Sochacki in connection with land development involving the construction of the Experimental Laboratory of Plant Cultivation and Acclimatization (Zakład Doświadczalny Hodowli i Aklimatyzacji Roślin – ZDHiAR) in Grodkowice.

The major difficulty is the absence of the field documentation from the excavations, as well as the fact that an unidentified number of artefacts have been lost. Although some of them have been published, some of the artefacts cannot be found in the storerooms of the Faculty of Archaeology of the University of Warsaw (FA UW) or in the collection of the Province Heritage Monuments Protection Office in Kraków. Thanks to personal communication from Albert Zastawny, whom I am sincerely grateful, it is clear that they are not to be found in the Archaeological Museum in Kraków or its Branch in Nowa Huta. All attempts at establishing the location of the artefacts and documentation have failed. Consequently, the analyses and conclusions must be based on incomplete information from Sochacki's publications and materials collected by FA UW.

The results of previously conducted analyses have appeared in literature solely in form of short communications and reports (Sochacki 1963; 1964; 1967; 1970; 1971; 1980). Considering the available data, it was concluded that 50 features were unearthed in the course of the three excavation campaigns.

During the first season, launched in 1959, 20 features were unearthed, however, only 13 were explored. Another 17 features were discovered in 1962, but 15 were explored. In the final year of the work 13 pits were excavated and explored, together with another nine from the previous seasons. Owing to the rather fragmentary information, it is very difficult to estimate the area of the excavations and of the site. On the basis of the published plan it can be supposed that an area of approx. 1.15 ha was explored. However, the discoveries led Sochacki not only to confirm the existence of an extensive Baden culture settlement, but also to establish that the settlement probably occupied an area of approx. 2.5 ha (Sochacki 1963, 35). Simple calculations clearly indicate that at least a half of the site is still to be excavated.

The rather sparse amount of information about the region of Wieliczka-Bochnia is detrimental to the number of publications concerning this area (Zastawny 2000, 15, 16). The main reason is the type of research conducted there. Out of 41 sites, 35 have only been subjected to surface surveys. A mere seven settlement sites, including Grodkowice 4, were excavated, at least partially: Brzezie Site 1, Chełm Site 1, Gdów Site 2, Szarów Site 5, Wiatowice Site 2, Kokotów Site 13. Out of the latter, only three have been published to a considerable degree: Brzezie Site 1 (Godłowska 1969a; 1969b), Chełm Site 1 (Cabalska 1969; Cabalska 1975; Zastawny and Brzeska-Zastawna 2018) and Kokotów Site 13 (Zastawny 2014).

A working visit to the site was organized in autumn 2018. On the basis of geographic coordinates, field surveys, and, above all, personal communications from the local population, it was established that the area researched by Sochacki is now entirely covered by the buildings of ZDHiAR. Despite that, a geophysical survey was conducted in August 2019 to check whether remains of the Baden culture settlement or traces of earlier archaeological trenches could be found in the undeveloped area.

GEOPHYSICAL SURVEY

The non-invasive survey was undertaken mainly because of the absence of field documentation and unsatisfactory results of the surface survey. An area of 1.5 ha was examined. It contained the highest elevation of the hill (approx. 280.5 m a.s.l.) and the slope along the eastern border of the developed area, probably the place explored by Sochacki. The difference between the flat area of the highest elevation of the hill and the base of the slope ranged between 25 and 40 m. Wiesław Małkowski of FA UW conducted the field work and analysed the data.

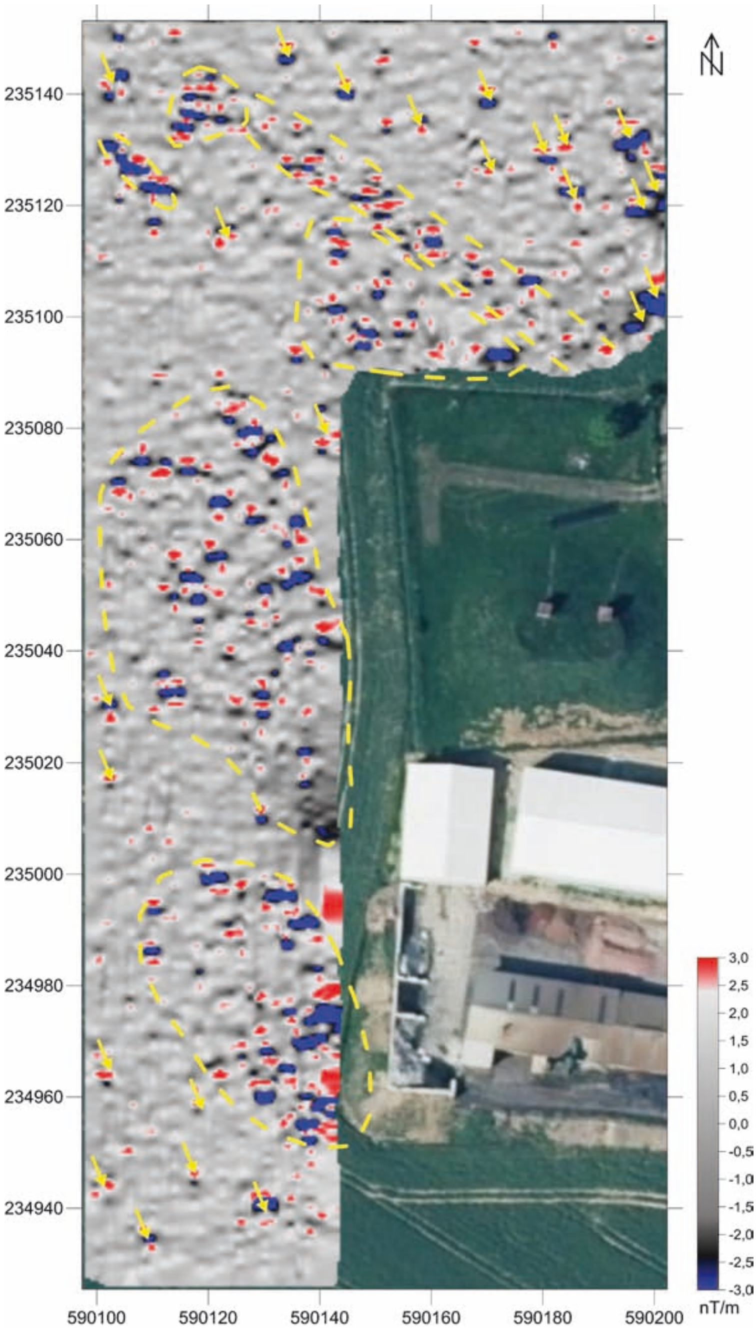


Fig. 1. Interpreted magnetic map with distinguished anomalies. Author: W. Małkowski

The data were acquired with a caesium vapour magnetometer equipped with the Global Navigation Satellite System. The bi-directional survey was made at 2-metre intervals and the probes were placed horizontally at a distance of 1 m. The values of the total magnetic field strength vector ranged from 49350 to 49550 nT and the values of the pseudo-gradient of the horizontal component of this field reached -20/+30 nT/m. Fig. 1 shows the measurement results. Isolated anomalies, clusters of anomalies, as well as linear changes were distinguished in the data set. The isolated anomalies are marked with yellow arrows and the clusters of dipole anomalies are circled with a yellow dashed line. The anomalies are not generated by the terrain, but most likely reflect burned elements in the archaeological layers, the presence of burned organic or clay substances or isolated metal objects. Due to the low or middle-range dynamics of the changes in the values (-3+3 nT/M), the clusters of anomalies might possibly correspond with archaeological features.

GEOGRAPHIC LOCATION

The researched area is situated approximately 30 km east of Kraków. According to the geographic division of Poland, it belongs to the meso-region of Kraków Plateau (Solon *et al.* 2018). The latter is a part of the macro-region of the Sandomierz Lowland, which, in turn, is a part of the sub-province of North Subcarpathia. It is limited by the Vistula Lowland in the north, the Skawina Trench in the west, as well as the Wieliczka Plateau and Bochnia Plateau in the south and east (Fig. 2).

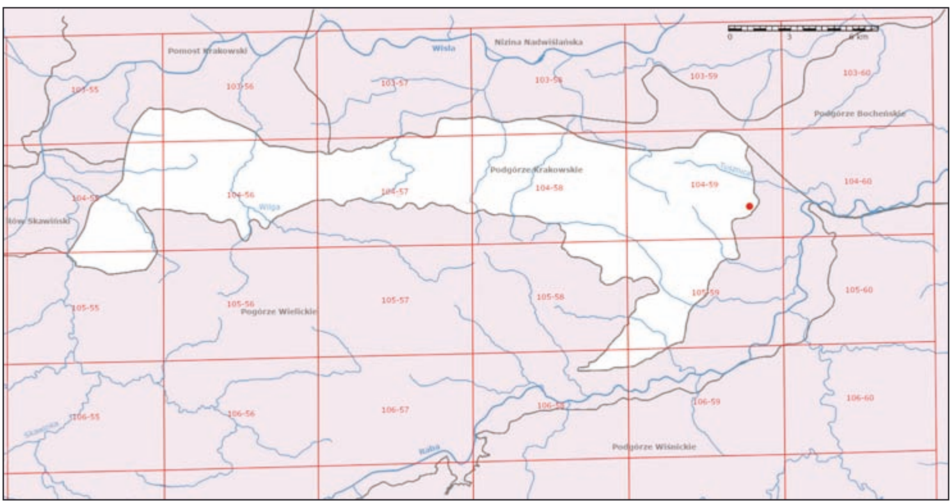


Fig. 2. Grodkowice Site 4. Location in the Cracow Foothill region (division after Solon *et al.* 2018). Author: Agata Borowska

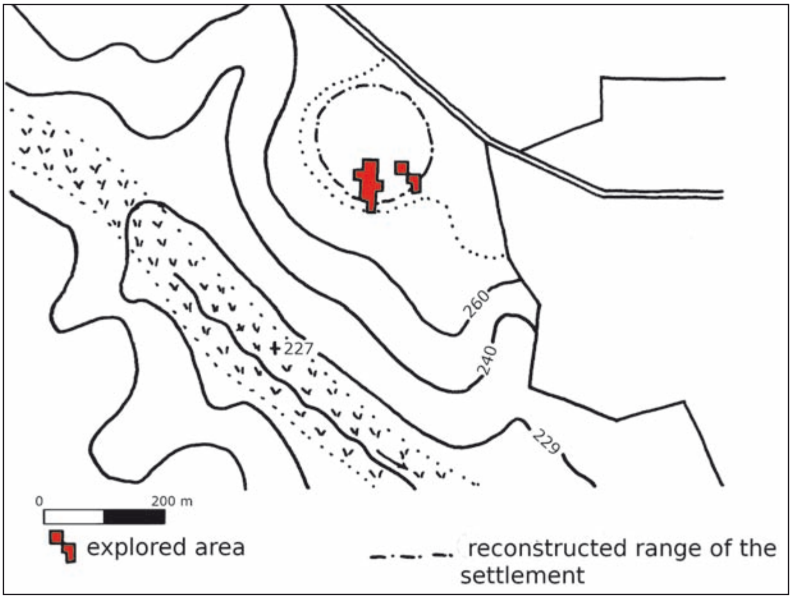


Fig. 3. Reconstructed range of the settlement with excavated trenches. After Sochacki 1971, abb. 2

Fig. 4. Northward view of the site. Photo: A. Grabarek

Numerous stretches of hills and hillocks, divided by a dense network of river valleys, are a characteristic feature of this area. The hills might reach a height of 300 m a.s.l. Grodkowice Site 4 is located on one of such hills.

The settlement is situated on a clay and loess hill, locally called "Lisia Góra" (Fox Mountain), reaching a height of approx. 280 m a.s.l. (Figs 3; 4). During the occupation of the settlement, there was a watercourse located approximately 300 m south of the highest elevation of the area, which is indicated not only by the well-marked valley, but also the vegetation, whose present growth reflects the old riverbed. Despite the considerable elevations of the land surface, ranging from 20 to 40 m, this was the closest source of water for the inhabitants of the settlement.

ANALYSIS OF THE SOURCES

Due to the absence of documentation, the interpretation and reconstruction of the settlement should be approached with caution. At the same time, this state of affairs requires references to the general information about the features (drawings and description) provided by Sochacki. This rather guarded approach is a consequence of the absence of information regarding the methodology of his research. It is reflected in the unclear system of numbers assigned to the features (on object labels and published plans), missing details of the location of the artefacts, spatial relations between the features and basic data concerning their shapes and dimensions. Even the preserved inventory numbers found on the artefacts do not reveal the rationale behind the system of classification. In the case of sealed assemblages, the information compiled by Sochacki does not make it possible to associate them with the material available now. Considering these difficulties, we decided to leave the numbers of the features unchanged since we hope the missing documentation will be found and the material will be systematically organized.

Features

Fifty features were unearthed and explored during the three research seasons at Grodkowice Site 4. Only four of them were briefly published (Sochacki 1970, fig. 14c, 17a; 1980, fig. 20: 9; 21). Only the concentration of the features situated in the southern portion of the settlement were described in more detail, however, more because of their function rather than because of the characteristics of their structures, as could be expected (Sochacki 1971, Abb. 3). According to the information provided by Sochacki, the features discovered at the Baden culture settlement at Grodkowice included dwellings, refuse pits, open hearths, a clay-sourcing pit, as well as a structure that possibly had a ritual function (Sochacki 1963, 38).

This does not change the fact that taking the available data into account, it is not possible to state the exact number of the different categories of features or their functions.

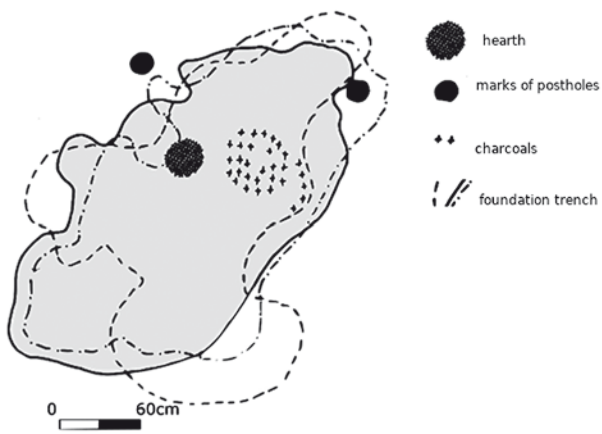


Fig. 5. A post-hole feature at Grodkowice Site 4. After Sochacki 1980, pl. XX.9

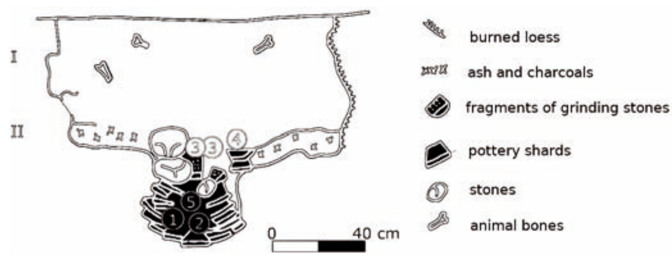


Fig. 6. Feature 17/59/63 profile. I-II – layers of the fill, 1 – broken stone axe, 2 – broken vessel, 3 – spindle whorls, 4 – glass bead, 5 – decayed organic substance, broken vessels, fragments of grinding stones and unworked stones. After Sochacki 1980, pl. 21

Nevertheless, a certain regularity was observed and it could be regarded as a canon of the procedures undertaken in the past studies. This is mainly connected with pit-houses and semi-pit-houses, which sometimes showed relics connected with post-holes. The establishing of their function did not draw upon the actual manner of their exploitation, but was usually associated with their big surface area. However, considering the fact that most of them were relatively small, reaching slightly more than 2 m diameter, such a conclusion is not entirely obvious, at least not in the context of interpretation of some of the features (Sochacki 1971, 14c). If the poor state of preservation precluded interpretation, the identification of the function of the feature was probably arbitrary and such a feature was described as a dwelling or a household structure.

The interesting features which Sochacki had regarded as dwellings include structures sunken in the ground, with an hearth inside and a roof which was possibly supported with

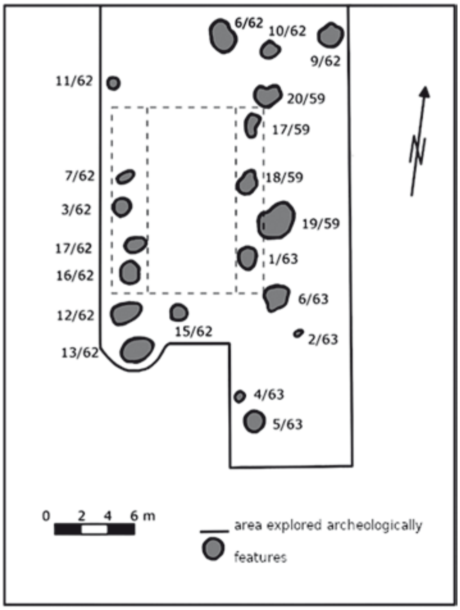


Fig. 7. Map of the southern part of the settlement with reconstructed outline of the house. After Sochacki 1971, fig. 4, as presented by Balcer 2012, fig. 46

posts (Fig. 5), sometimes also with a layer of vessel fragments laid flat, which perhaps were relics of the floor.

In the context of the analysis of the nature of particular structures and their functions, Feature 17/59/63, with its bottom covered with pottery fragments, is an especially interesting one. In its centre there was a pit whose fill, apart from vessel sherds, contained fragments of grinding stones, unworked stones and spindle whorls (Fig. 6; Sochacki 1963, 38). It seems that this feature should rather be treated as remains of a kiln than a structure of a ritual function, the latter being suggested earlier by Sochacki (1964, 36). This new interpretation is definitely supported by the strongly burned, or even deformed fragments of vessels. Parallel features can be found *e.g.* at the Funnel Beaker culture settlement at Bronocice, where they were described as kilns/firing structures (Kruk and Milisauskas 1981, 71). It is also possible that initially it was a pit with a storage vessel placed inside, which was then destroyed by exposure to high temperature. Perhaps the pit was a part of a larger household complex. The absence of the documentation and, consequently, of the context of the discovery preclude drawing further conclusions.

Feature 5/62/63, a relic of a big above-ground structure measuring 6 × 8 m, also deserves attention. Inside there were remains of two hearths and marks of postholes. The dimensions, distinguishing the feature among the others found at the site, and its location in the centre of the settlement at the top of the hill, suggested a significant function, but one that it is difficult to conclusively establish function (Sochacki 1970, 345). This brief description provides no clues to regard this feature as exceptional.

The partially published plan of the settlement (Fig. 7) is also confusing. It presents its southern part with two clearly distinguished concentrations of features, which supposedly might have been separated by a communication route (Sochacki 1971, 52). However, according to Bogdan Balcer, the two lines of pits, that is, the western one consisting of four features and the eastern one consisting of three features, would rather mark the walls of a big residential building (Fig. 7). According to his reconstruction, the surface area was approx. 90-100 m^2 and it showed strongly marked typological similarities to late, Badenized Funnel Beaker culture structures (Balcer 2012, 127, 128). Nevertheless, the dimensions of the postholes are a weakness of this concept. Assuming that the scale recorded in the drawing is correct, some of the pits marking the walls reach diameters ranging from 2 to at least 4 m. In my opinion, it seems that Sochacki's hypothesis, despite the absence of supporting records in the fragmentary documentation, is more likely. In particular, the principle of interpretation of large features as residential or household structures would suggest that the concentration of the features and their logical distribution indicate two separate concentrations divided by an obviously marked empty space – the supposed communication route. It is definitely possible that each big pit might have accommodated two or even three posts supporting a roof. However, Sochacki as the director of the research did not propose such a hypothesis. This means that either Sochacki did not show sufficient sense of observation, or Balcer went too far in his interpretation. Another issue is connected with the reconstruction of the course of the walls. Why were Features 11/62, 12/62, 13/62 not taken into consideration? Or the course along a line with features 15/62, 4/63, 5/63 and a parallel line on the other side? It seems that in this case, the dimensions of the features or the distances between them were the reason. On one hand, we can observe sufficient imagination to reconstruct a big house with posts, on the other hand, this imagination is too limited to conceive a big house with a gabled roof, much bigger than what would normally be expected. Features from the remaining part of the site, which was not shown on the plan, were characterized by a dispersed and irregular pattern of location. This is similar to the situation at most of Baden culture sites in Małopolska (Sochacki 1971, 52, 53).

Pottery vessels

As a consequence of the missing part of the material, it is impossible to conclusively establish the percentages of the categories of material evidence. The inventory prepared for the current study shows that fragments of pottery vessels are the biggest group that now survive. After the reconstruction of forms and reduction of the number of sherds by joining broken ones, the material belonging to the collection of FA UW from the exploration of the features and cultural layers, as well as from the surface surveys, consists of 4943 fragments of vessels. Most of them (4220) come from the fills of the 46 features. This

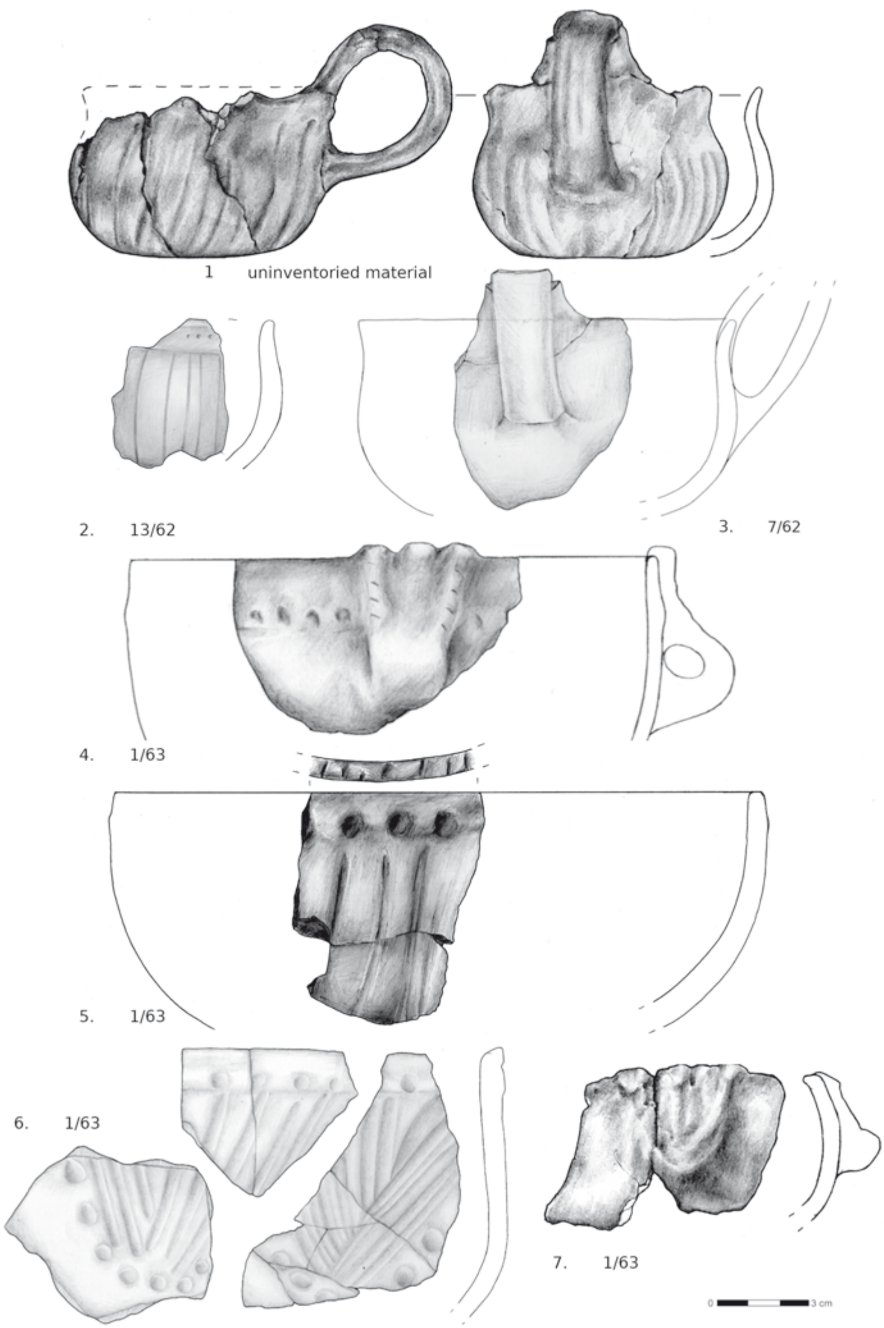


Fig. 8. Grodkowice Site 4. Selected pottery. Author: Agata Borowska

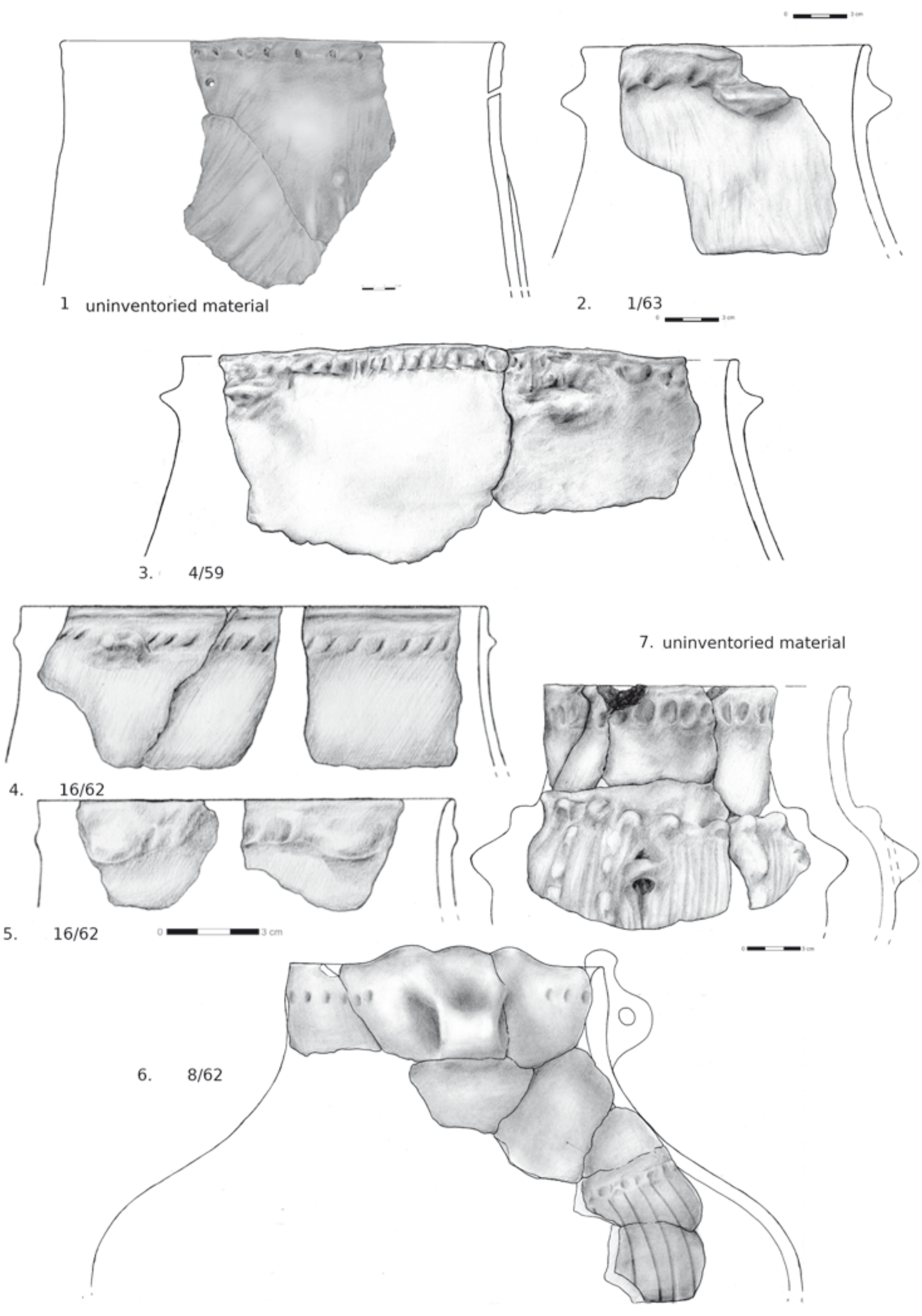


Fig. 9. Grodkowice Site 4. Selected pottery. Author: Agata Borowska

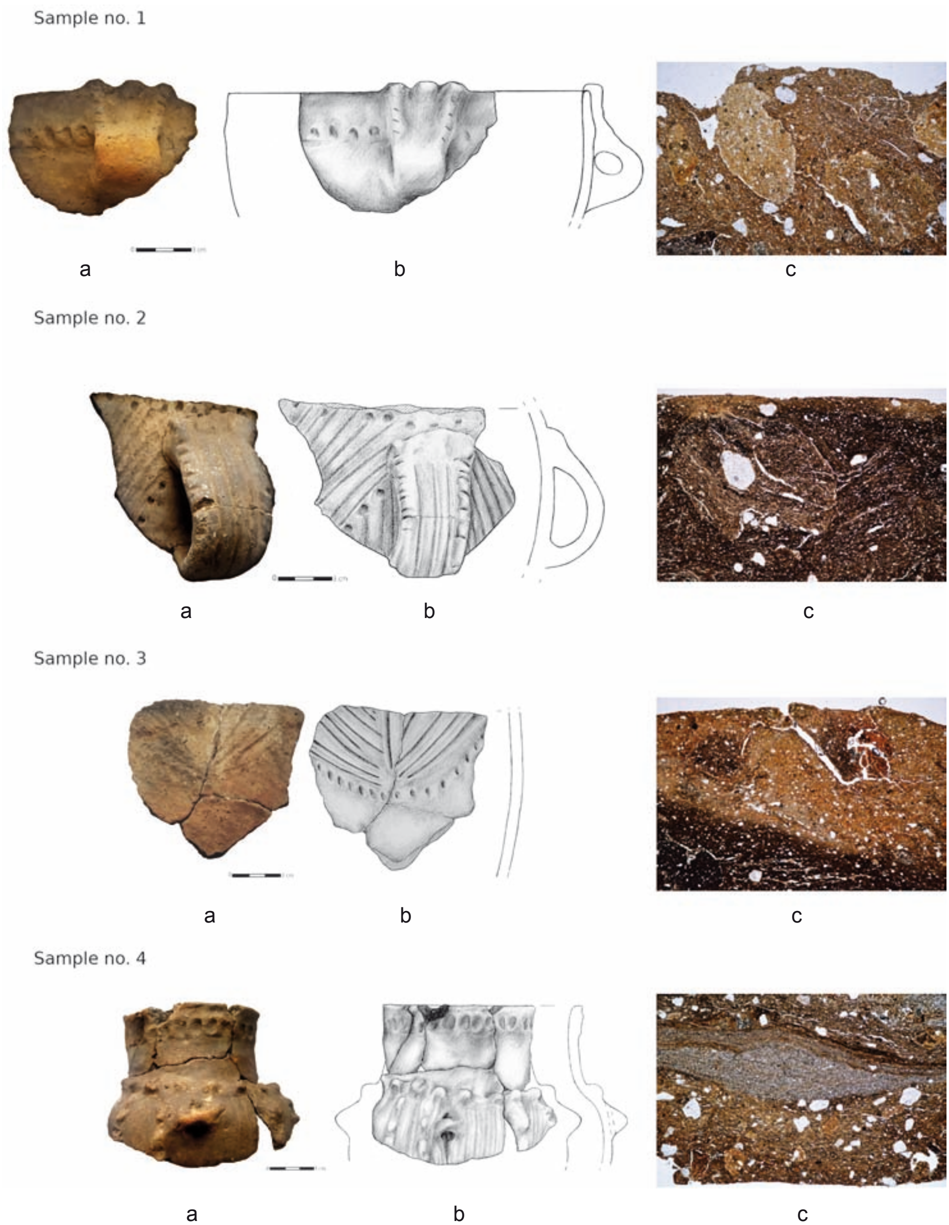


Fig. 10. Pottery samples and photomicrographs.
Author: A. Rauba-Bukowska (1: c, 2: c, 3: c, 4: c), Agata Borowska (1: a, b, 2: a, b, 3: a, b, 4: a, b)

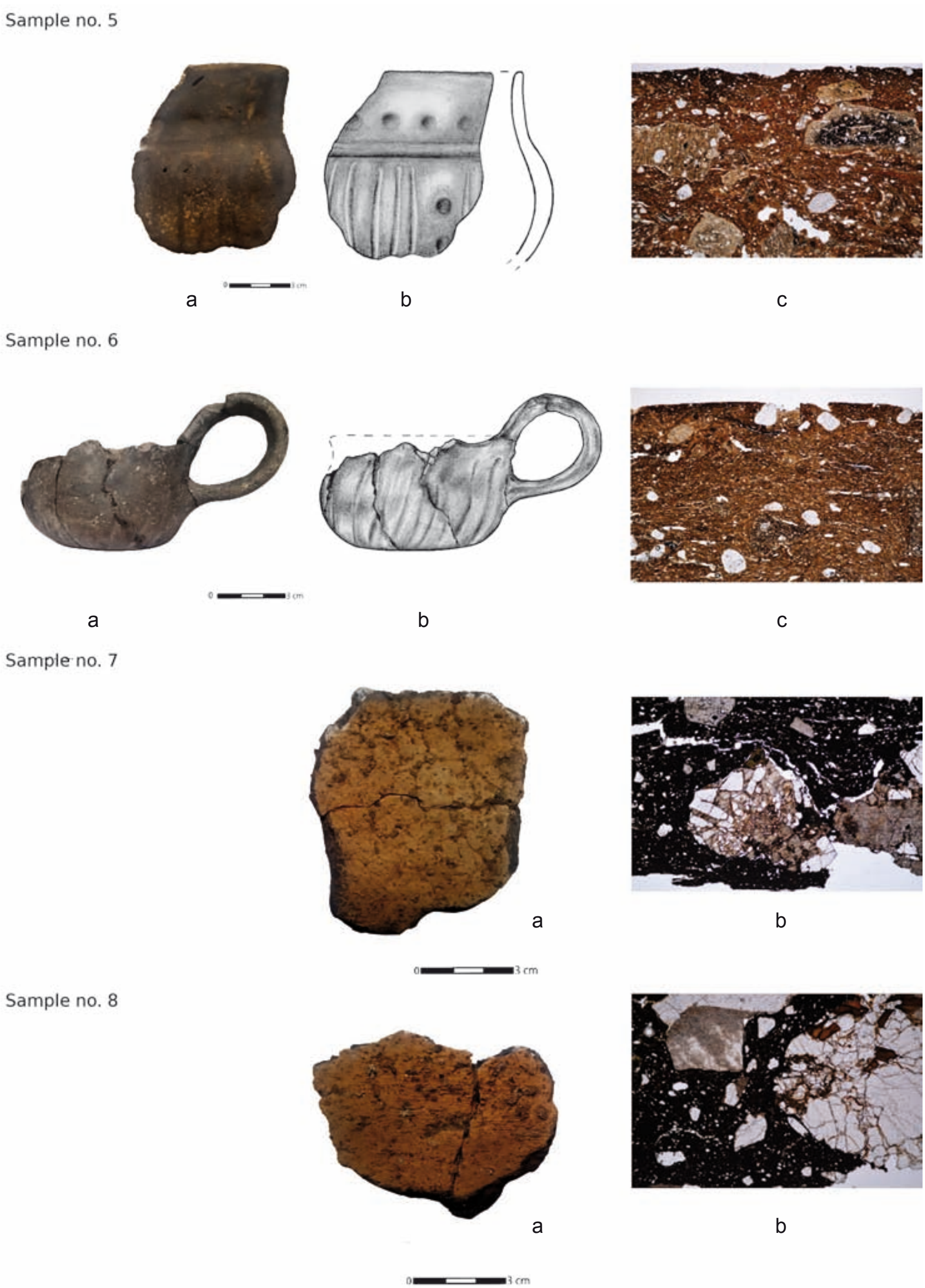


Fig. 11. Pottery samples and photomicrographs.
Author: A. Rauba-Bukowska (1: c, 2: c, 3: b, 4: b), Agata Borowska (1: a, b, 2: a, b, 3: a, 4: a)

group was characterized by the homogeneity of the ceramic fabric, except for the inventory from Feature 5/59/63, where, apart from Baden culture pottery, five sherds of vessels displaying different technological properties, possibly dated to the Early Bronze Age, were found.

The classification of the types and varieties of vessel forms was based on the analysis of sources from Kraków Nowa Huta (Bober 1994; 2015; 2018) and adjusted for the sources analysed in this paper. Due to the limit of the length of the publication, we present only examples of the most important forms of vessels. The pottery material includes a few typological groups: mugs, scoop-like vessels, bowls, amphorae and pots.

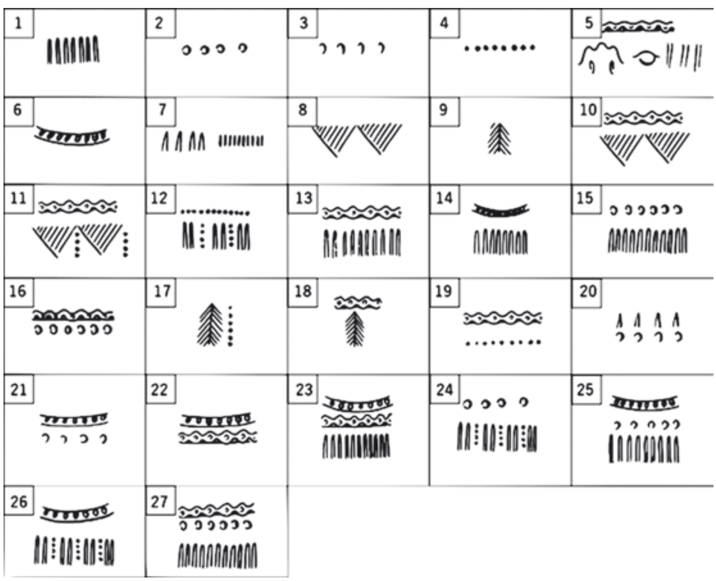
The mugs are vessels with ribbon-like handles extending over the rim and rounded, sometimes slightly flattened bellies, as well as indistinct bottoms. They usually bore no decoration, but some of them were decorated with groove patterns and sometimes groove patterns combined with stamped ornamentation (Fig. 8: 1). Both decorated and undecorated mugs are common artefacts at Baden culture sites in Poland and Europe. Their forms remained generally unchanged since the emergence of the Baden culture (Rook 1971, Pl. 9: 3, 13: 11, 26: 15; Sochacki 1988, Pl. 22: b.23). The differences between vessels mainly involve changes in the proportions of the handles and in the decoration styles: apart from the groove patterns, there were groove and stamp patterns, in which rows of horizontal and vertical stamp impressions surround vertically fluted areas (Bober 1994, 21; Sochacki 1988, Pl. 26: 3). Undecorated mugs and ones decorated only with grooves were the most common at the analysed material from Grodkowice Site 4. Only one fragment of a vessel form decorated with narrow vertical fluting and a horizontal line above it (Fig. 8: 2) as well as one fragment of a vessel decorated with vertical and horizontal fluting combined with stamp decoration can be found in the records (Fig. 11: 1a, b).

The category of scoop-like vessels included ones with ribbon-like handles extending over the rim, with the diameter of the rim bigger than the diameter of the belly and usually an indistinct bottom (fig. 8: 3). Just like the mugs, some were decorated, others were not. Grooves were the only decoration pattern used in this category of artefacts (Bober 1993, Pl. 4: 18, 5: 4, 7: 23; Rook 1971, Pl. 4: 3, 8, 11: 9, 24: 3, 29: 4; Sochacki 1988, Pl. 38: 8, 9). No scoop-like vessels with conical bottom were identified, however, such vessels were found at Baden culture sites in the area surrounding Kraków, *e.g.*, at Kraków Zesławice Site 21.

Bowls are vessels with a wide opening and semi-circular or conical belly, and quite often with a handle extending from the rim of the mouth (Fig. 8: 4-7). Baden culture bowls are characterized by a long chronology and diverse forms at its different stages (Bober 1993, Pl. 8: 9; 9: 1; 12: 3; Rook 1971, Pl. 3: 7, 10: 5, 15: 1, 42: 7, 43: 5, 44: 1, 5, 9; Sochacki 1988, Pl. 1: 10; 8: 4; 20: 6; 26: 16, 22). They presented various types of decoration (nos. 1, 2, 3, 5, 6, 11, 12, 13, 14, 21, 24 and 25 according to the motifs and patterns in Table 1). Interestingly, ruffling of the rims was observed only in this group of vessels. It is generally thought that the origins of conical bowls might be found in the Funnel Beaker culture or

Table 1. Decoration motives and patterns with corresponding graphic representation

Decoration motifs	14. grooves and ruffled rim
1. grooves	15. grooves and finger impressions
2. finger impressions	16. cordon/nodule/handle and finger impressions
3. finger and fingernail impressions	17. chevron and stamp impressions
4. stamp impressions	18. chevron and cordon/nodule/handle
5. cordon/nodule/handle	19. cordon/nodule/handle and stamp impressions
6. ruffled rim	20. finger impressions and imprint decoration
7. elongated ruffle impressions	21. finger impressions and ruffled rim
8. open triangles	22. cordon/nodule/handle and ruffled rim
9. chevron	23. grooves, cordon/nodule/handle and ruffled rim
Decoration patterns	24. grooves, finger and stamp impressions
10. cordon/nodule/handle combined with open triangles	25. grooves, finger impressions and ruffled rim
11. cordon/nodule/handle combined with open triangles and stamp impressions	26. grooves, stamp impressions and ruffled rim
12. grooves combined with stamp impressions	27. grooves, finger impressions and cordon/nodule/handle
13. grooves and cordon/nodule/handle	



Lengyel culture (Sochacki 1980, 16). The most common decoration motifs (Table 1, nos. 1, 2, 3, 5, 6, 11, 12, 13, 14, 21, 22, 24, and 25), combined with Ózd type handles, have parallels at many Baden culture site of late classical chronology (Sochacki 1980, 87).

The amphorae include vessels with slender necks, gourd-shaped, pear-shaped or biconical bellies and handles located near the mouth or the belly (Fig. 9: 6, 7). The edge of the neck often features a cordon decorated with finger or stick impressions. The amphorae from the analysed site display types of decoration motifs nos. 1, 5, 13, 15 and 27 (Table 1). According to Sochacki, the vessels with bi-conical and pear-shaped bellies might be inspired by the Funnel Beaker culture while those with gourd-shaped bellies were probably original inventions of the Baden culture (Sochacki 1988, 71). The greatest diversity of the forms in this group falls to the developed, classical phase of the Baden culture (Bober 1993, Pl. 5: 1; 6: 14; 7: 18; 9: 4; Rook 1971, Pl. 37: 6, 67: 9). The amphorae were characterized by significant differences in dimensions, which led to distinguishing two separate categories at Kraków Zesławice Site 21: small amphorae and bigger vessels of a storage function (Sochacki 1988). This paper, however, observes a division based exclusively on the properties of shapes, and not on the supposed function of the vessels.

Another group of vessels are pots. This category includes forms with an S-shaped profile and the diameter of the mouth comparable with the diameter of the belly (Fig. 9: 1-5). In terms of the surface finish they can be divided into two classes: those with the belly covered with smudged clay and those with the belly polished with a burnishing stone. Small single or double nodules situated near edges are a common motif. Apart from this motif, they were decorated with cordons and finger impressions, as well as grooves and stamps.

The material from Grodkowice Site 4 definitely bears some resemblance to the materials associated with the Zesławice-Pleszów and Mogiła groups (Zastawny 1999, 19). Their potential association with the latter group stems from the absence of elements that are characteristic of the Zesławice-Pleszów group. The features that are common for both groups include rugged pot surfaces, decoration motives such as cordon, vertical grooves, open triangles, chevron, as well as patterns of grooves combined with stamp impressions.

The absence of such distinct forms as mugs with conical bottom, bipartite bowls, pseudokernos type vessels, or of the decoration motif of a diagonal criss-cross pattern, suggest the association of these materials with the Mogiła group. Bowls with a partition, conical mugs (the variety with a flattened bottom) and diagonal criss-cross pattern are additionally a remnant of the early classical style. It is characteristic that all stylistic transformations corresponding with successive phases of the development of the Baden culture in Małopolska are more clearly marked in the territory occupied by the Zesławice-Pleszów group. These features are not so obvious in the Mogiła group and it is more difficult to find parallels in the regions of their origin (Zastawny 1999, 25, 26; 2011, 441-446).

On the basis of stylistic features of the pottery (and considering chronological indications from the association of artefacts at Kraków Zesławice Site 21; Godłowska 1968, 107, 108; Sochacki, 62-102) it is possible to try to distinguish two phases of occupation of the settlement. The discriminants of these phases come from different objects and do not coexist with each other. The first would correspond with the undecorated or fluted mugs, amphorae with handles inspired by the Viss type, as well as groove and cordon decoration. The characteristic features of the other one were the flattened handles of Ózd type, rich groove and impression motifs, motifs consisting of vertical and horizontal grooves, as well as the ruffling of the rim. The latter motif is rather problematic in the context of the analysis of the materials from Kraków Mogiła Site 55, where the ruffling of the rim is earlier in terms of chronology and is an element associated with the initial phase of the development of settlement activity at that site (Bober 1994, 33). Perhaps this dissimilarity results from the developmental differences between the Zesławice-Pleszów and Mogiła groups. Nevertheless, the inventory as a whole is accommodated within the range of forms and decoration styles of the late classical horizon of the Baden culture in Małopolska.

MINERALOGICAL AND PETROGRAPHIC ANALYSES

In the context of the analysis of pottery materials, it is important to understand the whole technological process of vessel production. Therefore, eight fragments of vessels from four features were selected for mineralogical and petrographic analysis (conducted by Anna Rauba-Bukowska of the Institute of Archaeology and Ethnology, Polish Academy of Sciences, whom I wish to sincerely thank).

Two samples came from Feature 1/63 (Fig. 10: 1, 2), two from Feature 5/59/63 (Fig. 11: 3, 4), one from Feature 4/59 (Fig. 11: 1) and one from Feature 12/62 (Fig. 10: 3), as well as another two from locations not identified precisely (Fig. 10: 4, 11: 2). The samples were cut into sections and slides were observed under polarizing microscope in transmitted light in order to identify the degree of mixing, firing conditions and temperature, as well as the composition of the ceramic fabric. The firing temperature was estimated on the basis of thermic transformation of clay minerals as well as observation of biotite, hornblende and glauconite.

The analysis revealed that the vessels were made of clay and fine-grained materials, which contained mica components. Crushed pottery material, the so-called grog was a significant ingredient (10.6 to 20.1%), and it was intentionally added to clay material. However, it was not particularly finely crushed, the grains ranged from 0.3 to 2 mm. Most of them displayed marks of secondary exposure to high temperature. Apart from grog, sand was also present in all the samples (up to 5% in the ceramic fabric). The ceramic fabric shows a low to medium degree of mixing, and banded colouring as well as accumulations of fine grains can be observed.

The samples from Feature 5/59/63 seem to reflect a different technology (Fig. 10: 3, 4). Most likely, they were fragments of one vessel. Although they also consisted of clay minerals and fine-grained fraction, they contained a significant share of crystalline and igneous rocks derived from transformed feldspars, quartz, biotite and hornblende. Biotite flakes were another component, they might come from crushed rock intentionally added to the ceramic fabric. There were no indications suggesting addition of grog in this ceramic fabric.

On the basis of the mineral composition it can be concluded that the samples that evidenced the two different recipes for preparation of ceramic fabric were made of local raw materials. The differences were visible only in the intentional admixtures, contradictory in the addition of grog and sand or crushed rock. Other differences can be observed in the firing technology. The samples from Feature 5/59/63 were fired at a temperature of approx. 850 °C while the firing temperature of the other analysed samples reached 700-750 °C. Both processes were conducted in reduction firing conditions with limited availability of air. The microscopic examinations confirmed the conclusions of the macroscopic analysis. The analysed ceramics were characterized by the homogeneity of the fabrics and the firing method, with the exception of some of the material from Feature 5/59/63. In addition to the ceramics of the Baden culture, it probably contained material from a later period.

ABSOLUTE CHRONOLOGY

The main aim of the dating analysis was to establish the position of the settlement at Grodkowice Site 4 against the background of the regional development of Baden culture settlement activity, as well as to compensate for the information gaps resulting from the unsatisfactory state of the source base. Since Feature 17/63 contained charcoal fragments, the material was sampled and sent to the Poznan Radiocarbon Laboratory for analysis by ^{14}C AMS method. The radiocarbon date may also be compared with the results of conventional style-based dating of the pottery.

The measurements returned a date of 4440 ± 30 BP. The date was calibrated with OxCal v4.2.3 (Fig. 12). After calibration the range of dates fell to ranges of 3331-2931 BC (95.4% probability). Considering only the values representing the highest probability, the result falls within the range of 3127-3007 BC (52.6%) and 3331-3215 (31.9%).

Twenty-four absolute dates were previously known from the area occupied by Zesławice-Pleszów and Mogiła groups. Two of them come from the region of Wieliczka-Bochnia and Bochnia (Kraków Bieżanów Site 8, Gdów Site 2; Zastawny 2015). The chronological ranges mentioned above overlap with the chronology of Kraków Mogiła Site 55, which was dated to 4435±35 BP (Feature 175) and 4430±35 BP (Feature 35). After calibration, they fall within the ranges of 3330-2924 BC (95.4% probability) and 3316-2941 BC (68.2% probability; Zastawny 2015, 95, fig. 4). Similar values were calculated for sites in Kraków Pleszów Site 17. Features 1237 and 876A returned dates which fall within the range of 3339-2922 BC (95.4% probability; (Godłowska and Gluza 1989, 251; Zastawny 2015, 98, fig. 6). The values from Kraków Zesławice Site 21, Features 97i and 140A, were 4420±43 BP

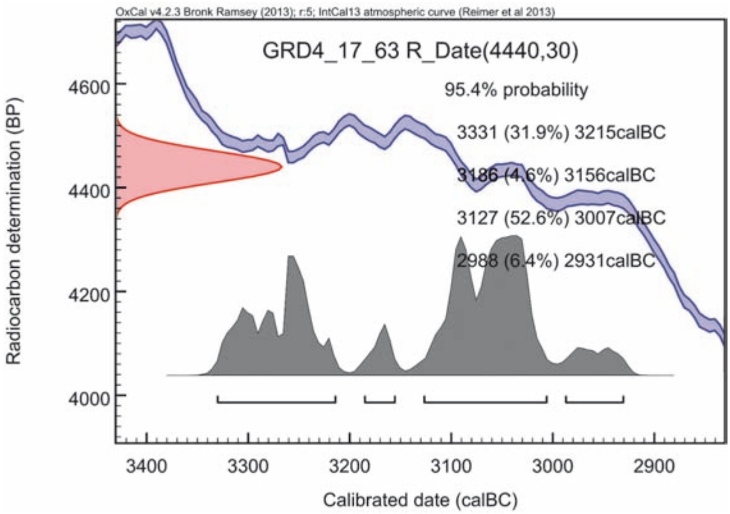


Fig. 12. Radiocarbon date for the charcoal sample from pit 17/63

and after calibration the dates ranged from 3330 to 2890 BC (95.4% probability; Furholt and Machnik 2006, 336).

The chronologies of the settlements at Kraków Mogiła Site 55, Pleszów Site 17, Zesławice Site 21 and Grodkowice Site 4 fell within the common range from 4445-4420 BP. This is the oldest phase of the development of Baden culture settlement activity in Małopolska (Zastawny 2015, 100). We might hypothesize that the settlement at Grodkowice Site 4 participated in the earliest phase of formation of permanent Baden culture settlements in Małopolska, if not for the lack of early classical elements in pottery. Perhaps the old wood effect is to blame. This issue certainly requires further research.

ANALYSIS OF PLANT MACRO-REMAINS

The archaeobotanic analysis focussed on fragments of fired daub with preserved plant imprints. The material, consisting of 162 daub fragments and four charcoal pieces, was examined by Grzegorz Skrzyński of the Museum of the Earth, Polish Academy of Sciences (Table 2). The samples came from the Features 3/59, 5/59, 7/59, 13/59, 12/62 (135 daub fragments and the charcoal) and the cultural layer, as well as the ground surface from Sochacki's excavations (27 daub fragments). The daub was broken into pieces to reveal plant imprints and then the imprinted plants were identified by morphological-comparative method with identification keys for diaspores and generative parts of plants (Kowal and Rudnicka-Sterna 1969; Jacomet 2006).

Table 2. Fragments of daub with preserved plant imprints

Feature	Number of fragments	Taxon	Numbar of imprints
3/59	30	*Triticum* sp.	1
		Cerealia	6
5/59	11	*Triticum dicoccon*	3
		Cerealia	2
7/59	74	*Triticum dicoccon*	6
		Triticum monococcum	1
		Hordeum vulgare	1
		Triticum cf. spelta	1
		Cerealia	12
13/59	19	*Triticum* sp.	1
		Cerealia	4
12/62	1	*Triticum* sp.	1
Cultural layer	24	*Triticum dicoccon*	1
		Triticum sp.	1
		Bromus secalinus	1
		Cerealia	7
Ground surface	3	*Poaceae*	4

The fragments of charcoal were identified on the basis of characteristic anatomical structure of the wood with the Schweingruber identification key (1978). The plant remains were compared with contemporary herbaria. The sampled material limits the possibilities of presentation of reliable data regarding the quantitative distribution of different species and genera. This could only be achieved by flotation of soil samples, which would result in a quantifiable assemblage. The analysis of daub samples delivers information about the qualitative composition of the plant remains (Marciniak *et al.* 2015, 127).

Cereal (Cerealia) remains dominated in the identified material. Wheat was the most represented and three species were identified: emmer (*Triticum dicoccon*), einkorn (*Triticum monococcum*) and spelt (*Triticum spelta*). The spikelets and chaff pieces which bore no distinctive morphological features were identified only to the level of genus (*Triticum*). Apart from the wheat species, remains of barley (*Hordeum vulgare*) were discovered. A carbonized grain of rye brome (*Bromus secalinus*), found in a lump of daub, is a relatively rare discovery due to its state of preservation. It was also the only identified weed. Apart from the plants mentioned above, there were some representatives of grasses (Poaceae). The remains of wood belonged to two taxa: pine (*Pinus sylvestris*) and birch (*Betula* sp.).

The analysis of plant remains showed that the inhabitants of the settlement definitely grew three species of wheat. The first two species are the most commonly found species at Neolithic sites in Poland (Lityńska-Zając and Nalepka 2012, 1032). Archaeobotanic studies indicate that together with barley they were the basic cereal crops. The proportion of the two wheat species gradually decreased and lost significance while barley occupied a relatively stable position and only in the Roman period did it begin to dominate over other cereal species (Lityńska-Zając and Nalepka 2012, 1032). The proportion of spelt, although its presence was detected at Neolithic and Bronze Age sites, was never high in botanic material. This crop probably played a marginal role (Lityńska-Zając and Nalepka 2012, 1032).

CONCLUSIONS

This paper has presented the results of analyses of pottery material from the Baden culture settlement at Grodkowice Site 4, which belonged to the late classical Mogiła group from the vicinity of Wieliczka-Bochnia region, as well as the Kraków-Częstochowa Upland. The re-analysis of the archaeological remains excavated years ago by Sochacki has shed new light on the relics of settlement activity at Grodkowice Site 4. Despite a significant depletion of the original data, a consequence of a long period of storage of the artefacts and documentation in changing locations and conditions, we found a lot of new information, crucial for the understanding of the functioning of the societies occupying the area. The interdisciplinary analyses conducted in cooperation with researchers representing other fields of science has opened broader perspectives. The new radiocarbon dating suggests that the settlement functioned in roughly the same period as those situated at Kraków Mogiła Site 55, Pleszów Site 17 and Zesławice Site 21. The preferred model of economy is indicated by the remains of several species of cereals, including three species of wheat. The geophysical survey with the magnetometer raises hopes for further excavations at Grodkowice Site 4 since a significant part of the settlement might still be found in the ground.

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ANOTHER PIECE OF THE PUZZLE – BARROW III OF THE CORDED WARE CULTURE AT SITE NO. 3 IN ULÓW, IN MIDDLE ROZTOCZE

ABSTRACT

Niezabitowska-Wiśniewska B. and Wiśniewski T. 2022. Another piece of the puzzle – Barrow III of the Corded Ware culture at Site no. 3 in Ulów, in Middle Roztocze. *Sprawozdania Archeologiczne* 74/2, 189-225.

One of the most distinct settlement phases in the Ulów microregion in Middle Roztocze in southeast Poland, is related to the Corded Ware culture. At present, ten archaeological sites are dated to this period. At Site 3, a barrow cemetery of this culture, consisting of three mounds, has been recorded. All of them have been subjected to excavations. The paper presents the results of investigations of Barrow III with an almost indistinct mound. In the centre of it was a burial pit, with another grave of this culture cut into its upper fill. A hearth with a stone paving of the Wielbark culture was also dug into the mound. The text also discusses the cemetery at Site 3 in the context of other barrow cemeteries in the Ulów microregion.

Keywords: Middle Roztocze, Late Neolithic, Corded Ware culture, barrow, Roman period, Wielbark culture
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INTRODUCTION

Ulów is a small village in Tomaszów Lubelski commune (Tomaszów Lubelski district, Lublin province). It is situated in Middle Roztocze (Roztocze Środkowe according to Solon *et al*. 2018), sometimes also referred to as Tomaszów Roztocze (Roztocze Tomaszowskie), at the foot of its highest elevation – Wapielnia (385 m above sea level) (Fig. 1).

The complex of archaeological sites in woodland near Ulów was found by prospectors with metal detectors, who were searching for military items from the Second World War. Since then, long-term interdisciplinary research conducted in the Ulów settlement micro-region has yielded 30 archaeological sites; 16 of them have been excavated to varying degrees, four have been subjected to geological and geomorphological investigations as well as surface surveys, with 10 having undergone only surface investigations (Fig. 2). At 10 sites (nos. 3, 4, 5, 19, 20, 21, 22, 25, 26 and probably 23), cemeteries or single barrows of the Corded Ware culture (hereafter CWC) have been discovered (Fig. 2). The cemetery at Site no. 3, which consists of three barrows, has been excavated entirely, and the results of exploration of two of them have already been published (Niezabitowska-Wiśniewska and Wiśniewski 2011). This paper pertains to the third barrow.

Barrow I is located in the eastern outskirts of the cemetery and was explored in 2005; Barrow II located near the central part of the site in 2006 and Barrow III located in the western outskirts of the cemetery were examined in 2009 and 2010 (Niezabitowska-Wiśniewska and Wiśniewski 2011). Measured in a straight line from the centres of the mounds, Barrow III lies about 67.5 metres from Barrow II and about 144 metres from Barrow I (Fig. 3: A).

At Site 3, except the cemetery of the CWC, evidence of much older and younger settlement were found. This is associated with the Late Paleolithic, the Mesolithic, the Neolithic (the Lublin-Volhynia and Funnel Beaker cultures), the Bronze Age and the early Iron Age (the Trzciniec and Lusatian cultures), the Roman and Migration periods (the Wielbark culture and traces of the late, not specified, Germanic settlement), the Middle Ages, as well as the Modern period (*e.g*., Wiśniewski 2007; 2017; Niezabitowska-Wiśniewska 2008, 81-85, figs 7-10; 2017).

Before the time of the discovery of the CWC barrows in Ulów, from the area of Middle Roztocze apart from stray finds of CWC materials (*cf*. Balcer *et al*. 2002, 98, 99, 102-105, 122, tab. 23, 130, 143-145, 151; Koman 2005, 48, 49, photo 2, 3, map 1), only two or three excavated barrows of this culture were known (nos. IX and XIV in Guciów according to Rogozińska 1963, 89, 90, fig. 3, 4; nos. I and IX according to Górski and Tyniec 2018, 53, 54, 57-59; Jarosz 2018, 67-71).

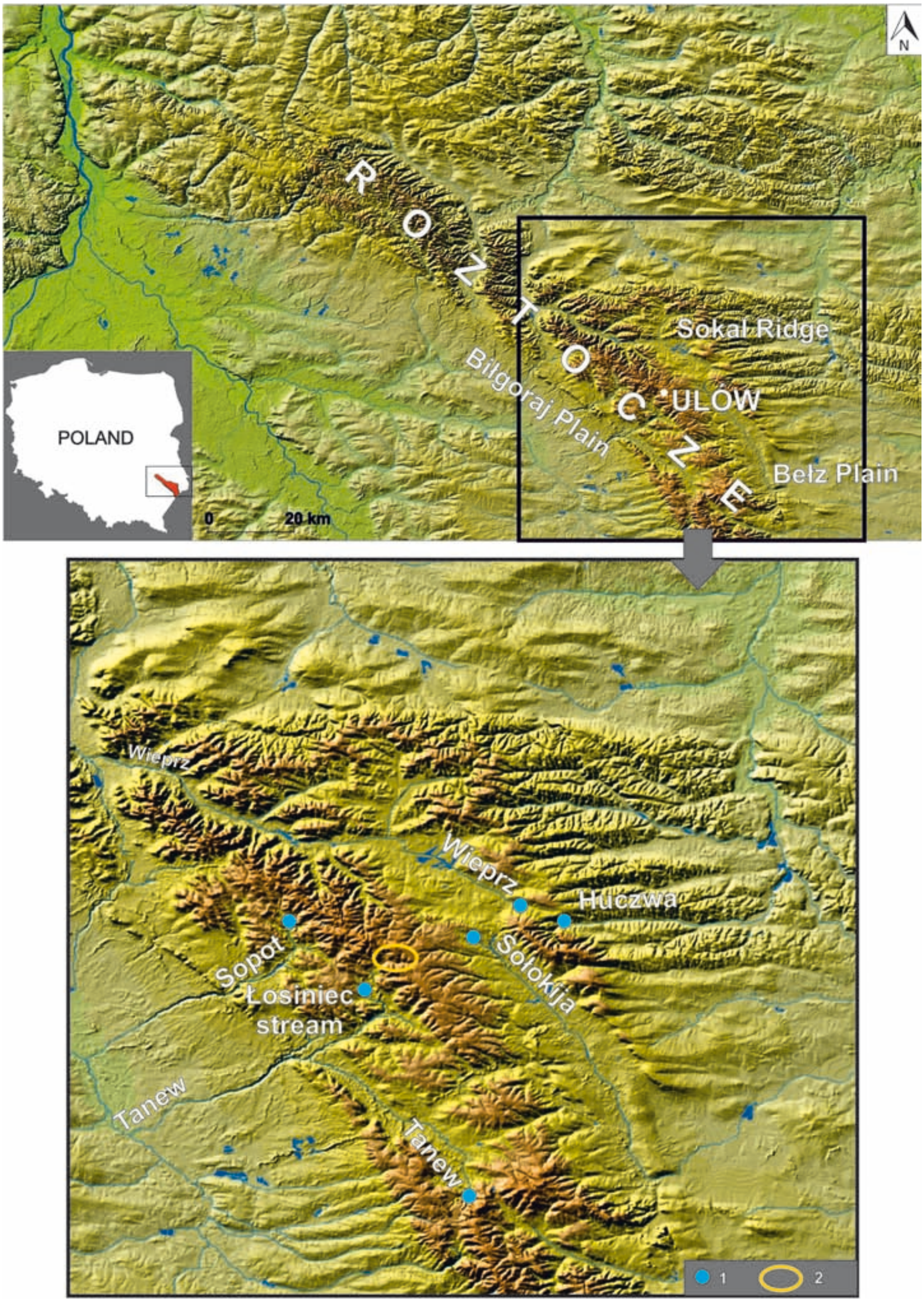


Fig. 1. Location of Ulów village on the background of the map of Roztocze (Gawrysiak 2004).
1 – the springs of the region main rivers. 2 – the range of the Ulów microregion
(Compiled by B. Niezabitowska-Wiśniewska)

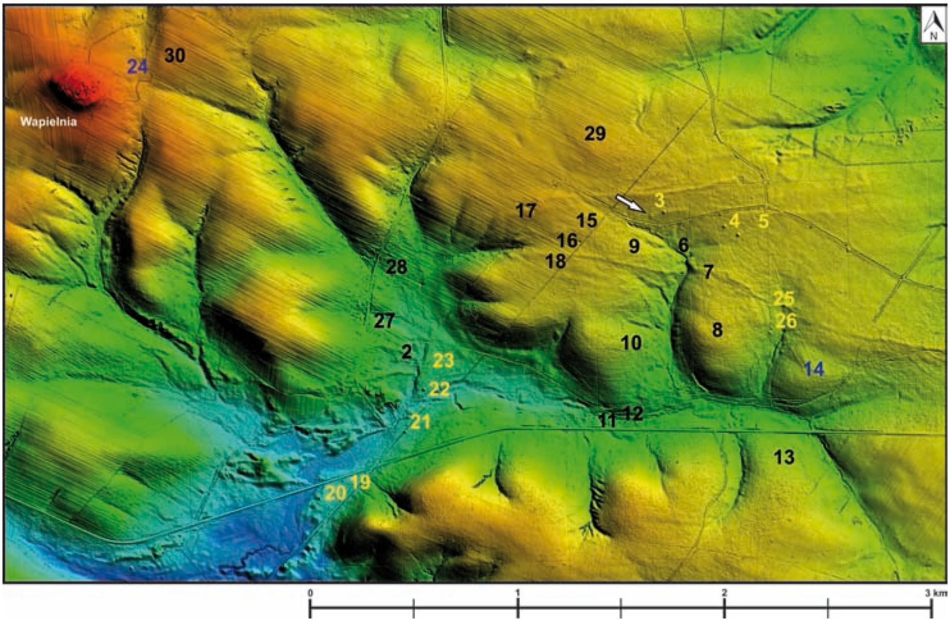


Fig. 2. The Ulów microregion with marked location of archaeological sites; yellow numbers – barrow cemeteries of the Corded Ware culture; blue numbers – sites with prehistoric mounds of unknown chronology, perhaps belonging to the Corded Ware culture; white arrow – location of Barrow III at Site 3 (Compiled by B. Niezabitowska-Wiśniewska)

BARROW III

History of research

Before the excavation started, the mound of Barrow III had been completely imperceptible. The barrow was discovered by accident in 2009 during research in the western part of Site 3. In one of the trenches (no. 70) which was 2 × 19 metres, in the humus layer and just under it (at the depth of 26-35 cm from the surface of the ground) a deposit of fragments of pottery of CWC was found (at a stretch of 13-13.5 m). It was decided to broaden the area of excavation. In order to do that, two trenches, numbers 71 and 72, were marked, each one was 4.5 × 3 metres. They fitted to the E and W edges of Trench 70 (on a stretch of 10-14.5 m). At first, two baulks, each 0.5 m long, were left between the trenches. They were taken away after the humus layer in Trenches 71 and 72 was removed. As a result, a fragment of the E and W profile of Trench 70 was documented over the length 10-14.5 m. The ground elevation in place of the levelled barrow was visible in places and the difference between the surrounding areas was 5-15 cm.

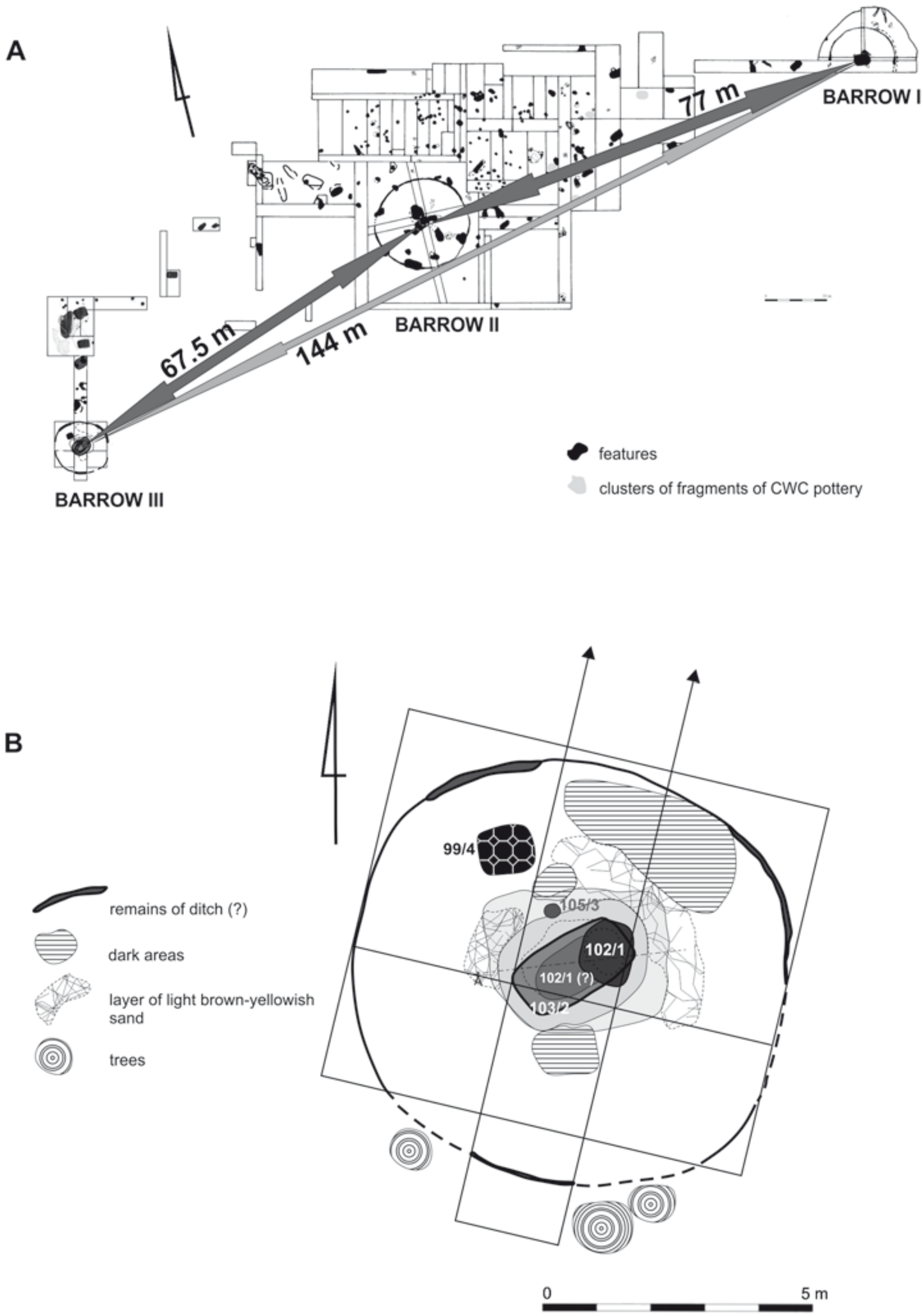


Fig. 3. Ulów, site 3. A – plan of the examined part of the site, including the barrow cemetery of the Corded Ware culture. B – plan of Barrow III (Drawn by B. Niezabitowska-Wiśniewska)

In the trenches, the northern part of very low barrow mound and upper fills of three features were found. The first was the central pit under the barrow (Feature 103/2; 103 – number of feature with respect to the continuous numbering of the features at Site 3; 2 – number of feature within Barrow III; analogously in the case of other features). Cut into its upper fill was a feature, probably a grave (Feature 102/1). The third was a hearth that was cut into the mound of the barrow (Feature 99/4). It soon turned out that the fragments of pottery of CWC which had been found earlier in the humus layer, were a part of vessels found in Feature 102/1 (Fig. 3: B).

In 2009, due to the end of excavation works, only the northern part of the central pit under the barrow and Feature 102/1 were explored. A single layer in the southern part of these features was removed (33/36-48.5/49 cm) in order to extract fragments of pottery from the southern part of Feature 102/1. The remaining part of the grave was planked over and the trench was covered with earth.

In August 2010, the southern part of the central grave pit (Feature 103/2), the base of the southern part of the feature dug in the pit (Feature 102/1) and the southern part of the mound of the barrow were explored. Two new trenches were marked, 73 and 74, each 3 × 2.5 metres. Unfortunately, the south-east and south-west edge of the levelled mound could not be excavated because of the densely grown roots of nearby beech trees (Fig. 3).

Description of the barrow

The outline of the central pit under the barrow (Feature 103/2), with Feature 102/1 dug into its upper fill, was visible just after removing the humus layer. The features were surrounded by a layer of light brown-yellowish sand visible especially in the north and east edges. The layer contrasted with a dark brown-grey-light grey strongly spotted layer with ferruginous concentrations which stretched along the edge of the mound of the barrow and was best visible in its north-east part. The width of light brown-yellowish material was between 95 and 130 cm and its thickness was about 20-25 cm. After the disappearance of this layer during excavation, the dominant layer in the mound was a light brown-light grey layer with numerous ferruginous concentrations and small charcoal clusters.

Unfortunately, because of the considerable damage to the barrow, it was not possible to discern visible traces of a ditch. Only at the north edge of the mound a homogenous layer of light brown, light beige in places, soil was visible. It was from 5 to 25 cm wide and its thickness was about 20 to 35 cm. It had an oval profile. Thus, it may be regarded as the remains of a ditch. Similar, yet less visible, brownish structures were found in the E and W profiles along a stretch of 16-19 metres of Trench 70, that is in the southern part of the mound of the barrow (Fig. 3: B). The original diameter of the mound was thus probably about 8-8.5 m.

In Barrow III, four features were found: a central grave numbered 103/2, a feature (probably a grave) dug into the upper part of the central pit under the barrow, numbered

102/1, a posthole number 105/3 – all connected with the CWC; and a hearth, 99/4, from the Late Roman Period, cut into the mound of the barrow. In addition, three dark areas, the function of which was hard to determine, were found by the northern and southern edges of Feature 103/2 and by the north-east edge of the mound (Fig. 3: B).

Description of the features

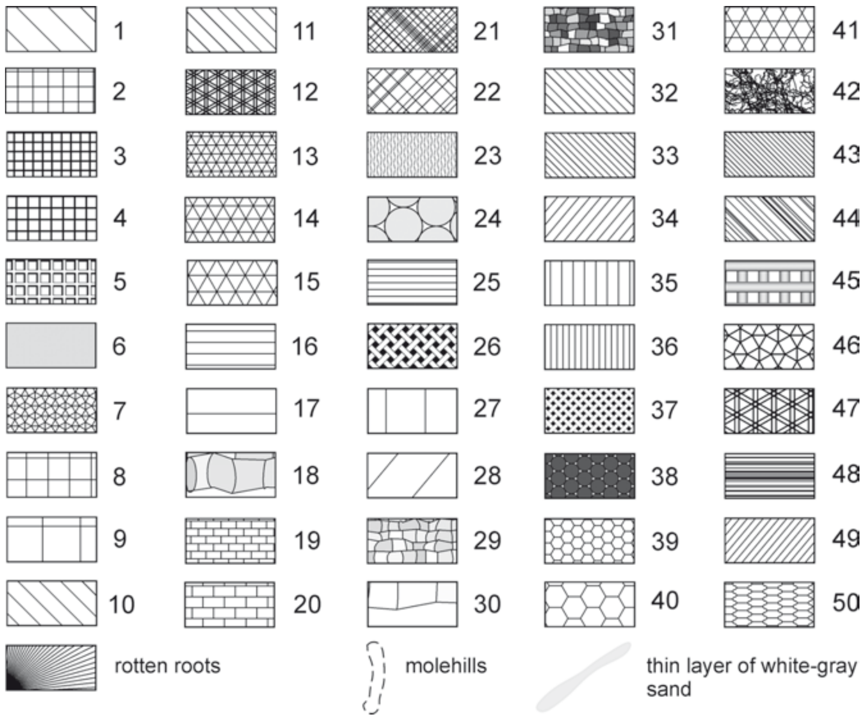
Feature 102/1 – a pit grave (?) cut into the upper fill of the central grave pit (Feature 103/2).

The partial outline of the feature was captured after removing the humus layer at the depth of 26 cm. At the depth of 33 cm, the feature had an oval shape and was about 100 × 135 cm big. It was made of a light brown-beige, homogenous layer (Fig. 4: A). At the depth of 26 cm in the north part of the feature, single fragments of pottery were found. At 34/35 cm the outlines of two vessels – an amphora and a small beaker – were uncovered (Fig. 4: B). The next vessel – amphora no. 2 – was found in the southern part of the feature and its outline was visible only at a depth of 40 cm (Fig. 6: B/3). During the exploration by the horizontal planum method, the feature was becoming smaller and more oval (Fig. 4: B).

To the west side of the feature was a long structure which at first was dark brown and homogenous and its edges were barely visible (Fig. 4: B). At a depth of 48/49 cm, the prevailing layer was light brown-light grey and was significantly spotted. It was surrounded by a thin layer of white-grey sand that was no more than 10 cm thick. This thin layer was the most clear at the southern border of the structure described here, where it had already appeared a little higher. As a result, the structure contrasted with the much darker fill of the central pit under the barrow. At this moment, it is hard to tell if the structure can be connected with Feature 102/1. If this was the case, the feature would have consisted of two connected parts which would make a long, oval structure oriented SW-NE along its axis, which was about 185/195 × 90/100 cm. Thus, the vessels would be in its eastern part (Fig. 4: B). The profile of such a feature would have been quite irregular with a "bath" shape. The depth of the eastern part of the feature was about 64.5 cm with the measurements taken from the ground level and 38.5 cm from the top of the feature. The depth of the central and western parts was respectively 50/52 cm and 24/26 cm (Fig. 6: B).

Undoubtedly, Feature 102/1 was cut into the upper fill of the central grave pit under the barrow. Its edges did not extend outside the border of the central grave pit. Both features had also the same orientation.

No human bones were found in the feature, yet it must be noted that in the sandy soil, which dominated at Site 3 in Ulów, no organic remains have been found. As a result it is hard to interpret the function of this feature. It could be an inhumation grave with pottery placed probably at the foot of a deceased. Yet it cannot be ruled out that the feature, especially considering as a feature only the structure with vessels, was a kind of grave deposit.



Legend (Figs. 4–6)

1 – brown-bronze, slightly spotted; 2 – brown, homogenous; 3 – light brown-beige, homogenous; 4 – brownish, homogenous; 5 – light brown-yellowish, slightly spotted; 6 – dark brown-bronze-gray, in some places with single ferruginous concentration; 7 – dark bronze; 8 – light brown-light grayish, spotted; 9 – light brown-whitish-grayish; 10 – brown-gray with single ferruginous concentration; 11 – light gray-light brown-beige, spotted with ferruginous concentration; 12 – dark bronze-dark brown-gray with single, small charcoal pieces; 13 – bronze-brown with single, small charcoal pieces; 14 – brown-gray-light brown in some places with single ferruginous concentration; 15 – light brown-beige-grayish, spotted; 16 – light brownish-beige, slightly spotted; 17 – beige-light gray, slightly spotted with single ferruginous concentration; 18 – dark brown-bronze; 19 – gray-brown-russet, slightly spotted; 20 – light brown-light bronze-grayish, slightly spotted; 21 – dark gray-brown-light brown with concentration of small pieces of charcoal; 22 – gray-brown-light brown with single, small charcoal pieces; 23 – most clearly visible ferruginous concentrations; 24 – gray-beige-brown; 25 – brown-gray, slightly spotted; 26 – brown-dark brown-gray, with single, small charcoal pieces; 27 – light beige-whitish; 28 – whitish-light beige with single ferruginous concentration; 29 – steel gray-brown, slightly loamy; 30 – gray-light brown; 31 – dark gray-dark brown; 32 – light brown-brown-gray-beige, heavily spotted with intense and horizontally arranged ferruginous concentrations; 33 – light brown-beige, slightly spotted; 34 – light yellow-light brown with single ferruginous concentration; 35 – light yellow; 36 – light brown-light beige; 37 – dark brown-gray with single charcoal pieces; 38 – concentration of charcoal pieces; 39 – light gray-light brown-brown, slightly spotted with single ferruginous concentration; 40 – light brown-light gray-beige, spotted with single charcoal pieces; 41 – light brown, in places intensive, bronze spots; 42 – light yellow-light gray-reddish with single ferruginous concentration; 43 – steel gray-brown-light brown, highly spotted with intensive ferruginous concentration; 44 – light brown-beige, highly spotted with numerous ferruginous concentration; 45 – beige-light bronze-yellowish with numerous ferruginous concentration; 46 – bronze-beige, highly spotted; 47 – light brown-light bronze; 48 – gray-brown with single, small charcoal pieces; 49 – yellow-light brown with single ferruginous concentration; 50 – light brown-beige-gray

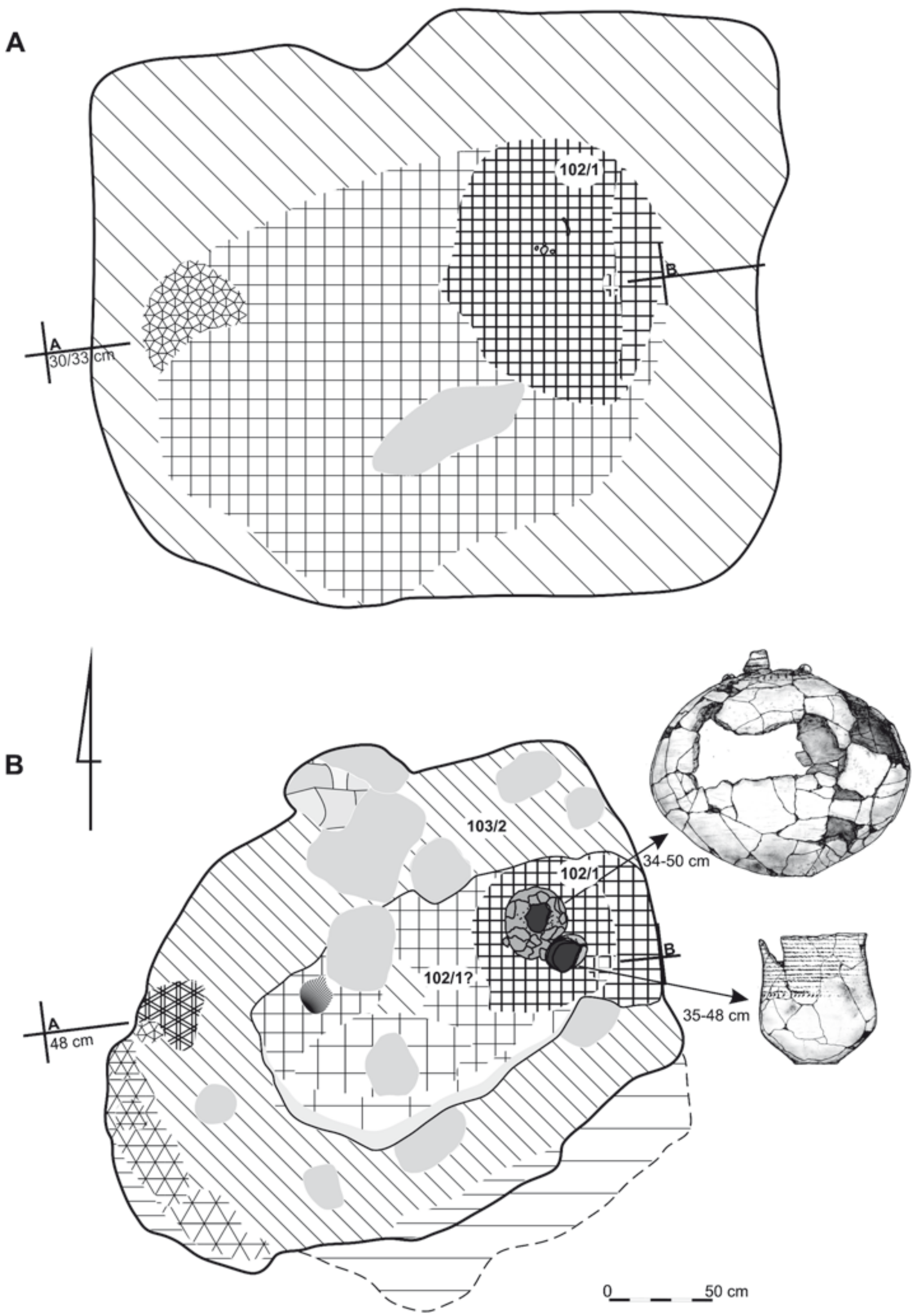


Fig. 4. Ulów, Site 3, Barrow III, plan of Feature 102/1 (grave?) and Feature 103/2 (central pit under the barrow). A – at the level 30/33 cm. B – at the level 48 cm (Drawn by B. Niezabitowska-Wiśniewska)

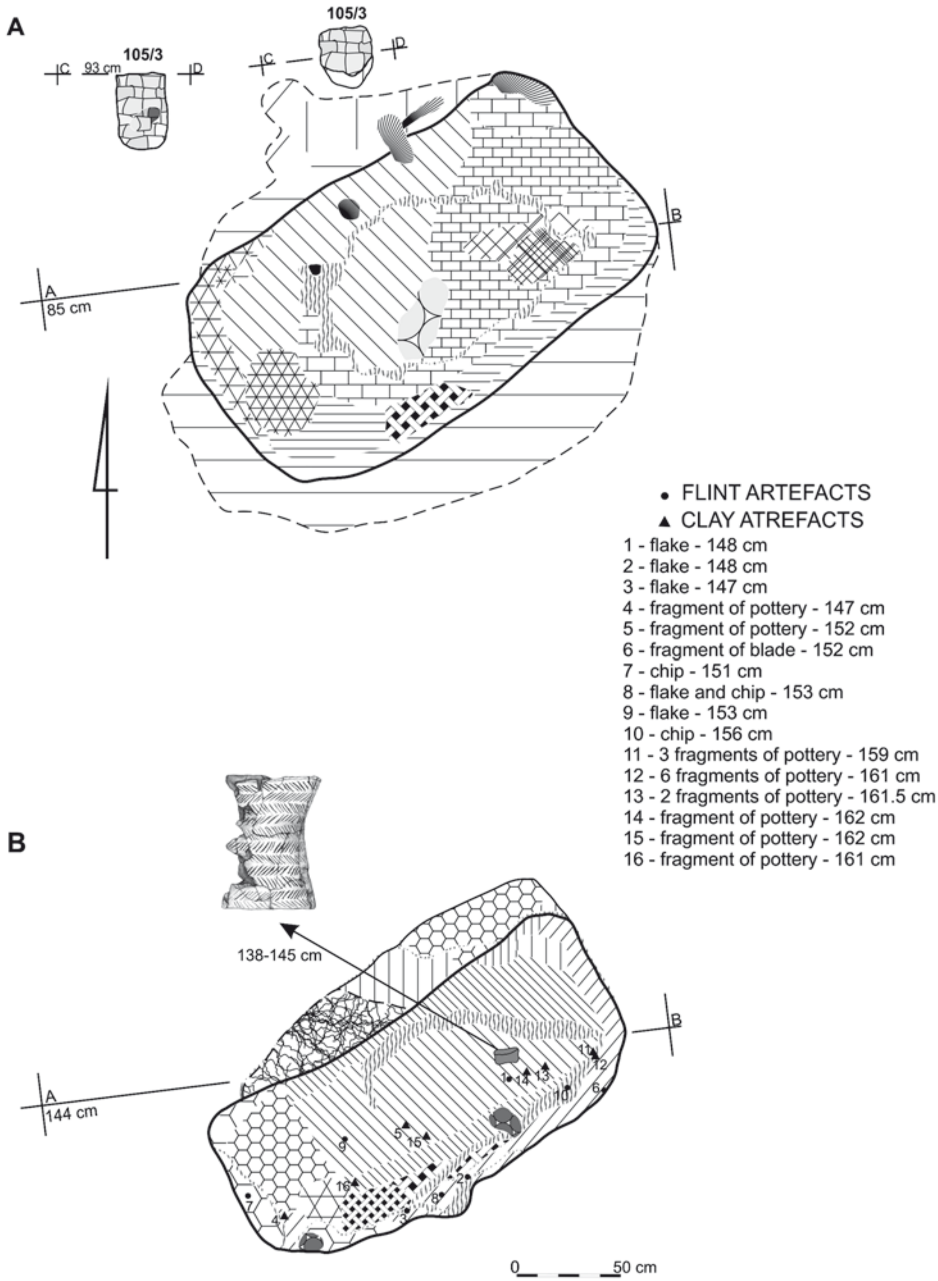


Fig. 5. Ulów, Site 3, Barrow III, plan of Feature 103/2 (central pit under the barrow) and plan and profile of Feature 105/3 (posthole). A – Features 103/2 and 105/3 at the level 85 cm. B – Feature 103/2 at the level 144 cm (Drawn by B. Niezabitowska-Wiśniewska)

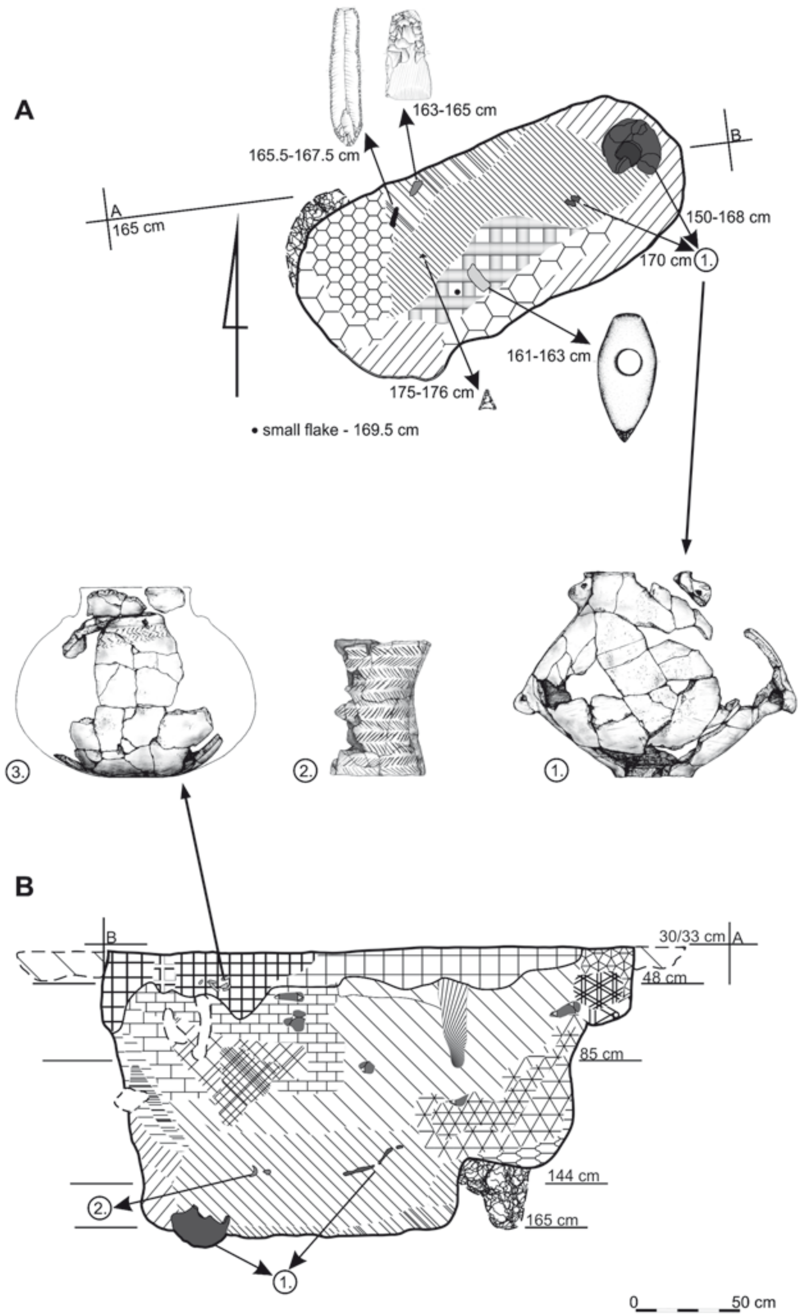


Fig. 6. Ulów, Site 3, Barrow III. A – plan of Feature 103/2 (central pit under the barrow) at the level 165 cm. B – profile S of Features 102/1 and 103/2 (Drawn by B. Niezabitowska-Wiśniewska)

Inventory

The finds inventory of the feature consisted of three vessels: two amphorae, a small beaker (Figs 7; 8), two small flint flakes and a small stone.

1) Amphora no. 1 (Fig. 7) – preserved in small fragments and partially re-deformed, slightly burnt and very fragile; similar to amphorae of type IIa according to J. Machnik (1966, 33, Pl. 48) and amphorae of type AIIBb1 according to P. Włodarczak (2006, 15, Pl. 14), with a globular belly with a shoulder at the half-height of vessel and a short funnel neck with three right angle shaped handles at the base of the neck; a small bottom, not separated, with small cavities arranged in a circle around 0.3-0.5 cm away from the edge; partially obliterated decoration on the neck and upper part of the belly, not reaching its shoulder in the form of four horizontal cord impressions, wherein the lower band extends between the holes in the lugs; below the base of the handles a band of ornament formed by symmetrically placed vertical rows of incisions / pseudo stamps, at the bottom limited by a horizontal cord impression; a light brown-beige surface, partially damaged, with wispy traces of smearing mainly on the shoulder and in the lower part of the vessel. Dimensions: height about – 29 cm; diameter of the rim – about 8 cm; the largest diameter of the belly – about 33-33.5 cm; diameter of the bottom – 5 cm.

2) Amphora no. 2 (Fig. 8: 1) – fragmentarily preserved, highly damaged; slightly similar to amphorae of type IIb according to J. Machnik (1966, 33, Pl. 48) and amphorae of type AIIBb2 according to P. Włodarczak (2006, 15), with a globular belly with a shoulder slightly below half the height of the vessel and with a short, slightly flared neck; in the upper part of the vessel, at the base of the neck, a horizontal plastic band vertically pierced in eight places (originally probably in nine); punctures arranged almost symmetrically; the plastic band in the places of punctures slightly thickened and forming small, crescent projections in a form like lugs; a small bottom, not separated, slightly concave; below the plastic band a belt of ornament in the form of poorly visible, horizontal and shallow incised herringbone motif (two bands?); an orange-brick red surface, partially damaged. Dimensions: height – about 18 cm; diameter of the rim – about 10-10.5 cm; the largest diameter of the belly – about 22.5 cm; diameter of the bottom – 4.5 cm.

3) Beaker (Fig. 8: 2) – preserved almost completely; slightly similar to beakers of type IVc according to J. Machnik (1966, 27, 28, Pl. 48) and beakers of type PIVBc5 according to P. Włodarczak (2006, 14, Pl. 3: 10-15), with a slightly flaring neck and with a shoulder below half the height of the vessel; bottom separated, slightly concave; partially obliterated ornament covering the neck and the upper part of the belly, reaching down to about half the height of the vessel; the ornament consists of 13 horizontal cord impressions; in a few places, just below the edge of the rim poorly visible an additional cord impression (14^{th}); corded ornament from the bottom limited by a row of incisions in the form of small bows; a light brown-beige surface, partially damaged, with poorly visible traces of wispy smearing mainly on the shoulder and in the lower part of the vessel. Dimensions: height – 16.6-17 cm; diameter of the rim – 13.8 cm; the largest diameter of the belly – 15 cm; diameter of the bottom – 5.4 cm.

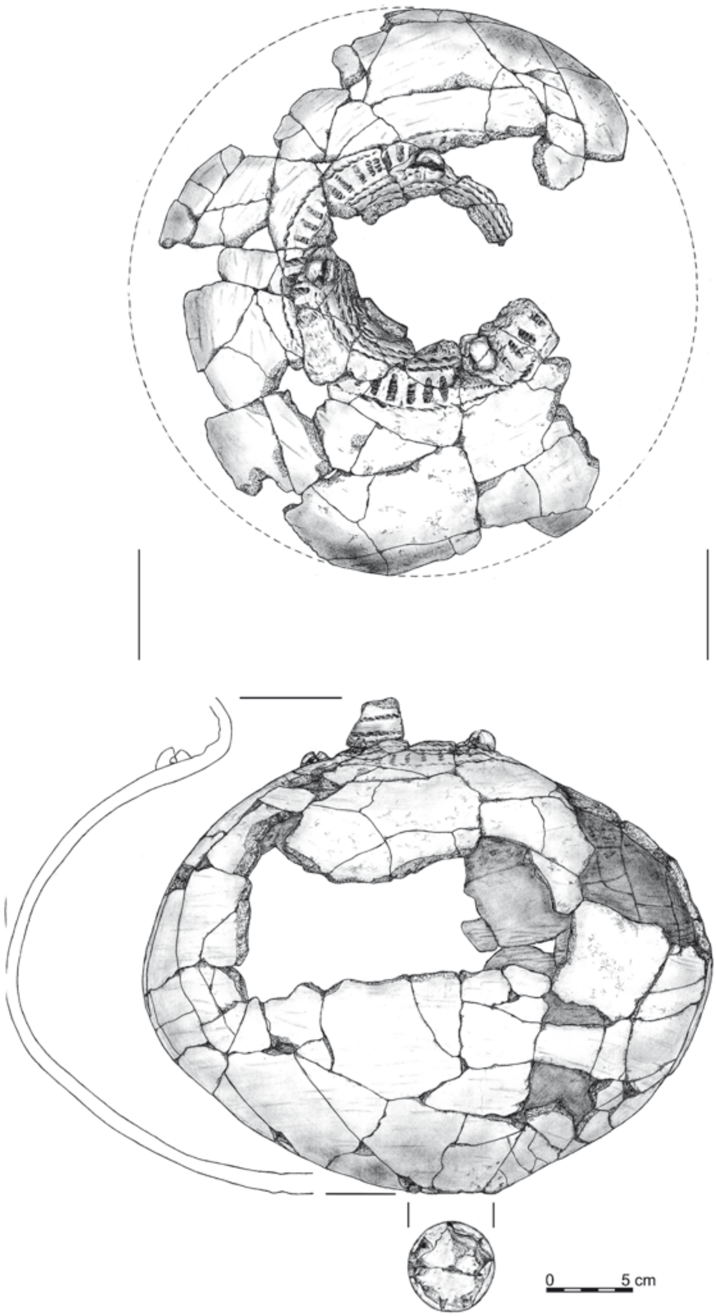


Fig. 7. Ulów, Site 3, Barrow III, Feature 102/1 (grave?) – amphora no. 1
(Drawn by B. Niezabitowska-Wiśniewska)

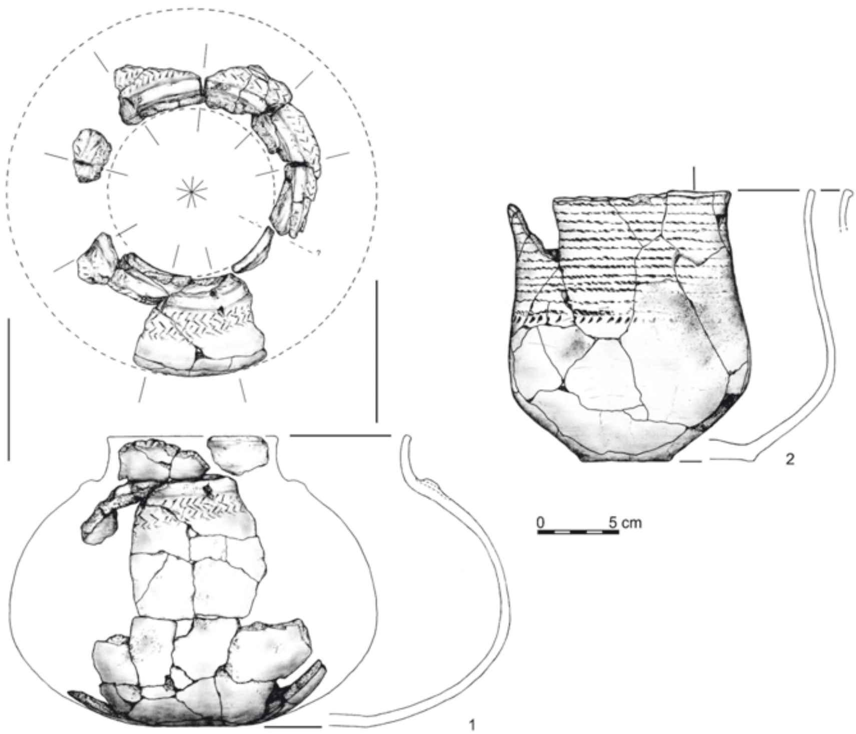


Fig. 8. Ulów, Site 3, Barrow III, Feature 102/1 (grave?). 1 – amphora no. 2. 2 – beaker (Drawn by B. Niezabitowska-Wiśniewska)

Feature 103/2 – the central pit under the barrow

In the upper fill (at a depth of 30/33 cm from the ground surface) of the central pit under the barrow, oval in shape and about 320 × 260/290 cm, its southern edge was barely visible. At this level it was oriented approximately on a W-E axis (Fig. 4: A). During excavation by the horizontal planum method, the size of the grave pit was becoming smaller and its shape was becoming more rectangular (respectively: at a depth of 43/44 cm – 320 × 200/220 cm; 48 cm – 310 × 190/220 cm – Fig. 4: B; 58/59 cm – 240 × 140 cm; 85/87 cm – 220×120/135 cm – Fig. 5: A; 123 cm – 210 × 120 cm; 143/144 cm – 200/210 × 115/120 cm – Fig. 5:B; 164/165 cm – 190/200 × 90/100 cm – Fig. 6: A). The orientation of the central pit under the barrow also changed. It was oriented SW-NE along its axis. The depth of the grave pit from the ground surface was about 165/170 cm and from the top of the pit about 135/140 cm (Fig. 6: B).

The extent and in places weak visibility of the pit in the upper part of the feature, as well as the fact that it was cut into Feature 102/1 meant that the line of the features section was not perpendicular to the edge of the pit.

Feature 102/1was visible very well in the upper fill of the grave pit, into which it was cut. In addition, the pit was surrounded by a layer of light-brown – yellowish sand especially visible by the northern and eastern edges of the pit. After Feature 102/1 was removed during the further excavation by the horizontal planum method, two layers dominated in the central pit: in the centre – a lightly spotted light grey-light brown-beige layer; on the edges, mainly by the east and west edge of the pit – a darker and spotted layer with brown-grey-light grey-beige colour. Ferruginous concentrations were visible in both layers, especially in the place where the two layers met. In places small pieces of charcoal were found. A regular and narrow layer, much lighter in colour than the fill of grave was adjacent to the north, east and southern edges of the pit. The layer was light brown-beige, in places even white. Its width was average from 5 to 18 cm. It was best visible at a depth of 144-158 cm at the north and southern edges of the pit. At the north edge its width was partly even 28 cm and colour was more yellow.

In the grave pit, mainly in its western part, oval, approximately dark brown-grey or dark brown-bronze structures with single and very small pieces of charcoal were visible. One of them became visible at a depth of 30 cm, the rest of the structures were best visible at a depth of 85-115/125 cm. The layers and structures mentioned above indicate that a wooden construction was located inside the grave pit.

The profile of the grave pit was irregular. The east wall was slightly slanting and directed at the inside of the grave. The west edge resembled steps. To a depth of about 65 cm it descended almost vertically and next it was narrowing towards the inside of the grave (for about 20 cm) creating the first step. Then, again it run almost vertically, next it was arched and finally it was horizontally narrowing towards the inside of the grave (for about 40 cm) at a depth of 135 cm creating another step. From there, it descended almost vertically to the floor of the grave (to a depth of 165/170 cm). The stepped shape of the western edge of the pit proves that a wooden construction was placed inside the grave pit. The bottom of the main part of the feature (in the place where a deceased was placed) was almost flat (Fig. 6: B).

In the fill of the grave pit, mainly by its southern edge, 36 fragments of pottery were found. The first of them were found at a depth of 85-86 cm, the next ones at 122-123, 138-143, 147 (Fig. 5: B/4) and 152 cm (Fig. 5: B/5). The biggest number of fragments was found at a depth of 159-162 cm (Fig. 5: B/11-16). In addition, three flint chips (less than 1 cm), six small flint flakes (greater than 1 cm) and two small flint blades were found in the fill. Similarly to the fragments of pottery, they were mainly found by the southern edge of the pit. Most of them were found at a depth of 147-156 cm (Fig. 5: B/1-3,6-10), except one artefact which was found at 123 cm and one found at 169.5 cm (Fig. 6: A).

Within the grave pit, on the level of the original deposition of the skeleton discovered artefacts such as (in accordance with the depth of the deposition): 138-145 cm – a significantly damaged clay beaker (Figs 5: B; 6: B/2); 155-170/175 cm – a highly damaged clay amphora (Fig. 6: A-B/1); 161-163 cm – a stone battle-axe; 163-165 cm an axe made of

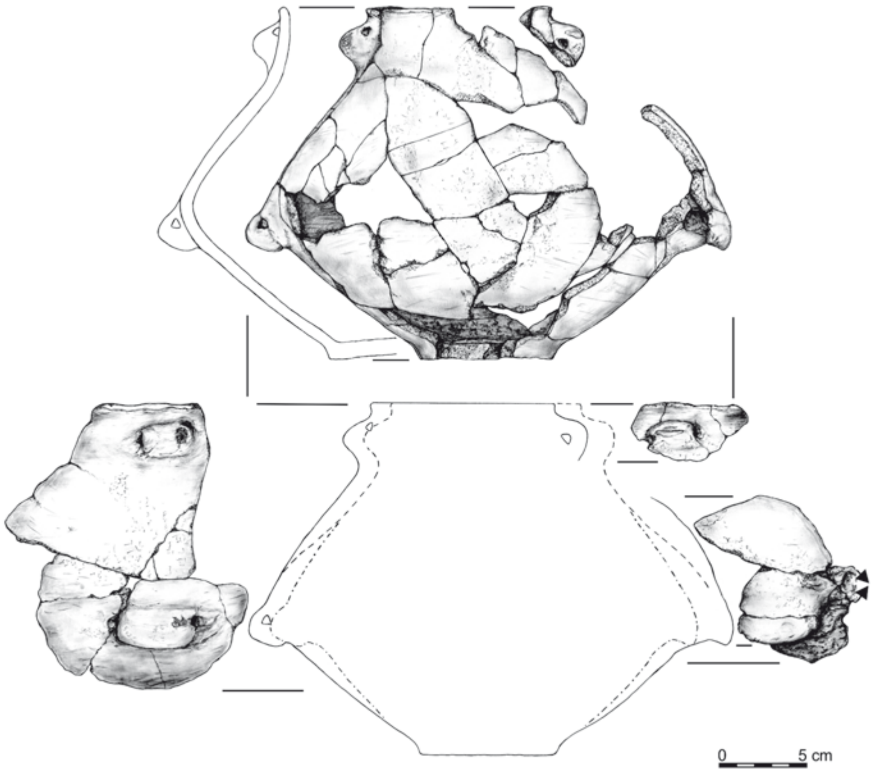


Fig. 9. Ulów, Site 3, Barrow III, Feature 103/2 (central pit under the barrow) – amphora (Drawn by B. Niezabitowska-Wiśniewska)

Cretaceous "Volhynian" type of flint; 165.5-167.5 cm – a retouched blade; 175-176 cm – a strongly burned flint arrowhead (Fig. 6: A). Because of sandy soil, no human bones were preserved.

It is worth noting that fragments of the upper part of the amphora, including its rim, were found much higher (at a depth of 126-140 cm) than the rest of the fragments of this vessel (a belly and a bottom). In addition they were found 55-85 cm west from the main parts of the amphora (Fig. 6: B/1).

Inventory

1) Amphora (Fig. 9) – fragmentarily preserved, heavily damaged and secondarily deformed, slightly burnt and very fragile; only slightly similar to amphorae of type Ic according to J. Machnik (1966, 32, 33, Pl. 48) and amphorae of type AIB according to P. Włodarczak (2006, 15, Pl. 12: 2); closest to amphorae of the Czech type A25e (mainly due to the proportions and shape of the vessel) according to M. Buchvaldek (1967, 31, fig. 3); with a biconical belly with a shoulder slightly below half the height of the vessel; a neck gently

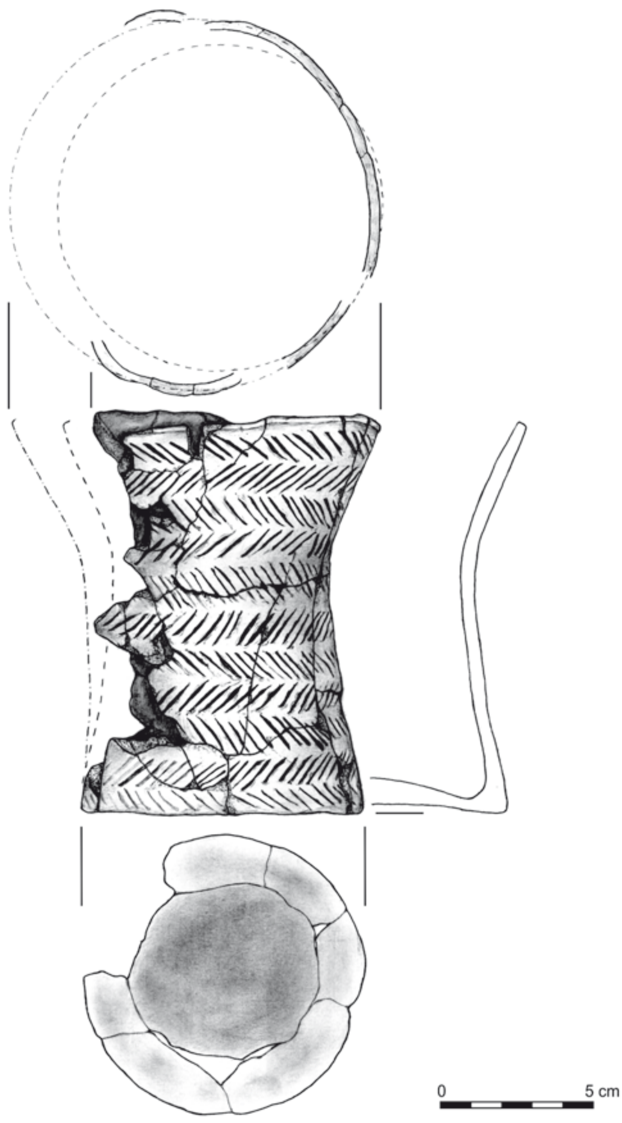


Fig. 10. Ulów, Site 3, Barrow III, Feature 103/2 (central pit under the barrow) – beaker (Drawn by B. Niezabitowska-Wiśniewska)

separate and slightly funnel flaring; two approximately right angle shaped lugs, symmetrically arranged at the base of the neck; the next two, sleeve – shaped, on the shoulder; upper lugs placed approximately on one axis of the lower lugs; bottom formed as a low foot, slightly concave; the amphora undecorated; light brown surface, partially strongly damaged with the traces of wispy smearing, mainly on the shoulder and in the lower part of the

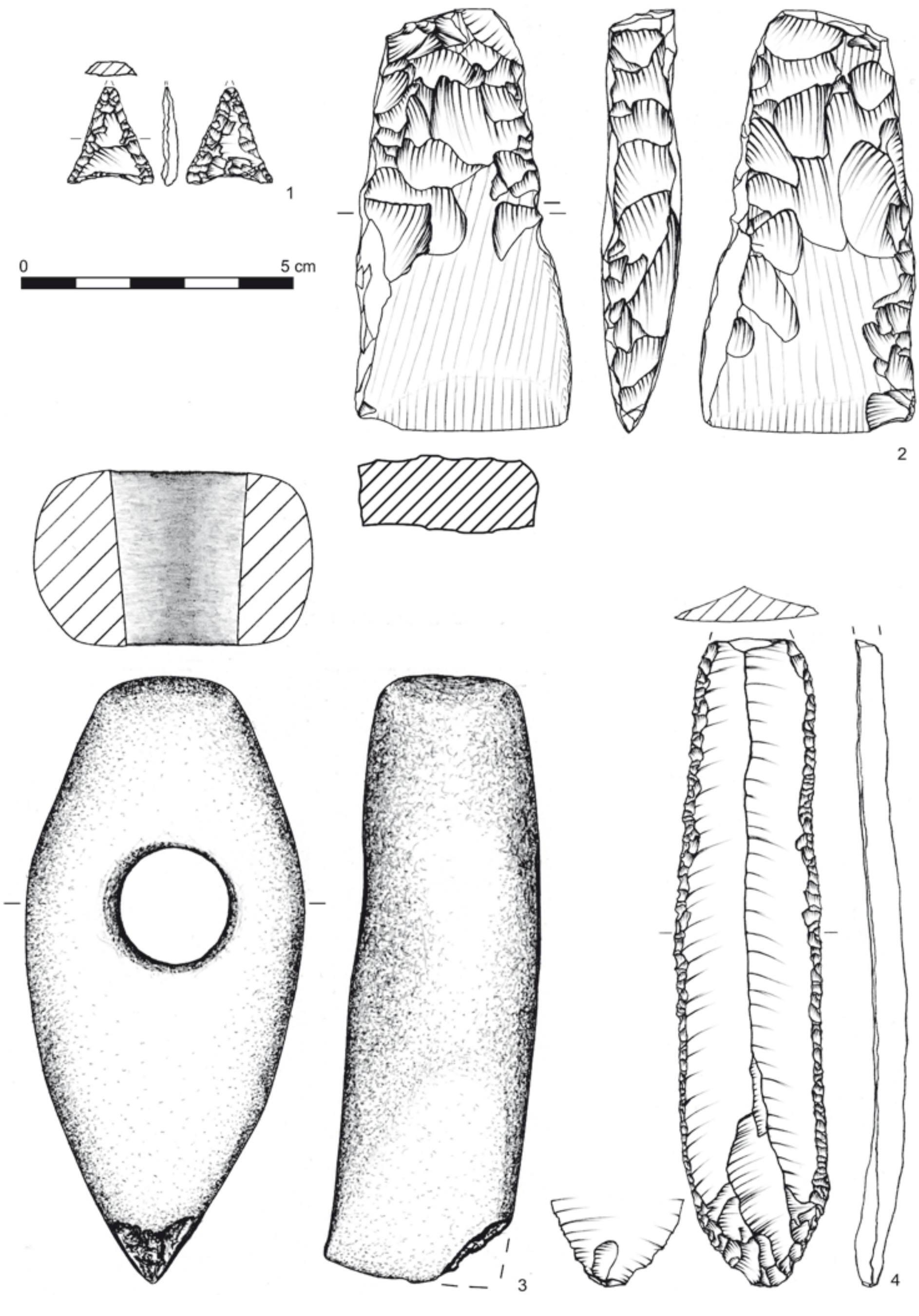


Fig. 11. Ulów, Site 3, Barrow III, Feature 103/2 (central pit under the barrow). 1 – arrowhead. 2 – axe. 3 – stone battle-axe. 4 – retouched blade (Drawn by T. Wiśniewski)

vessel. Dimensions: height – about 20 cm; diameter of the rim – about 10.5 cm; the largest diameter of the belly – about 25-26 cm; diameter of the bottom – 7.5 cm.

2) Small beaker (Fig. 10) – pot-shaped or mortar-like or hourglass-shaped – fragmentarily preserved, heavily damaged and secondarily deformed, poorly burnt and fragile; only in general similar to the beakers of type VIc according to J. Machnik (1966, 30, 31, Pl. 48) and the beakers of type PVIC according to P. Włodarczak (2006, 15, Pl. 11: 23, 24); closest to the beakers of the newly separated type VId (Machnik *et al.* 2009, 180); walls curved inside about half the height of the vessel; a wide bottom, clearly concave; ornamentation on the whole surface in the form of horizontal, deeply incised herring-bone motif (5.5 bands); surface in places heavily damaged, spotted, and with dominant colour of brown-bronze and light brown-greyish places. Dimensions: height – about 13 cm; diameter of the rim – 10.5 or 12 cm; diameter of the bottom – 9 cm.

3) Axe (Fig. 11: 2) – quadrangular of type ID according to P. Włodarczak (2006, 28, fig. 23: 10); made of Cretaceous "Volhynian" type of flint; trapezoidal in a contour plane; wedge-shaped in a longitudinal section; quadrangular in a cross-section; rectangular shape of the butt; irregularly polished on whole surfaces (dorsal and ventral). Dimensions: length – 7.8 cm; width of the cutting edge – 3.8 cm; max. thickness – 1.5 cm.

4) Stone battle-axe (Fig. 11: 3) – made of amphibolite; rhomboidal shape with symmetrical, slightly hanging, partially damaged cutting edge; upper broader side is slightly convex, lower broader side is slightly concave; a hole of a shaft placed closer to the butt. Dimensions: length – 11.2 cm; max. width – 5.1 cm; max. thickness – 3.4 cm; height of the butt – 2.3 cm.

5) Retouched blade (Fig. 11: 4) – made of Cretaceous "Volhynian" type of flint; with bilateral retouch, partially flat and halfsteep, made to the upper side; broken tip; the blade blank was detached from a single-platform core. Dimensions: preserved length – 11.9 cm; max. width – 2.3 cm; max. thickness – 0.6 cm.

6) Arrowhead (Fig. 11: 1) – made of an indeterminate raw material; strongly burned; shaped by the partially bifacial retouch; slightly asymmetrical, triangular with indented base. Dimensions: length – 1.9 cm; max. width – 1.6 cm; max. thickness – 0.3 cm.

Feature 105/3 – posthole

At a depth of 41 cm below the level of the ground by the north wall of the central grave pit, an irregular dark brown-bronze darker area was found. At 56 cm depth its shape became almost square and colour steel grey-brown, it was 30 × 30 cm in dimensions. This proved that it was a posthole, probably connected with the construction of the central grave pit. At a depth of 93 cm, after reducing its size to 25 × 25 cm, it was dug in half-sections. Its base was found at 131 cm below the ground and 90 cm below the top of the feature. The shape of the profile of the posthole was similar to a letter "U" and its bottom was slightly curved (Fig. 5: A).

Feature 99/4 – hearth connected with the cemetery from the Roman Period.

The feature was found in the north-west part of the mound of the barrow and was placed north of the western part of the central grave pit. It had an almost perfect rectangular shape and at the top, it measured 95 × 80 cm. Because of the big amount of charcoal, giving it a black colouring, it was clearly visible even at 19 cm. Its base was found at 55.5/56 cm. Below the base of the feature, to 68.5 cm, a clear layer of significantly scorched soil was found. Within the feature, a large amount of burned stones and fragments of a re-burned clay vessel were found (Fig. 3: B).

Except the features mentioned above, three darker areas were found within the mound of the barrow, yet it is hard to discover their functions. Maybe two of them, by the northern and southern edge of the central grave pit, were connected with the construction of the pit (Fig. 3: B).

ANALYSIS

Construction of the barrow and the central grave pit

Barrow III, the original diameter of which was about 8-8.5 m, is the smallest among the excavated barrows at Site 3 in Ulów. The original diameter of Barrow I at this site was about 10-10.5 m, and Barrow II – about 15.20 m on the line N-S and about 14.54 m on the line E-W (Niezabitowska-Wiśniewska and Wiśniewski 2011, 330, 348). The diameter of Barrow III, the remains of a weakly visible ditch as well as the dimensions and orientation of the grave pit do not differ from the rules of funeral rites of CWC (Machnik 1966, 70-74; 1979, 343). A gradual decrease of the size and shape of grave pits – oval in its upper parts and becoming a rectangular at the bottom – is typical mainly for areas east of the Vistula river (Jarosz 2002, 13).

A light brown-yellowish sand layer, which was visible after removing the humus layer around the central pit under the mound and was best visible by the northern and eastern edge of the pit, may be the remains of a small mound formed before the grave was completely covered by the burial mound. Evidence of such small mound was found in Barrow II in Ulów. It was covering a central grave (no. 97/1; Niezabitowska-Wiśniewska and Wiśniewski 2011, 354, 361). A small mound was also covering Feature 4 (a grave) located in the centre of Barrow B in Bierówka, Jasło district (Gancarski and Machnikowie 1990, 106, 114, fig. 3), a central grave pit under Barrow 1 in Średnia, Przemyśl district (Machnik and Sosnowska 1996, 19, fig. 5), and a central grave pit in Wola Węgierska, Jarosław district (Machnik and Sosnowska 1998, 5-7, 15, fig. 5). However, it cannot be excluded that the lighter layer was created by the soil which was thrown in the northern and eastern direction during digging of the central pit under the barrow. Another possibility, though less probable, is that it was created from the soil removed during digging Feature 102/1 into the upper fill of the pit. Evidence of mounding the soil from digging a grave pit was also found in Barrow B in Bierówka (Gancarski and Machnikowie 1990, 114).

The presence of dark brown-grey or dark brown-bronze structures, visible mainly in the western part of the central pit under the barrow, may be evidence for the presence of a wooden construction. One such structure, visible even from the upper surface of the feature by the western edge of the grave pit may be interpreted as a posthole. A similar feature was found by the northern edge of the grave pit and most probably was an element of the mentioned construction. The absence of clear traces of burning seems to indicate that the wood used in the construction was not burned. It might have been a shoring supporting and protecting walls of the pit from collapsing or remains of an indefinable overground construction. Traces of similar constructions were found in Grave 95/1 in Barrow I and in graves 98/2, 99/3 and Feature 66/8 in Barrow II in Ulów. In addition, the western edge of Feature 66/8 was formed in the shape of steps, almost exactly like the western edge of the central grave pit in Barrow III (Niezabitowska-Wiśniewska and Wiśniewski 2011, 330-337, 340-342, 355-361). This quality may also indicate the presence of a wooden constructions. What is more, the floor of the posthole located by the northern edge of Feature 103/2 (a grave) was almost at the same depth as the floor of the lower step in the western part of the feature (respectively 131 and about 135 cm).

The remains of the interior or overground constructions made of wood are very often found in graves under barrows of CWC, in Lesser Poland and the Carpathian Foothills (Machnik 1966, 73; 1992a, 73, fig. 2; 2001, 124; 2007, 22, 25, fig. 13; Gancarski 1992, 20, 21; Włodarczak 2006, 51; Jarosz 2011, 257-260, fig. 2). They were found, among others, in: the central part of Barrow 1 (Machnik and Sosnowska 1996, 9, 10, fig. 9) and Barrow 2 at Site 3 in Średnia (Jarosz 2002, 7, 13, figs 7, 9); Barrow I in Brzezinki, Lubaczów district (Machnik 1966, 240, 241); Feature no. 9 in Lelowice, Proszowice district (Rodak 2002, 126, 127, fig. 7, photo 6), Grave no. 1 in Kocmyrzów, Kraków district (Włodarczak 2000, 486; 2006, 51); Grave no. 1 in Gabułtów, Kazimierza Wielka district (Górski and Jarosz 2006, 405-407, figs 5, 6); Krajowice, Jasło district (Gancarski 1992, 24, fig. 18); Barrow A, Feature no. 1 and Barrow B, Feature no. 4 in Bierówka (Gancarski and Machnikowie 1986, 63, 64, 71, fig. 8; 1990, 103-106, 114, 119, figs 5, 7); Barrow 1 in Niepla, Jasło district (Machnik 1992a, 73, fig. 2: 2; 1992b, 269, fig. 3; 1998, 102, 103, fig. 3: 3; 2007, 25, fig. 13: C), and also probably in Barrow I in Lipie, Rzeszów district (Machnik 1966, 247) and in a mound in Morawsko, Jarosław district (Machnik 1995, 10). Traces of a wooden construction were also found in a grave pit, originally located at the edges of a barrow in Młodów-Zakącie, Lubaczów district (Pilch 1997, 175, 177, figs 3: b, c; 4). The remains of wooden constructions next to grave pits, above or within them, were found in Brestov in Slovakia (Gancarski *et al.* 2001, 29-31, 47, figs 5, 6, 8, 11) and in the Dniester basin in places like Kołpiec (Kollets, now part of Stebnyk, Lviv Oblast, UA), Kulczyce-Szlacheckie (Kulchytsy, Lviv Oblast, UA) and Ozimina (Velyka/Mala Ozymyna, Lviv Oblast, UA) (Sulimirski 1968, 125, 133, 134, 136, 138). Similar constructions were recognized also in the Middle Dnieper culture (Artemenko 1967, 61, 72, 81).

The presence of a lighter layer (border) around the central grave pit of Barrow III also has many analogies. It might be connected with traces of an organic construction, for instance casing of a grave. Similar layers, besides Grave 99/3 and Feature 66/8 in Barrow II in Ulów (Niezabitowska-Wiśniewska and Wiśniewski 2011), were found in Barrow 1 in

Wola Węgierska (Machnik and Sosnowska 1998, 5, 14, 15, figs 6, 7) and in Barrow 1 in Średnia (Machnik and Sosnowska 1996, 8, 9, 17-19, figs 5, 7), and in other graves under barrows of CWC, especially in the Carpathian Mountains (Machnik 1992a, 73, fig. 2).

Most probably, in the central grave (Feature 103/2), later covered by the mound, a male adult was laid. This matches norms observed in the barrow cemetreies of CWC. The presence of weapons in the inventory, a stone axe, an arrowhead and a retouched blade also indicates that the an adult male was buried inside the grave (Jarosz 2003, 250, 251, 253; Włodarczak 2006, 63, 66, 67).

A very interesting element is Feature 102/1 cut into the upper fill of the central pit under the barrow (Feature 103/2). Unfortunately we cannot be sure if it was made only of an oval structure consisting of three vessels or the feature was originally much bigger oval in shape and longer and the mentioned structure with three vessels was in its eastern part. We may assume that it was an inhumation grave, yet we cannot be certain since no bones were preserved.

If we assume that only the oval structure with vessels was the grave, its upper part was 100 × 135 cm, it seems we are dealing with grave of a child. Nevertheless, children were rarely buried under barrows, especially in their central parts/graves (*e.g.* Nedeżów, Tomaszów Lubelski district, Site 22, Barrow 2, Grave 2 – Bagińska 1996, 63; Machnik *et al.* 2009, 127, 130; Łubcze, Tomaszów Lubelski district, Site 1, Barrow 1, Grave 1; Barrow 2, Grave 1; Łubcze, Site 16, Barrow 2, Graves 1 and 2 – Machnik *et. al.* 2009, 43-46, 51-54, 244, 244; Zakłodzie, Grave 2 – Machnik 1966, 239 and probably Lelowice – Rodak 2002, 126, 127; Włodarczak 2004, 343, fig. 2: A). Whereas, in flat graves burials of men, women and children are similar in numbers (Jarosz 2003, 250) and, for example, in Kraków-Sandomierz CWC group graves of children are a significant part of all graves of this type (Włodarczak 2004, 341). Children were also very often buried in simple pit graves (Włodarczak 2004, 342, fig. 2: B). Mass graves where adults were buried together with children, whose bodies were placed in large beakers, are also known (Żerniki Górne, grave 31 and 34 – Włodarczak 2004, 346, 347). Child's pit graves dug into the upper fill of a grave under a barrow have never been found. Only at Site 4 in Ulów, were two other features dug into the central burial pit of Barrow II. Their size and furnishing indirectly suggest that they could be associated with children's graves, yet due to the fact that no bones were preserved, this fact cannot be proven conclusively (unpublished results of research; about use-wear analysis of flint artefacts from this barrow, see: Pyżewicz 2017,126, fig. 7).

The inventory of Feature 102/2, consisting of three vessels, is also troubling. Ceramic vessels were a basic element of the inventory of children's graves, but in most cases there was only one vessel. Furthermore, in children's graves, miniaturization of objects was clearly visible, including vessels (Włodarczak 2004, 348). Whereas, in the inventory of Feature 102/1 a large amphora, about 29 cm high, was found.

If we assume that Feature 102/1 is made of, not only the oval structure consisting of three vessels, but also another oval, longer structure which adjoined it from the west, the feature would be approximately 185/195 × 90/100 cm and could be a grave of an adult. In this case, the three vessels were probably placed at the foot of the body. The size and type of the vessels, as well as the lack of weapons suggest that it was a grave of an adult female (Jarosz 2003, 253). Sometimes graves of adults were dug in mounds of barrows or on their edges (Machnik *et al.* 2009, 243, 244). In Barrow B in Bierówka, Feature 4a (grave) was cut into Feature (grave) 4 located in the centre of the barrow, damaging its western part. Both features had been created before the mound of the barrow (Gancarski and Machnikowie 1990, 114, 115). An even more complicated situation was observed in Barrow 2 in Średnia (Site 3), which was a multi-phase structure, where, among others, the centrally placed burial pit (no. 3) was damaged by a trench containing most likely two burials (nos. 1, 1a) stacked above each other (Jarosz 2021, 154-162, figs 2-7). Nevertheless, the most similar stratigraphic arrangement of graves was documented in a barrow in Nedeżów (Site 22). In the central part of the barrow there were two graves dug into each other. They were rectangular in shape and had similar size, and the newer grave was placed almost perfectly above the older grave pit. In Grave 2 (the lower one) the remains of a young male, aged 14-16, were found, Grave 1 (the upper one) consisted a male burial, aged 25-30 (Bagińska 1996). Similarly to the graves in Barrow III in Ulów, the lack of a preserved mound makes it impossible to say in what time intervals the graves were created. The younger grave could have been dug just after the older grave was created and before the mound was built, or if we assume that the older grave was covered with a small mound, the newer grave could have been dug before it was completely covered with a mound. It could have been also dug into the central point of an existing mound and by accident right into the middle of an existing grave which was under it. This latter hypothesis seems, however, unlikely. In addition, the inventory of the graves, which comes from the same period, does not help to discover at what time intervals the graves were dug.

We cannot also exclude the possibility, yet it is less probable, that the vessels dug into the upper part of the central grave under Barrow III at Ulów were a kind of deposit of grave goods. However, in most cases, grave goods were placed in mounds which were already built and very often they were small vessels (*cf.* Ulów, Barrow II – Niezabitowska-Wiśniewska and Wiśniewski 2011, 362, fig. 23: 2; Brzezinki, Barrow IV; Lipie, Barrow 1 – Machnik 1979, 343, 347). A completely different situation was recorded in Barrow 6 in Białka (Site 3), Krasnystaw district, where burial equipment was discovered in the upper fill of the burial pit, as in Ulów. At the bottom of the pit, however, no remains of a skeleton and other grave goods were found, which is definitely different from the situation observed in the grave from Ulów (Budziszewski *et al.* 2016, 373-377).

Feature 99/4 which was dug into the mound, should be interpreted as a hearth, functionally connected with the cemetery of the Wielbark culture. At Site 3 in Ulów, features of this type are located by the western border of a dense cluster of burials of this culture. Similar structures with cobbled stone paving were discovered, among others, at a biritual cemetery of the Wielbark culture in Krosno, Elbląg district (Okulicz and Bursche 1987, 223-229; Chowaniec 2005; Jarzec 2018). The mere fact that Feature 99/4 was dug into the CWC barrow indirectly suggests that it was undetectable at the time of the Goths' presence near Ulów. This population, at least in Ulów, did not disturb earlier barrows, which is best evidenced by the lack of features dated to this period in the mound of the largest one (Barrow II), which was certainly recognisable in this area in the Roman period.

Inventory

Taking into consideration the amount of artefacts discovered in the two features of Barrow III, it should be recognized as the richest among other barrows explored in the site in Ulów.

The large amphora no. 1, with three handles placed on the base of the neck (Fig. 7), and the beaker (Fig. 8: 2) from Feature 102/1 represent widely spread types of CWC vessels which have been found in the area of the Little Poland Uplands, in the San river basin and in the southern part of the Lublin Land. There are also similarities in the way of decorating the beaker. Amphorae of type IIa, according to J. Machnik, were often decorated with patterns of horizontal cord impressions, similar to ones found in the vessel from Ulów. There is only a problem finding the exact analogy to the whole composition of the ornament, which cover the amphora no. 1, including the strings of horizontal cuts.

The other three vessels seem more interesting. The first of them is a small amphora (no. 2) from Feature 102/2 with a horizontal plastic band vertically pierced in eight places at the base of the neck (Fig. 8: 1). Amphorae with horizontal bands with crescent projections in the form of perforated lugs are characteristic mainly for the Little Poland Uplands (Machnik 2011, 63; Hozer *et al.* 2017, 81-83). These amphorae are known basically from the sites as: Pełczyska, Pińczów district, Site 6, Feature 50 (Włodarczak 2006, Pl. 40: 13); Miechów, Miechów district, Site 18 (Włodarczak 2006, Pl. 81: 3); Witów, Proszowice district, Site 5, Grave 2 (Rydzewski 1973, 74, fig. 4: a; Włodarczak 2006, Pl. 34: 11). Two vessels of this type also come from the Rzeszów foothills, from recently discovered graves in Szczytna, Jarosław district (Site 5, Grave 220; Site 6, Grave 84 – Ligoda and Podgórska-Czopek 2011, 239 cat. 63: 8; Hozer *et al.* 2017, 24-26, 62, 81-83, figs 12: 4; 35: 2). All the above-mentioned amphorae are however different from the amphora from Ulów. They have different proportions and the way of forming the belly, the bottom and plastic band. Moreover, their height often highly exceeds twenty centimetres. Among the aforementioned amphorae, we will also not find the ornament similar to the one on the amphora from Ulów. Apart from the lack of similar decorative motifs, their position also differs – in all examples it is on the neck, often on the plastic band and sometimes it occurs below the band, in the upper part of the belly.

The next two vessels come from the central grave pit of Barrow III (Feature 103/2). Mortar or pot-shaped beaker (alternatively an hourglass shape) ornamented on the whole surface with a herringbone pattern (Fig. 10) is the most similar to the vessel from Wola Węgierska (Barrow 1, central grave – Machnik and Sosnowska 1998, 8, 16, fig. 11). The next two beakers come from Wierszczyca, Tomaszów Lubelski district (site 1 and 30), however they differ from the one from Ulów as there is lack of ornament on the lower part of the vessel (Site 1, Barrow 1, Feature 1 – Bagińska 1997, 50, 51, fig. 4: c; Machnik *et al.* 2009, 139-142, fig. 111: 2) or the ornament in the shape of oblique grooves only a bit similar to a herringbone pattern (Site 30, Barrow 1, Feature I – Machnik 1999, 236, fig. 4: B/4; Machnik *et al.* 2009, 151, 152, fig. 119: 5). It is generally maintained that such characteristic features of these beakers, such as clear narrowing at half height of the vessel, or slightly above and decorations with incisions (mainly in the herringbone pattern) on the whole or almost whole surface of the vessel, are similar to the beakers of the Middle Dnieper culture. We can only say here about the continued existence of a tradition and adapting it to the CWC canon (Machnik 1979, 58; Machnik and Pilch 1997, 161, fig. 9; Machnik 1999, 235, 239, figs 4: B/4; 6: A/4, 8; Machnik *et al.* 2001, 392).

Near the beaker, there was also found a double conical and non-ornamented amphora with handles placed one on top of the other – two on the base of the neck and two in the most protruding part of the belly (Fig. 9). From the areas east of the Vistula river, only one similar vessel is known, which was found in Nedeżów, site 22, Barrow 2, Feature 1 (Bagińska 1996, 63, fig. 4: a; Machnik *et al.* 2009, 127, fig. 99: 1). However, it differs from the amphora from Ulów in proportions as well as the presence of the spherical belly and much greater size. Fragments of an amphora with handles placed on the widest part of the belly and at the base of the neck are part of the collection of artefacts found on the surface in Markowa, Łańcut district. However, it differs from the specimen from Ulów in proportions, as well as the presence of a plastic band at the height of the upper handles and the presence of an ornament (Podgórska-Czopek and Czopek 1985, 51-54, fig. 1: 5). The tradition of placing handles on non-ornamented amphorae, placed one above the other, is characteristic for the area of Czech Republic. However, the number of upper handles is often higher (usually four). The amphora from Ulów is placed in the type 25 according to M. Buchvaldek (1967, 31, fig. 3, map 11; 1986, 88, figs 44; 52: 2). The proportions, size and the belly form are closer to the variant "e" of this type. The most similar to the amphora from Ulów is the amphora found in Vikletice, Chomutov district, Grave 141 (1963) – Buchvaldek and Koutecký 1970, 39, 208 tab. 1: 141/1, fig. 60: 1). Similar, yet representing type 25f and 25g, are the amphorae from graves 60 (1963), 109 (1963) and 54 (1964) – (Buchvaldek and Koutecký 1970, 27, 30, 54, tab. 1: 60/2, 109/1, 54/3, figs 18: 2; 29: 1; 100: 3).

USE-WEAR ANALYSIS

Use-wear analysis included a retouched blade and a flint axe (Fig. 12). A flint arrowhead, on account of its high degree of burning, was not subjected to it. As results of use-wear analysis conducted by Katarzyna Pyżewicz have already been published (Pyżewicz 2017), this paper includes only general findings. The retouched blade exhibits minor traces of storage, discernible along both side edges and on prominent inter-scar ridges. The

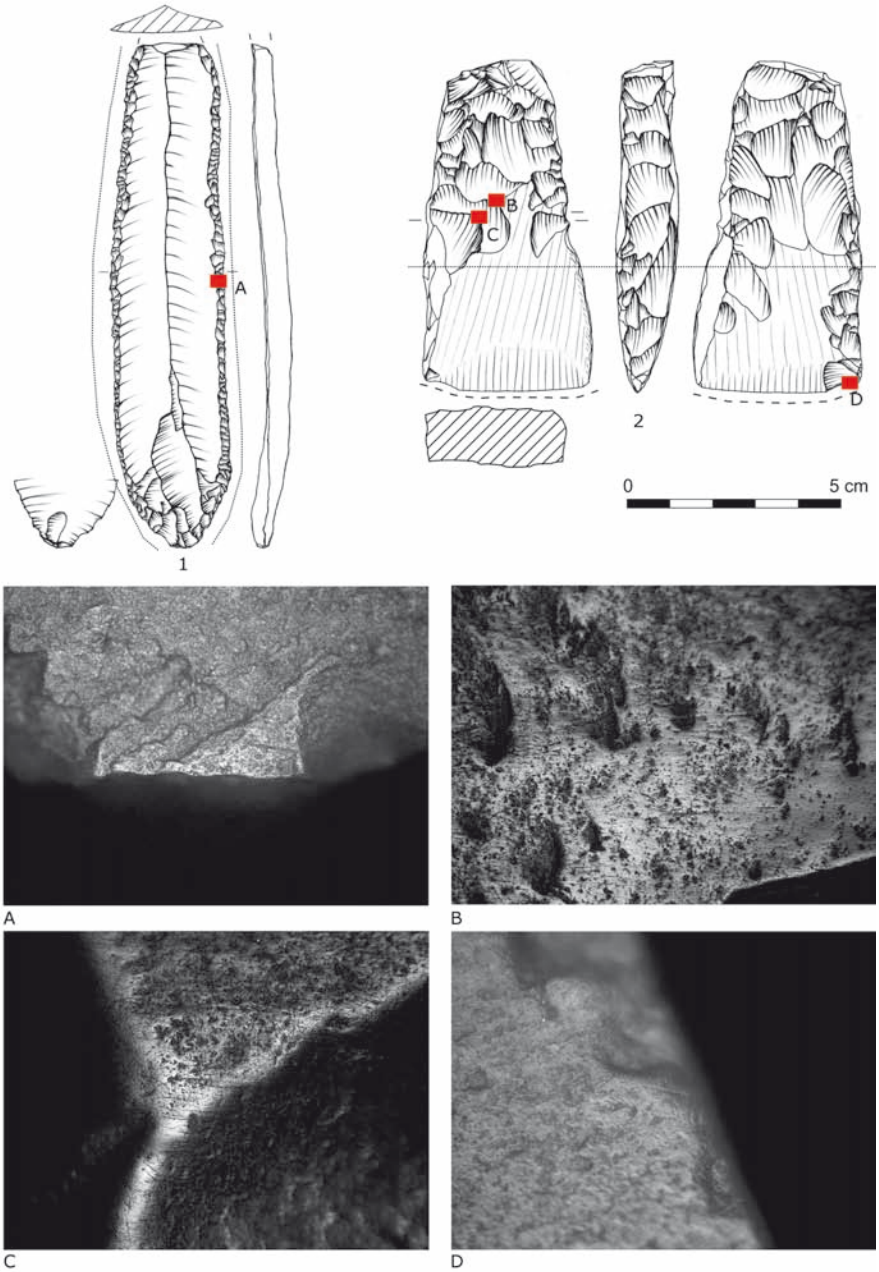


Fig. 12. Ulów, Site 3. Flint artefacts from Barrow III. 1 – retouched blade. 2 – axe. A – traces of contact with hide/plant fibre (storage/transport). B–C – traces of contact with hide/plant fibre (hafting). D – traces of wood chopping. A – 100× magnification. B–C – 50× magnification. D – 200× magnification (After Pyżewicz 2017)

axe, apart from intense traces of hafting made of organic materials, including plants and hide, is distinguished by chipping and polish on the cutting edge, which most likely developed as a result of using it for wood processing. The reach of the haft largely coincides with the end of the polished zone of the cutting edge, approx. half of which was stuck in a haft (Pyżewicz 2017, 123, 126-130, fig. 4).

CHRONOLOGY

On the basis of the inventory, the central grave (Feature 103/2) in Barrow III in Ulów can be compared with younger CWC complexes (III phase of CWC or the last stage of the II phase of CWC). This is confirmed by the chronological position of the mortar beakers (Bagińska 1997, 52; Machnik and Sosnowska 1998, 16; Machnik *et al.* 2009, 214, 230, fig. 137), as well as placing unornamented amphorae with handles placed one above the other in the late III phase of CWC in Czech Republic (Buchvaldek 1967, fig. 21; Machnik 1999, 233-235, fig. 5: 3). In this way, the Feature 102/1 dug in the central grave pit is surely younger, yet it is difficult to determine unambiguously the time interval that separated the creation of these two features.

Unfortunately, Barrow III, including its central grave, did not yield organic traces that would enable radiocarbon dating (the charcoal fragments were too small and most of them could not be taken out). Nonetheless, we have obtained a date for charcoal (*Fraxinus excelsior*) from the central grave under Barrow I at the same cemetery – *ca.* 2621-2491 BC (68.2% probability). Feature 60/2, dug into the south-east part of Barrow II, just by its encircling ditch, is dated to a similar period – *ca.* 2569-2467 BC (68.2% probability). Within it, a fragment of a well-preserved, burnt wooden beam (*Quercus* sp.) was discovered (cf. Niezabitowska-Wiśniewska and Wiśniewski 2011, 351; this paper was produced before conducting radiocarbon dating and it erroneously indicated that features cut into the edges of the barrow should be associated with the cemetery of the Wielbark culture). Unfortunately, we do not have radiocarbon dates from the central burial pit under Barrow II (Grave 97/1). It was nearly completely destroyed by three later additions, including the oldest one, which had probably been dug before the mound was constructed (Feature 67/9), one from the end of antiquity (Feature 68/10 – *ca.* 474-600AD; 68.2% probability), and another from the Middle Ages (Feature 68A/11 – *ca.* 1310-1401AD; 68.2% probability; Fig. 13; Table 1; *cf.* Moskal-del Hoyo *et al.* 2017, tab. 1). Thus, it is very likely that the dating of Barrow III roughly corresponds to that of Barrow I from the same cemetery. This dating coincides with the findings about the occurrence of CWC in what is now Poland. In south-eastern Poland, the CWC emerged between 2800 and 2700 BC and declined about 2300 BC. Absolute age estimates, however, are complicated by the two flattenings of the calibration curve (plateaux) covering the periods 2880-2580 BC and 2470-2200 BC. This significantly extends the ranges of dating probability of some of the samples (Włodarczak 2006, 121, 122; 2009; 2016; 2018; Jarosz and Włodarczak 2007).

Table 1. Ulów, site 3. Radiocarbon dating of charcoal samples from features within the barrows of the Corded Ware culture (compare Fig. 13)

Sample name	Taxon (charcoals)	Lab nr	Age ^{14}C	Cal age BC/AD (68.2%)	Cal age BC/AD (95.4%)
Barrow I, central grave	*Fraxinus excelsior*	Poz-73135	4045 ± 35 BP	2621BC (36.8%) 2559BC 2536BC (31.4%) 2491BC	2836BC (4.4%) 2816BC 2670BC (91.0%) 2473BC
Barrow II, feature 60/2	*Quercus* sp.	MKL-2846	3980 ± 40 BP	2569BC (40.3%) 2517BC 2500BC (27.9%) 2467BC	2618BC (0.6%) 2610BC 2582BC (90.4%) 2399BC 2383BC (4.4%) 2347BC
Barrow III, feature 99/4	*Quercus* sp.	MKL-2730	1750 ± 40 BP	239AD (68.2%) 340AD	144AD (1.1%) 154AD 168AD (3.2%) 195AD 210AD (91.0%) 392AD
Barrow II, feature 68/10	*Carpinus betulus*	Poz-76338	1515 ± 30 BP	474AD (5.6%) 485AD 536AD (62.6%) 600AD	428AD (24.6%) 495AD 507AD (2.1%) 520AD 527AD (68.6%) 615AD
Barrow II, feature 68A/11	*Fagus sylvatica*	Poz-76337	595 ± 30 BP	1310AD (53.7%) 1360AD 1387AD (14.5%) 1401AD	1298AD (69.7%) 1371AD 1379AD (25.7%) 1410AD

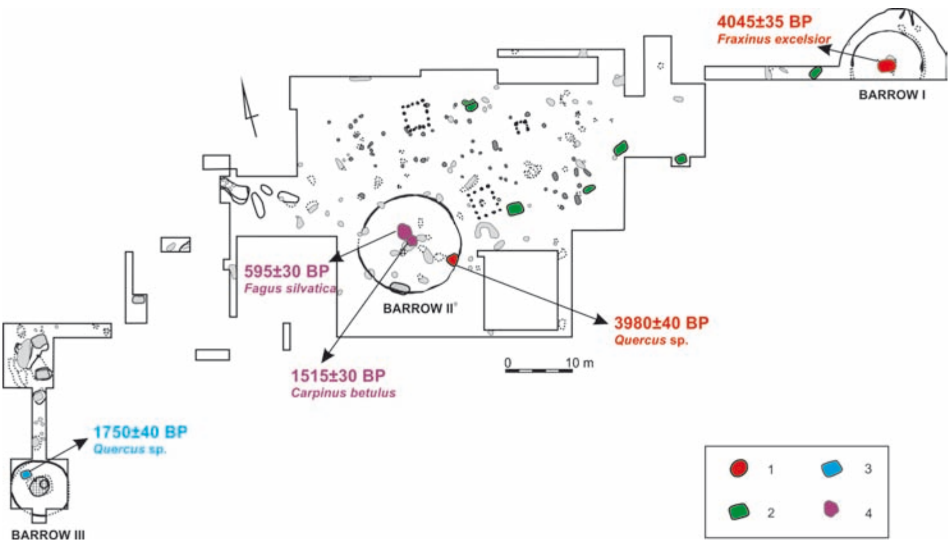


Fig. 13. Ulów, Site 3. Radiocarbon dated features within the barrows of the Corded Ware culture (compare Table 1). 1 – features of the Corded Ware culture. 2 – other radiocarbon dated features with remains of wooden construction from the late Neolithic (the Corded Ware culture?). 3 – feature of the Wielbark culture (hearth with a stone paving). 4 – features from the end of antiquity and from the Middle Ages destroying the central part of Barrow II (Compiled by B. Niezabitowska-Wiśniewska)

Several features containing burnt wooden beams (*Quercus* sp.) were also discovered at Site 3 in Ulów, the radiocarbon dating of which indicated that they should be associated with the end of the Neolithic. A discussion of this dating goes far beyond the scope of this article and requires comparison with dating obtained for other barrow cemeteries in the Ulów microregion (*cf.* Moskal-del Hoyo *et al.* 2017, tab. 1; Niezabitowska-Wiśniewska 2017, 25-27, 37-38).

Feature 99/4, which was dug into Barrow III, can be ^{14}C dated to *ca.* 239-340 AD (68.2% probability), which precisely corresponds with dating of other features and graves associated with the cemetery of the Wielbark culture. It also coincides with the archaeological dating (Fig. 13; Table 1; *cf.* Moskal-del Hoyo *et al.* 2017, tab. 1; Niezabitowska-Wiśniewska 2017, 25-30, 37-39).

THE CEMETERY AT SITE 3 IN THE CONTEXT OF OTHER BARROW CEMETERIES IN ULÓW

As previously mentioned, the CWC cemetery at Site 3 is not the only structure of this type near Ulów. Ten sites of this culture are located in two, strikingly different zones – on the hilltop (five sites) and on meadow terraces in the valley floor (five sites). These two settlement enclaves are 1.5 to 2 km distant from each other (Figs 2; 14).

The location of individual barrows on the hilltop reveals certain differences. Three sites (nos. 3, 4, 5) are situated on its relatively flat part, forming two barrow fields approx. 150 metres apart. Two other sites (nos. 25 and 26) are located above the slope of a small, dry valley and should be treated as one barrow field. All barrows are situated on, or in the immediate vicinity of, long and narrow dunes oriented along the E-W or NW-SE axes (Fig. 14).

Barrows on the valley floor, divided into five archaeological sites (nos. 19, 20, 21, 22, 23) form a series of mounds arranged in accordance with the direction of the valley, which stretches from NE to SW. In all likelihood, some of them were destroyed during construction of an asphalt road which cuts across the valley (Fig. 14).

In total, there are at least 34 barrows in the environs of Ulów. Thirteen CWC barrows have been excavated, with ten having been explored entirely or almost completely along with their central burial pits; the rest underwent only trial excavations which confirmed that they could be associated with the CWC. One barrow was radiocarbon dated on the basis of a charcoal sample obtained through geological probing. Even though other mounds were probed only geologically, they are most likely related to this culture (probably with the exception of the a single mound at site no. 11, which – on the basis of geological probing – can be interpreted as a modern border mound; *cf.* Niezabitowska-Wiśniewska 2021, 173, 174, photo 65). This is evidenced by the arrangement and formation of layers recorded during geological probing, including the character of the fillings of central burial pits recorded in some of them. Most likely, a flat CWC cemetery also functioned at what is now Site 26. To date, only one grave of this type has been investigated (Fig. 14).

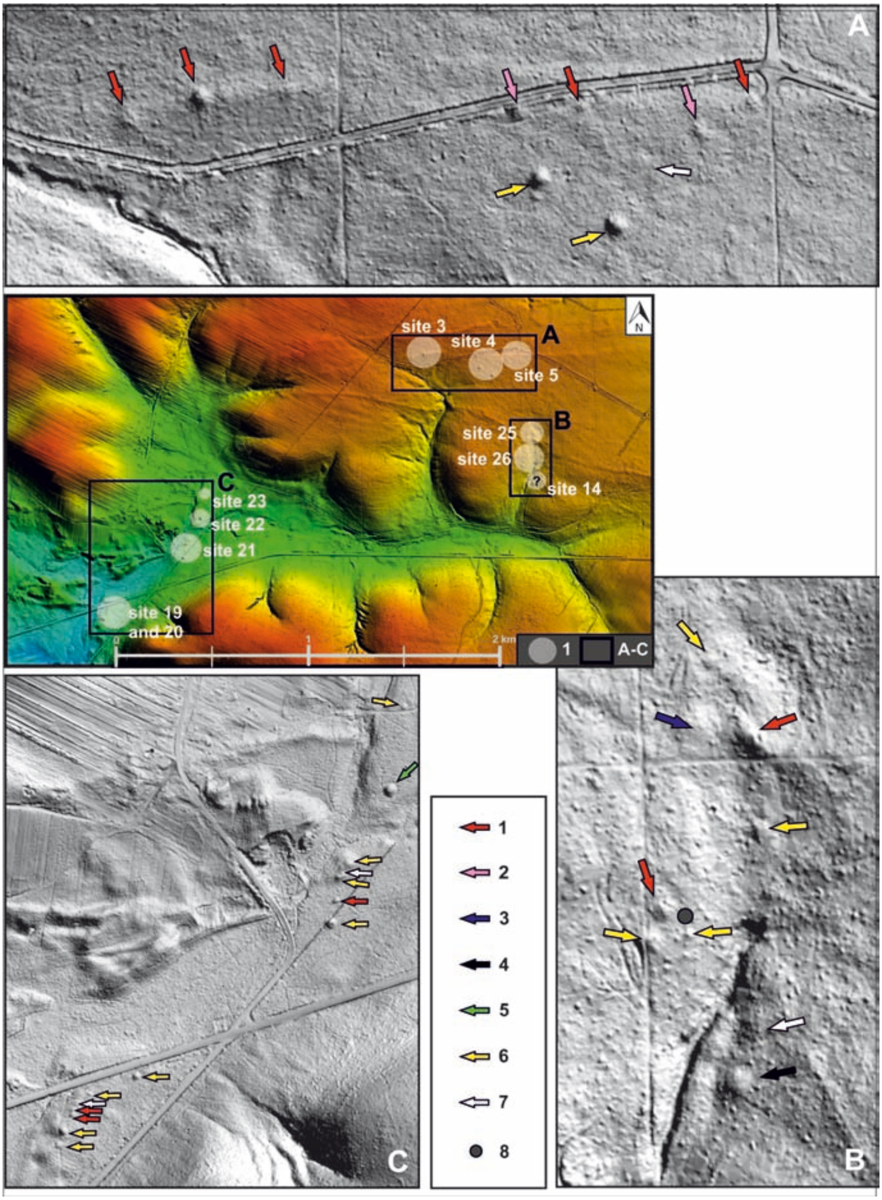


Fig. 14. The Ulów microregion – range of the Corded Ware culture settlement occurrence (1 – archaeological sites, A–C – barrow fields). A – burial mounds at Sites nos. 3, 4 and 5. B – burial mounds at Sites nos. 14, 25 and 26 (question mark – uncertain site). C – burial mounds at Sites nos. 19, 20, 21, 22 and 23. 1 – barrows excavated with central burial pits. 2 – barrows tested by the survey. 3 – an alleged barrow, heavily damaged and excavated. 4 – excavated barrow of undetermined chronology. 5 – barrow geologically probed and radiocarbon dated. 6 – barrows geologically probed. 7 – alleged barrows, almost invisible in the field. 8 – a flat grave of the Corded Ware culture (Compiled by B. Niezabitowska-Wiśniewska)

At this moment, it is difficult to address the cultural affiliation of two rather indistinct barrows, including one which was excavated, associated with Site 14. Due to the lack of artefactual material and the construction of the alleged central burial pit which has not been recorded at other sites, it is impossible to conclusively establish the chronology of the cemetery (Figs 2, 14; Niezabitowska-Wiśniewska 2017, 17; 2021, 188).

In the uplands of south-east Poland, the CWC population located their barrows on the top parts of loess hills, rather avoiding steep slopes and valley floors. In the Lublin region, we know of few sites located on small hills within wide river valleys or on their fringes. CWC barrows were very rarely built in low landscape zones, including terraces in river valleys. Such have been recorded, above all, in Łukawica and Brzezinki, Lubaczów district. Such a location is also characteristic of some barrow sites of the Middle Dnieper culture and CWC settlements (Machnik 1966, 240, 246; Jarosz 2011, 256, 257; 2016, 509-514).

Thus, it can be initially assumed that in Ulów, the CWC settlement recorded in the uplands is associated with a population arriving from the north-east – from the Sokal Ridge– where it built barrows in upland areas (Fig. 1; Machnik *et al.* 2001; 2009). Barrows situated in the valley perhaps should be associated with a CWC population arriving from the south – along Potok Łosiniecki, from the upper Tanew basin – where barrows are situated in valley bottoms, like those in Ulów (Fig. 1; Machnik 1966, 240, 246). This hypothesis is indirectly confirmed by LIDAR images that feature several unexplored clusters of barrows along the Tanew valley and Potok Łosiniecki, though the cluster near Ulów is the northernmost enclave of barrows situated in the Potok Łosiniecki valley and its mostly unnamed tributaries. The above-mentioned preliminary findings require further studies, also based on the comparison of radiocarbon dates. This, however, far exceeds the scope of this paper.

It was initially assumed that the occurrence of one large barrow (no. II) at Site 3 in Ulów, and two, almost indistinct ones in the area (nos. I and III), is connected with the levelling of two of the mounds. Upon inspection of the arrangement and sizes of mounds at other sites in the Ulów microregion, it can be assumed with high probability that the arrangement of cemeteries and various mound sizes were intentional. At nearly each cemetery there are maximally two, relatively large mounds, clearly visible in the landscape. They are accompanied by significantly smaller mounds, with some of them being visible only in the DTM image. As regards Site 3, the largest mound was built in the middle of the cemetery; the other two – at similar distances to the east and west from it (Figs 3: A; 14). The visibility of mounds in the field directly affected their future fate. As previously mentioned, the excavated Barrow II at Site 3 had previously been damaged by earlier incursions, quite possibly attempts at looting. Two large barrows at Site no.4 also exhibit evidence of incursions visible on their tops in the form of vast hollows in the ground. On the other hand, all the excavated barrows with indistinct or poorly visible mounds were found to have had the central burial pits that were undisturbed by the later populations inhabiting the environs of Ulów.

CONCLUSIONS

It is important to notice the similarities between the features discovered in Barrow III in Ulów and some features from Sokal Ridge. In the grave in Wierszczyca, which was mentioned earlier (Site 1, Barrow 1, Feature 1) apart from the mortar beaker, similar to the one from the central grave in Barrow III, a small amphora with two handles placed above the curve of the belly and with its upper part damaged, was discovered (Bagińska 1997, 50, 51, fig. 4: a). It is similar to the amphora from the central grave in Barrow III in Ulów in the placing the handles on the belly and lack of ornament. The damage to the upper part of the vessel from Wierszczyca does not allow a precise reconstruction of its form. The appearance of the original additional upper handles in the neck of the amphora cannot be exclusively denied.

The grave in Nedeżów (Site 22, Barrow 2, Feature 1) not only contained the amphora mentioned earlier (the handles of which were placed one on top of the other and was the only analogy from the areas east of the Vistula to the amphora found in the grave in Barrow III in Ulów), but also a small pot-shaped beaker, decorated with vertical and horizontal herringbone pattern (Bagińska 1996, 63, fig. 4: c). Although the shape of this beaker was slightly different from the shape of the beaker that accompanied the amphora with handles placed one on top of the other found in Ulów, its pattern of decoration is also similar to the Middle Dnieper culture (Machnik and Pilch 1997, 161, fig. 9: 32, 33). It is interesting that a set of vessels with similar features and references to similar cultural traditions were found in two grave complexes coming from sites that were relatively close to each other. Taking into consideration the location of these two graves, the biggest difference was that the grave from Nedeżów was cut into the fill of a lower and older CWC grave; whereas, the central grave (103/2) in the Barrow III in Ulów was a feature in which the younger CWC Feature (102/1) was cut.

There are two large groups of CWC barrows relatively close to Ulów: at a distance of about 20-35 kilometres east, on the area of Sokal Ridge, so called Sokal group (Machnik *et al.* 2001, 2009; Bagińska and Machnik 2003), and at a distance of about 15-20 kilometres south east, in the vicinity of Lubaczów, mainly on the Eastern Roztocze according to Solon *et al.* 2018 – the so-called former Lubaczów group (Machnik 1966; 1979). Without any doubt, that "neighbourhood" affected the cultural image of CWC settlement in the area of Ulów. The characteristic features of the burial rites show similarities and connections both in the areas mentioned earlier, as well as much more distant groups of that culture, which is the Kraków-Sandomierz group or the settlement from the Carpathian area. Many rituals or characteristic features of secondary artefacts from Ulów, however, do not exhibit exact similarities, which make the CWC ones specific in this particular area. Thus, the archaeological excavations of these CWC barrows in Ulów are a useful starting point in order to learn about this cultural unit in the area of Middle Roztocze.

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TEXTILE-IMPRESSED POTTERY FROM THE BRONZE AGE SETTLEMENT IN SZCZEPIDŁO, POLAND

ABSTRACT

Skrzyniecka W., Makarowicz P. and Silska P. 2022. Textile-impressed pottery from the Bronze Age settlement in Szczepidło, Poland. *Sprawozdania Archeologiczn*e 74/2, 227-248.

The practice of using textiles during the process of pottery manufacturing provides a unique insight into the technological aspect of prehistoric craft, the actual products of which are very rarely preserved to our times. In this study, microscopic analysis of ceramics fragments with textile or textile-like imprints was carried out in order to determine the type and structural features of textile products that were used by the inhabitants of the Bronze Age settlement in Szczepidło, Central Poland. In addition, issues related to the function of textile patterns on ceramics were discussed. Measurements made during the research were used to prepare a dataset of technical parameters of identified impressions, which, apart from being itself a valuable source of information, could be implemented in future comparative studies.

Keywords: Middle and Late Bronze Age, textile-impressed pottery, Szczepidło, microscopic analysis, textile production

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INTRODUCTION

Due to the perishable nature of organic materials, direct traces of textiles are rarely documented at archaeological sites. The earliest preserved textile finds from Poland are dated back to the Hallstatt period and for this reason, our knowledge of Bronze Age textile techniques in this region is still rather limited (Maik 2012; 293-303; Schaefer-Di Maida and Kneisel 2019, 204). One of the important categories of materials related to this issue, though often overlooked by researchers, are imprints of textiles impressed on pottery. Their appearance is associated with use of various kinds of products made of plant or animal-based fibres, during the process of pottery manufacturing, *e.g.* as pads used for building, polishing or transportation. This category also includes intentional textile imprints made for decorative purposes, such as the so-called 'cord' ornament, as well as various types of activities related to the preparation of the vessel's surface – textile ceramics or textile-impressed ceramics (Lavento 2001, 20, 21; Lopatina 2017a; Schaefer-Di Maida and Kneisel 2019, 197; Silska 2012, 101-103; Skrzyniecka 2020).

The latter is widely represented in pottery assemblages from North-Eastern Europe, dated from the Late Neolithic to the Iron Age and is interpreted as a separate ceramic category (Lang 2007; Lavento 2001; Lavento and Patrushev 2015; Lopatina 2017a). In Central Europe, especially in the Carpathian Basin, textile ceramics appear in materials of the Hatvan, Otomani-Füzesabony and Wietenberg cultures (Lasak and Lemańska-Czarniak 2013; Lasak 2014; Kopacz 2001, 18-29) among others. In Poland textile impressions on pottery were considered as a specific marker of the Vorlauzitzer ('pre-Lusatian') culture (Kostrzewski 1926; Kowiańska-Piaszykowa 1966, Map 1; Dąbrowski 1972; 2004; Gedl 1975, 62-71), however, as more recent studies show, they are also associated with other taxonomic units such as the Mierzanowice culture, late phase of Trzciniec Cultural Circle and Lusatian culture (Lasak and Lemańska-Czarniak 2013; Lasak 2014; Kadrow and Machnik 1997; Makarowicz 2017). In addition, large number of textile and textile-like ceramics (approx. 600 sherds) was extracted from layers dated to the Early Bronze Age horizons of the Bruszczewo settlement (1700-1650 BC) of the Únětice culture (Silska 2012, 101-103; Schaefer-Di Maida and Kneisel 2019, 201).

The aim of this study is to analyze the structural features of textile imprints visible on pottery, and identify what kind and what quality of products were used to create them by the Szczepidło settlement community. We also propose a new interpretation of a previously examined set of ceramics with textile imprints from this site (Sikorski 2016, 503-519). In addition, this paper is intended to discuss whether impressions were made only for decorative purposes or rather served a practical function during the process of pottery manufacturing.

Textiles in this case are considered in broad sense, as all products associated with processing and interconnecting plant- and animal based fibres, resulting in the creation of woven and non-woven products (Gleba and Mannering 2012, 1-24; Good 2001, 209-226;

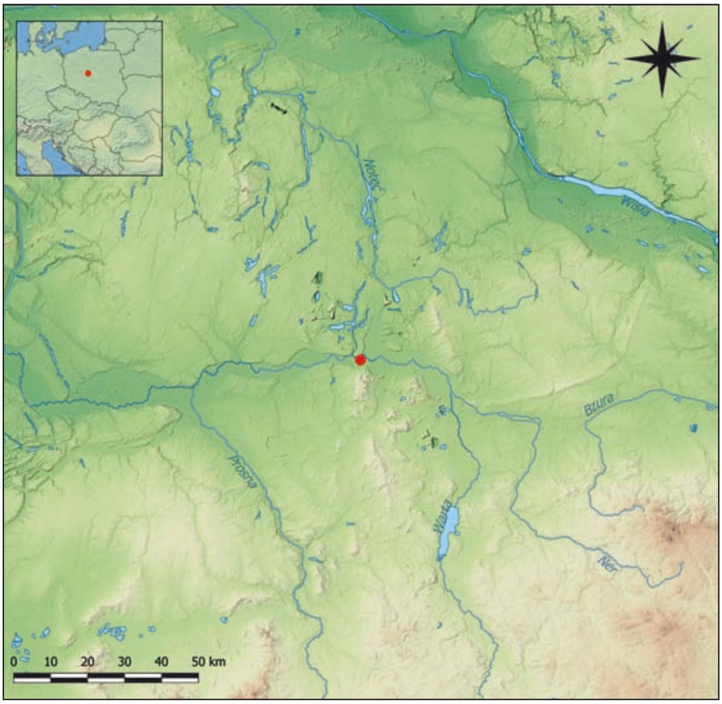

Fig. 1. Location of the Szczepidło archaeological site

Seiler Baldinger 1994, 5; Skrzyniecka 2020, 232). Despite some limitations, emerging from the deformations or shrinkage (10-20%) of the original products during the pressing and firing process as well as other factors, specialistic analyses of textile impressions represent a valuable source of information about traces of Bronze Age handicrafts that in most areas are absent in the archeological record (Drooker 2000, 59-68; Mazăre 2011, 27-48; Podkańska 2012, 207-213; Schaefer-Di Maida and Kneisel 2019).

SITE

The site is located in the eastern part of the Konin Valley (Kondracki 1994: 107f), which is a part of the Middle Warta Valley (Bartkowski 1978:13). It is located above the fluvial terrace of the Warta, 300 m east of the Brzeźno – Szczepidło road and placed on a parabolic windblown dune (partly in a blowout) stretching for 2 km along the E-W axis and 1 km along the N-S axis (Fig. 1). The largest and most spectacular habitation phase has been associated with the Middle and Late Bronze Ages societies representing the transition stage from the Trzciniec Cultural Circle to the Lusatian culture (Makarowicz 2016, 9-14).

Szczepidło was a long-term inhabited settlement in the second half of the 2nd millennium BC. In its development it is possible to distinguish two main phases divided by over a one-hundred-year hiatus. The first phase lasted for about 50 years (1500-1450 BC) or what is more probable even less (perhaps one generation only). The second phase, which is the crucial one, lasted for at least 100 years (1330-1230 BC). On the basis of the artefact analysis and chronometry it is possible to assume that the occupation of the younger phase was permanent.

Spatial analysis of the excavated part of the site has revealed the presence of at least five (I-V) living-activity zones of various sizes (from 400 to 1000 square metres). In those areas over a dozen farmsteads (houses with yards) were detected. Only in two cases was it possible to distinguish the shape of buildings (rectangular and on-ground constructions in zone I and a central production-living feature – the metallurgical workshop – in zone III). In other examples, only storage features were preserved (cellars) with a stratified rectangular, U-sectioned or trapezoidal-sectioned fillings (Makarowicz 2016, 273-277).

The stylistics of the pottery and metal artefacts exhibit the wide contacts of the settlement's society and reception of material culture patterns and tendencies specific for the second half of the 2nd millennium BC. The closest analogies to the analyzed set of patterns come from the Middle and Late Bronze Age sites from the Polish Lowlands, however some of them also have analogies in the upland zone of the Oder and Vistula basins.

MATERIALS AND METHODS

Within the excavated area, more than one hundred pottery fragments reveal textile and textile-like patterns (Fig. 2). The first examination of this type of pottery was published in a monograph of the Szczepidło site, where the results of analysis of 48 pottery fragments with textile or textile-like imprints were included (Sikorski 2016, 503-519). For the purpose of this research, 44 new samples (Tab. 1, samples no. 21-64) have been selected and chosen for specialist analysis. In addition, 20 previously published textile-impressed pottery fragments were re-examined (Tab. 1, samples no. 1-20). The study was carried out on the basis of commonly accepted and used methods of analysis of archaeological textiles and textile impressions (Doumani and Frachetti 2012, 368-382; Drooker 2000, 59-68; Gleba 2017, 1206, 1207; Grömer and Kern 2010; 3136, 3137). They include detailed measurements and visual examination by digital microscope and photographic documentation. Samples were chosen for microscopic observation using a Keyence VHX-6000 digital microscope with up to 100× magnification. The categories of data required to obtain information of structural features contain: spinning and twisting direction (Z-twisted if spun to the right or S-twisted if spun to the left); width measurements (mm) of the yarn imprints; twist angle (given in degrees °), which indicates the intensity (loose or tight) of the yarn or cord twist and the density, measured in number of twists per centime-

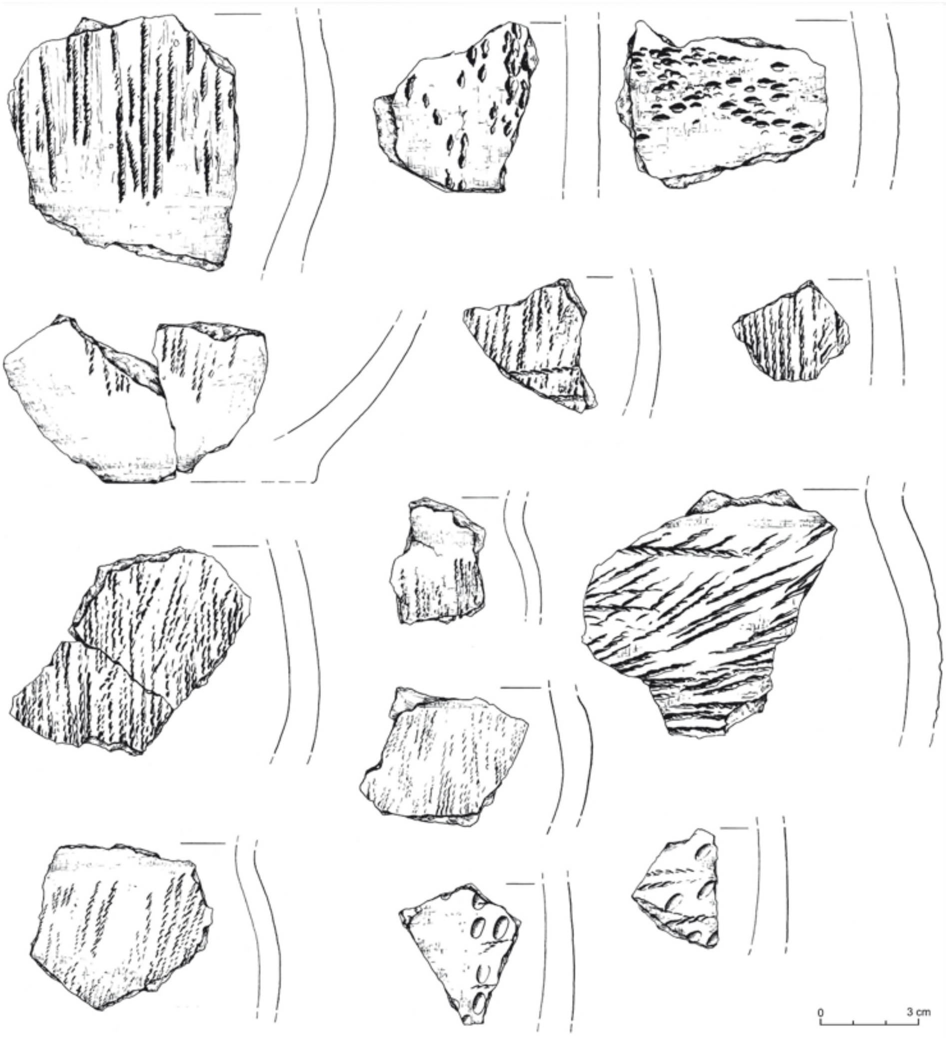

Fig. 2. Selected samples of textile-impressed pottery from Szczepidło (Makarowicz 2016, 201)

ter, indicating the fineness or coarseness of products. Results of the measurements were recorded in a table (Tab. 1) and used to identify technical parameters and most likely the technique of making an impression and textile products itself. In addition, selected samples were imprinted in sculpting clay in order to make a positive mould form of the negative of textile imprints, which were used to facilitate microscopic measurements and identification of textile structure.

Table 1. Textile impressions: technical data

Sample no. (inv. no.)	Textile structure	Twist direction imprint	Twist angle	Width of cord/ thread (mm)	Number of twists/threads per 1 cm
1 (14310)	thread/cord impressions in oblique, V-shaped arrangement; imprints of knots	Z	20-35°	0.5-2.4	-
2 (14112)	parallel thread impressions	S2z	20-30°	0.9-1.8	2
3 (14112)	parallel thread impressions	S2z	20-30°	0.7-1.2	-
4 (14006)	impressions in the form of oval and oblong recesses	Z	30-35°	2-3.2	2
5 (13972)	parallel thread impressions	Z	30-45°	1.3-2	-
6 (13966)	impressions in the form of oval and oblong recesses	S2z?	-	1.4-2.9	1
7 (14077)	textile-like impressions in irregular arrangement	-	-	1-1.7	-
8 (13909)	parallel thread impressions	Z	30°	1.7-1.9	-
9 (14413)	textile-like impressions in oblique, irregular, possibly layered arrangement	Z	25°	0.8-1.7	-
10 (14397)	parallel thread impressions	Z	20-25°	1.4	-
11 (14167)	textile-like impressions in irregular arrangement	-	-	0.5-1	-
12 (14434)	thread impressions in oblique, V-shaped arrangement	S2z?	35-40°	1.8-2	3
13 (14401)	impressions in the form of oval and oblong recesses or parallel imprints of coarser threads/cords	Z?	-	1.4-2.2	2
14 (14397)	parallel impressions of coarse threads	S2z	35-40°	1.6-2	2
15 (14192)	parallel thread/cord impressions	Z	20-30°	2-2.5	-
16 (14420)	parallel thread/cord impressions	S	-	0.9-1.8	-
17 (14538)	textile-like impressions in irregular arrangement	Z	30-35°	1.2-1.5	-
18 (14393)	parallel thread/cord impressions	S	35-40°	2-2.5	2
19 (14531)	parallel impressions of fine threads	Z	35-40°	0.5-0.8	-
20 (14186)	parallel impressions of fine threads	Z	35-40°	*ca.* 0.5	-
21 (13909)	thread impressions in parallel and V-shaped arrangement	Z2s	20-25°	0.5-1.4	4
22 (14401)	impressions in the form of oval and oblong recesses or parallel imprints of coarser threads	Z	40-45°	1.4-1.8	2
23 (14170)	thread impressions in close and parallel arrangement, in some parts overlapping	Z	25-35°	0.8-1.2	-
24 (14170)	thread impressions in close and parallel arrangement, in some parts overlapping (continuation of sample 23)	Z	25-30°	0.8-1.2	-
25 (14391b)	three strand cord impression under ornamented part	-	-	2-2.3 (each strand 0,9-1,2)	4.5

26 (14229)	thread impressions in parallel arrangement, in some parts overlapping	Z	30-35°	1.2-1.4	-
27 (14229)	slightly visible parallel impressions of fine threads	-	-	*ca.* 0.6-0.7	-
28 (14076)	thread impressions in separated and parallel arrangement	Z	25-35°	1.1-1.5	-
29 (14063)	shallow thread impressions in parallel arrangement	Z	30-35°	1.2-1.4	-
30 (14063)	parallel thread impressions	Z	30-40°	0.9-1.3	-
31 (14063)	thread impressions in parallel arrangement, in some parts overlapping	Z	20-25°	0.9-1.2	-
32 (14063)	parallel and separated impressions of coarse threads	Z	30-35°	1.7-2	-
33 (14063)	parallel thread impressions	Z	20-25°	0.9-1.2	-
34 (14063)	parallel thread impressions	Z	20-25°	1-1.3	-
35 (14078)	parallel thread impressions intersected by imprints applied in crosswise direction	S2z	25-35°	1.3-2	3
36 (14103)	parallel thread impressions	S2z	25-35°	1.3-2	2.5
37 (14101)	parallel thread impressions	Z	30-35°	1.4	-
38 (14050)	thread impressions in parallel and V-shaped arrangement	Z	25-35°	1.2-1.5	-
39 (14036)	shallow thread impressions in parallel arrangement	Z	-	1-1.2	-
40 (feature no. 7)	thread impressions in V-shaped and irregular arrangement	Z	*ca.* 30°	1.2-1.8	-
41 (14232)	parallel thread impressions, in some parts overlapping	S2z	20-25°	1,2-1,4	2
42 (14121)	irregular thread impressions	Z	25-30°	1.3-1.5	-
43 (14141)	parallel thread impressions	Z	30-40°	0.6-1.3	-
44 (13885)	parallel thread impressions	Z	30-35°	1-1.2	-
45 (14237)	parallel cord impressions in close arrangement???	Z	25-35°	3.8-5	-
46 (14223)	parallel thread impressions	Z	*ca.* 35°	1.2-1.3	3
47 (14049)	thread impressions in V-shaped arrangement	Z	25-35°	1.4-1.9	-
48 (14061)	parallel thread impressions in close arrangement, intersected by separated imprints applied in crosswise direction	Z	25-35°	0.9-1.8	2
49 (14061)	parallel thread impressions	Z	-	0.8-1.3	-
50 (14217)	textile-like impressions in parallel arrangement	-	-	0.7-1.2	-
51 (14217)	thread impressions in V-shaped arrangement	Z	20-25°	0.7-1.2	-
52 (14225)	parallel thread impressions in close arrangement	Z	25-35°	0.7-1	-
53 (14230)	parallel thread impressions	Z	25-30°	0.9-1.1	-
54 (14226)	parallel thread impressions	Z	25-30°	0.8-1	-

Sample no. (inv. no.)	Textile structure	Twist direction imprint	Twist angle	Width of cord/ thread (mm)	Number of twists/threads per 1 cm
55 (14226)	parallel thread impressions	Z	20-25°	0,9-1,1	-
56 (14233)	parallel thread impressions	Z	20-25°	0,9-1,7	-
57 (14267)	shallow thread impressions in irregular arrangement	Z	-	0,8-1,5	-
58 (13962)	parallel thread impressions	Z	25-35°	0,8-1,5	-
59 (13998)	parallel thread impressions	Z	*ca.* 30°	*ca.* 1,3	-
60 (14074)	shallow thread impressions in parallel arrangement	Z	20-25°	1,2-1,4	3?
61 (14163)	parallel thread impressions	Z	25-30°	1-1,2	-
62 (14165)	parallel thread impressions in some parts overlapping	Z	25-30°	0,7-1,1	-
63 (14165)	parallel thread impressions	Z	30-40°	1-1,5	-
64 (14511)	parallel impressions of fine threads	Z	25-30°	0,4-0,7	-

Fig. 3. Distribution of textile-impressed pottery and the approximate range of farmsteads

According to the diameter of the basic elements of the textiles, three terms are distinguished in literature and for classification purposes were employed in this paper: thread – up to 2 mm in diameter, cord – between 2 and 8 mm and rope – more than 8 mm (Grömer and Kern 2010, 3136-3138).

Impressions on pottery, identified as made by using textile products of various structure and thickness, represent 6.6% of the total ceramics collection from the Szczepidło settlement. The range of distribution of pottery fragments with this type of 'decorative motif' covers almost the entire area of the studied settlement space, with a concentration in its middle and eastern parts (Fig. 3). They appeared both in layers (68 fragments) and settlement features (10 fragments, separately and with other decorative patterns). For five of the above-mentioned features (16, 165, 170, 194 and 234) the chronology using the ^{14}C method was established. The chronological range of the discussed classification group covers the time span of 1280-1224 BC, however with a high degree of probability (68.2%) textile motifs on ceramics were used in the period 1271-1243 BC (Makarowicz 2016, 240-272). The distribution patterns showed no separate clusters of this type of ceramics. In addition, analysis using manual XRF spectrometer, did not point to any differences between the elemental composition of textile-impressed ceramics and other pottery fragments. It can be assumed that they were used as typical household ceramics.

Traces of textiles covered the outer walls of the vessels' body parts. They began below the neck, occasionally going down to the bottom parts, but there are no discernible impressions on the bases. The majority of imprints are visible only in the form of fragmentary and shallow impressions, in some cases fully or partially obliterated, which is indicated by the presence of smooth surfaces between each imprint, and covered with an additional layer of clay (angobe, rugged pottery) (Sikorski 2016, 503-507). The remainder of the potsherds bear traces of regular patterns resembling textile structures, but could have been made with different tools as well, *e.g.* comb, bunch of twigs, wooden or clay smoothing tool (Lopatina 2017b, 287-296; Rammo 2017, 111-119). This type of imprints might be referred to as 'pseudo-textile ornament' (*cf.* Lasak and Lemańska-Czarniak 2013; Lasak 2014, 127-157, fig. 18; Sikorski 2016, 503).

RESULTS AND DISCUSSION

Due to the state of preservation of textile impression and the presence of a fibrous pattern, a total of 64 ceramic fragments were selected for detailed microscopic observations. Structural features of identified textile imprints are diversified, however all of them might be considered as made by non-woven products. It means that no interlacing of two systems of yarns – warp and weft were identified on the impressions. Visible negatives of twisted fibrous structures suggest that the products used were made of spun or plied yarns. Therefore, it can be assumed that impressions were created using elastic materials, which could adjust to the shape of a vessel. The lack of textile imprints on the bases also disproves the use of rigid products, *e.g.* wicker baskets, during the pottery making process (Schaefer-Di Maida and Kneisel 2019, 204).

Most of the analyzed impressions (53) are discernible in the form of repeated rows of textile products resembling cords or threads. They appear in parallel or oblique and V-shaped arrangements (Fig. 4). The majority of the imprints are loosely placed, though some of them appear in close arrangements. Overlapping and intersecting parallel imprints by cord/thread impression applied in crosswise direction are also observed. The negatives of knots were recorded on one of the samples (Fig. 5, 6). Four ceramic fragments bear traces of less regular imprints, consisting of oval and oblong recesses, possibly made of coarser yarns (Fig. 7). A shallow imprint of a three-ply cord was recorded on one fragment of pottery and on the last six samples, fragments of textile/textile-like impressions in a disorganized and irregular arrangement were identified (Fig. 8).

From the whole set of the textile-impressed ceramics, traces of finely spun and plied yarns, as well as coarser products were identified (Figs 9, 10). The width of a single imprint on the analyzed samples ranged from 0.4-2 mm, with the dominance of 1.5 mm or thinner threads (Fig. 11). The coarser impressions left on the four samples (Fig. 12) were made of cords with a thickness of 2-5 mm. Some fragments bear traces of different yarn widths within one sherd. The analyzed impressions were made of both S-twisted (49 samples) and Z-twisted (10 samples) yarns. Among them, traces where each strand of yarn was plied of two components twisted in the opposite direction (to increase thickness and strength) – Z2s (7 samples) and S2z (1 sample), were also recorded (Fig. 13). It should be noted that the twisting direction observed on the impressions, given in the table 1, is a reversed image of the twist direction of the actual textile product. Twist angle ranged from 20° to 45°, which indicates that yarns were quite tightly spun and plied. The number of yarn twists per cm was discernible in case of 17 samples and measured from 1 to 4.5 twists (Tab. 1).

The identification of raw material on the basis of textile imprints is problematic. In this case, experimental research might prove useful, as it allows comparison of the microstructure of different types of fibres. The presence of fine, sharp and not always regular impressions of individual fibres might suggest that plant-derived raw material could have been chosen by the manufacturers from Szczepidło (*cf.* Grömer and Kern 2010; 3140-3144; Grömer *et al.* 2018, 275-284; Sikorski 2016, 503-519). During the Bronze Age in Central Europe, different plant fibres were used for textile production. The most common were flax, hemp, nettle, as well as bast and grass. In this period, the first animal materials, like wool or horsehair also appeared (Bender Jørgensen and Rast-Eicher 2018, 25).

As was discovered in the previous research, the arrangement of impressions and wide spectrum of technical parameters of imprinted products suggest that different types of non-woven textiles could have been utilized (Sikorski 2016, 505-509). However, the state of preservation, size of samples, almost complete lack of textile tools (only one large cylindrical loom weight was found on the Szczepidło settlement) and consequently the absence

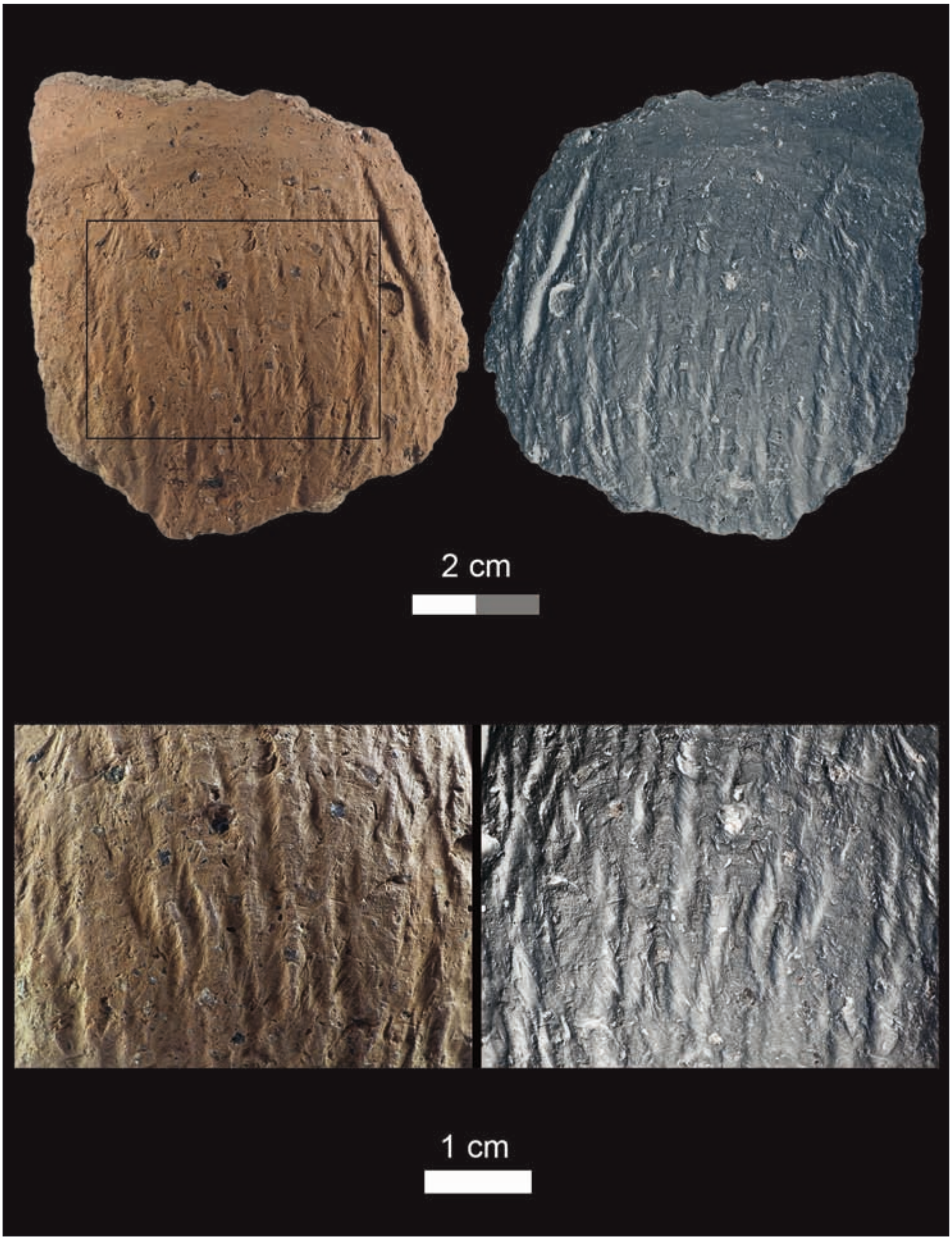

Fig. 4. Pottery fragment with oblique textile imprints, Szczepidło

Fig. 5. Textile imprints with traces of knots visible on pottery fragment, Szczepidło

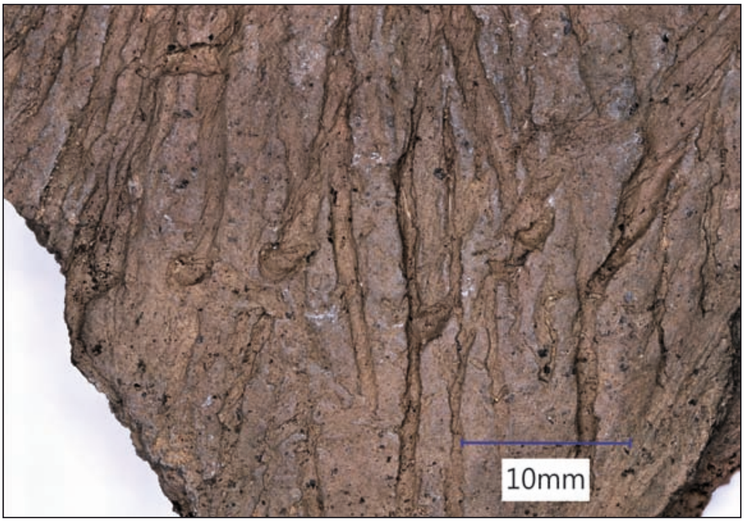

Fig. 6. Details of imprinted knotted threads on pottery fragment, Szczepidło

Fig. 7. Pottery fragment with textile imprints of coarser yarns, Szczepidło

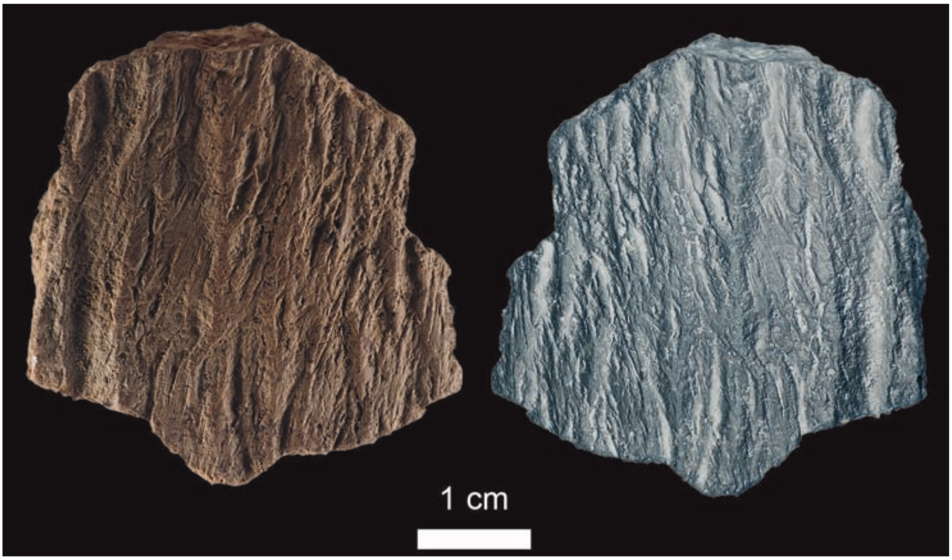

Fig. 8. Pottery fragment with textile or textile-like imprints, Szczepidło

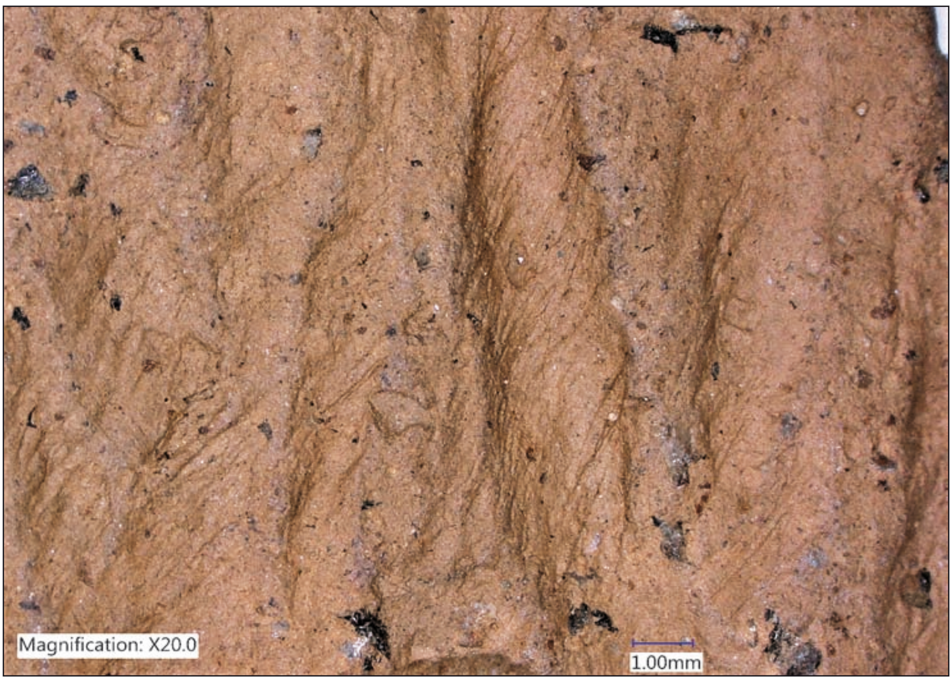

Fig. 9. Details of single yarn structural features imprinted on pottery fragment, Szczepidło

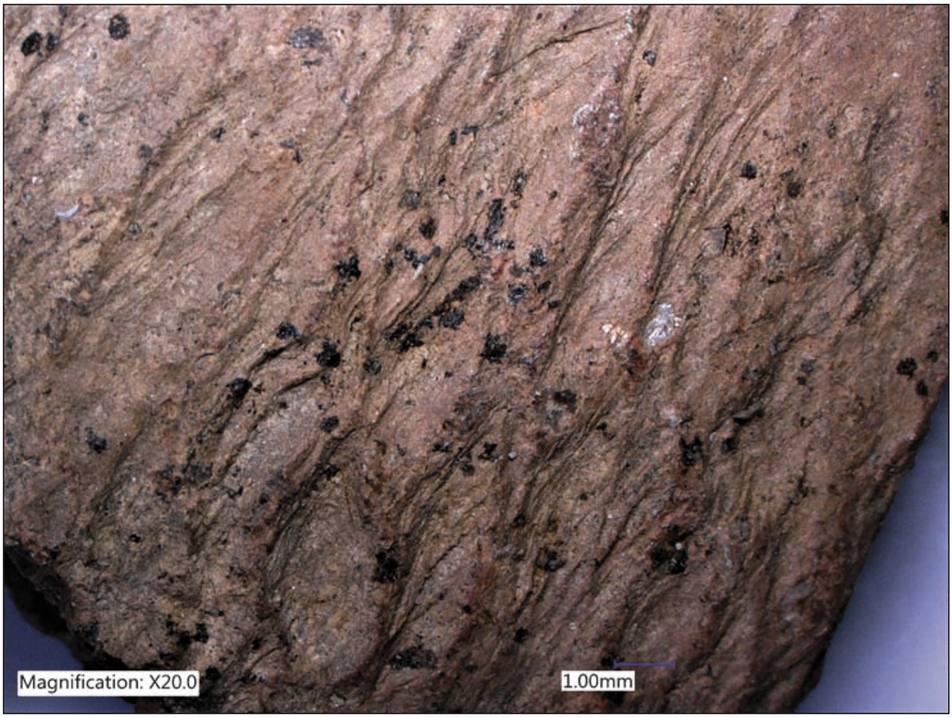

Fig. 10. Details of plied yarn structural features imprinted on pottery fragment, Szczepidło

Fig. 11. Pottery fragment with parallel textile imprints of fine threads, Szczepidło

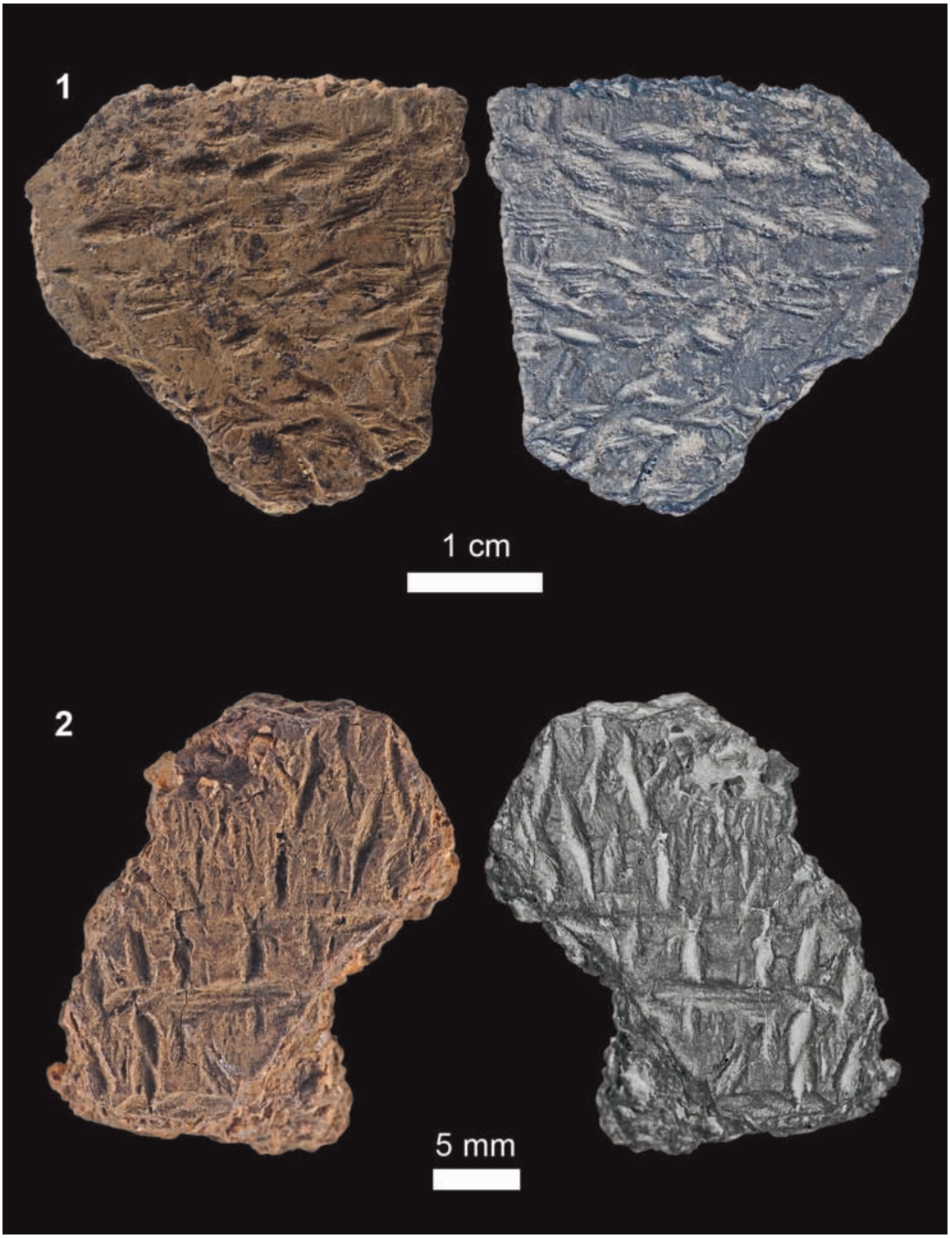

Fig. 12. Examples of pottery fragments with coarser textile imprints, Szczepidło

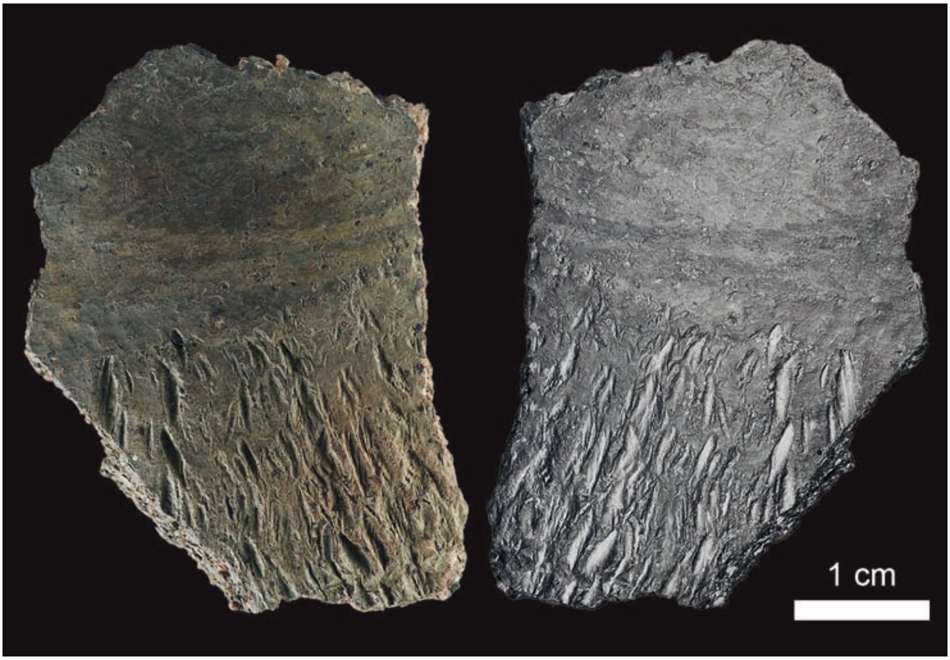

Fig. 13. Pottery fragment with textile imprint of plied yarns, Szczepidło

of clear imprints of interlacing or looped structures, makes it much more difficult to recognize techniques and implements that leave textile or textile-like pattern on the surface of vessels. It must be emphasized that variability represented *e.g.* by the difference in yarn width within one sherd with textile pattern or imprints in "intersecting" arrangement are often the result of using products with different technical parameters that were pressed on top of each other, creating a layered impression. In addition, imprints resembling 'textile' structures with no discernible fibrous pattern, distinctive for spun yarns, could arise with the use of varied types of tools for finishing the vessels surfaces (*cf.* Lasak and Lemańska-Czarniak 2013, figs 1, 2; Rammo 2017, 111-119).

Microscopic observations of pottery fragments and positive moulds led to the conclusion that the patterns resembling imprints of parallel yarn rows – the most numerous in the studied assemblage, were most likely produced by rolling cord or thread wrapped around an implement, such as a stick, rod, or folded cords over the wet surface of a pot. The coarser and less regular imprints, in the form of oval and oblong recesses, could have resulted from using the above-mentioned techniques, but with an application of coarser yarns. The observed characteristic features of this type of surface treatment are: overlapping of parts of imprints with others, shifting of the pattern direction, repeatability of structures and the presence of relatively long fragments of separated threads/cords imprints which are not dependent on the shape of the vessel. The oblique and V-shaped arrangement of impressions (identified on eight pottery fragments), might also result from 'rouletting' and alternating the direction of the rolled tool. In these cases, different kinds of plaited and knotted structures, for example netting, or knotted cords, which is additionally indicated by the negatives of knots, might have been used.

It is worth mentioning that a similar method of applying textile patterns was identified on the Late Neolithic and Bronze Age pottery from north-eastern Europe. This practice, additionally, has been confirmed by experimental research. Their results showed that the different textures of imprints can be obtained by diversifying the cord/thread raw material and its thickness, soft or hard based tool as well as wrapping density and regularity (*cf.* Dumpe 2006, 71-84; Doumani and Frachetti 2012, 368-382; Lopatina 2017b, 287-296, Fig. 2, 3; Rammo 2017, 111-119).

The arrangement of imprinted textile patterns and overall appearance of the pottery fragments indicate that making an impression was one of the final steps of the pottery preparation before the firing process and thus could be considered as one of the methods of surface finishing. The practice of using textiles during the process of pottery manufacturing could have functional or decorative purposes. It is considered that "technical" textiles were used as a support for shaping or drying/moistening parts of clay products before firing or transportation. The use of various types of rotary tools could provide better merging and levelling the surface of moist clay. A practical function might also have been involved, by increasing the comfort of direct use, especially in case of large vessels, by roughening the surfaces for more firm hold (Dumpe 2006, 71-84; Kłosińska 1997, 40; Lasak 2014, 147; Schaefer-Di Maida and Kneisel 2019, 207; Silska 2012, 101-103; Sørensen *et al.* 2017, 8). Selected fragments of textile-impressed pottery bear traces of smoothing or covering with an additional layer of clay, but only in the chosen parts of vessels, *e.g.* on the necks, leaving the rest of the textile imprint unchanged (*cf.* Makarowicz 2017, 152, fig. 18). The presence of the discussed practice might support the idea that using textiles for decorative purposes was also intentional and thus represented a specific cultural marker. Particular textile patterns on vessels surfaces could be interpreted in terms of skeuomorphs, which means that an ornament or object produced in one material is made to imitate another. This custom may indirectly indicate the growing social and economic importance of textiles during the Bronze Age.

CONCLUSIONS

Despite the lack of actual textile finds, the results of microscopic analyses of textile-impressed ceramics provide insight into technological aspects of Bronze Age textile production in Poland. The largest pool of data in this case is related to the basic elements that form textiles – yarns. Traces of single and plied yarns were recorded. The majority of single threads used were S-twisted, which is visible as a Z-twisted imprint and most of the analyzed examples of plied yarns were twisted in the opposite directions. The width and twist angle of yarn imprints indicate that both finely spun and coarser materials were in use. Regarding the yarn's quality, two basic categories of imprints can be distinguished: those made relatively precisely, with the use of finely prepared threads and less careful impressions, created using coarser and uneven yarns or cords. Structural features of imprinted threads and cords from the Szczepidło pottery show similarity to textile production patterns from the Bronze Age in other areas of Central Europe. They usually have a diameter of quite fine threads around 0.6-1.2 mm and coarser yarns measuring 1.2-2.5 mm (Grömer 2012, 30, 31; Belanová-Štolcová 2012, 309, 310). It can be stated that inhabitants of Szczepidło settlement had knowledge and skills to manufacture textiles of varying thickness and quality.

Using textile products for finishing the surface of the vessels proves not only the practical skills of the manufacturers but also offers better understanding of the aesthetic categories which they followed. Moreover, the fact that textiles were widely used in different utilitarian contexts makes it possible to trace how various crafts were combined. This study indicates that the geographically and chronologically broad tradition of making textile-impressed pottery was also cultivated by Middle and Late Bronze Age societies from the Szczepidło settlement. We argue that detailed analysis of textile imprints is a significant complement for comparative studies focused on textiles and pottery-making technologies as well as on interactions between social groups.

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RESEARCH OF ROMAN-PERIOD METALLURGY: REMARKS BASED ON THE CHEMICAL COMPOSITION ANALYSES OF THE EYE BROOCHES OF THE PRUSSIAN SERIES FROM THE BURIAL GROUND IN MALBORK-WIELBARK

ABSTRACT

Łuczkiewicz P., Gan P., Kleemann J. and Kuzioła A. 2022. Research of Roman-period metallurgy: Remarks based on the chemical composition analyses of the eye brooches of the Prussian series from the burial ground in Malbork-Wielbark. *Sprawozdania Archeologiczne* 74/2, 249-288.

Analyses of the alloy composition of the 114 artefacts from 21 sites of the Wielbark and Przeworsk cultures indicate that these brooches largely correspond to the Roman categories of alloys. The most numerous group of brooches was made of an alloy type M – middle, that is the product of mixing new pure brass with scrap bronze. Such finds are most often found in the cemeteries of the Wielbark culture. Other items were made of metal type B, often found in Roman period artefacts. It is high in zinc content and created with the use of non-mixed brass. This smallest group in the analysed data set appears both in cemeteries of the Wielbark and Przeworsk cultures. Also quite prelevant were recycled alloys, obtained through melting together various raw materials (lower zinc content metal – type A). Most of such brooches are from the Mazovian sites. This may indicate the functioning of local workshops there, which worked using available, processed raw material.

Keywords: eye brooches, Prussian series, Roman period, chemical analyses, workshops
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INTRODUCTION

The eponymous burial ground Fin Malbork-Wielbark, Pomeranian Voivodeship, is one of the biggest cemeteries of the Wielbark culture and virtually the only one that provided a continuous series of finds from the whole period of this culture. In the years 1927-1936, German archaeologists conducted research in the burial ground, which, however, was never fully published, most of the materials and documents perished at the end of World War II (German excavations and the research history: Kleemann 2017, there also earlier literature; also Andrzejowski and Martens 1996). Excavation work was renewed in 2008 and finished in 2021 (Kleemann 2010; Kleemann *et al.* 2013; 2017; Kleemann and Münster 2011; Chanko *et al.* 2018; Daszkiewicz *et al.* 2019; Łuczkiewicz and Kuzioła 2019; Łuczkiewicz *et al.* 2021). In total, over 2100 burials come from this site, dating from the Younger Pre-Roman Period (phase A1 – end of the 3rd/beginning of the 2nd century BC) up until the early stage of the migration period (phase D1 – beginning of the 5th century AD). The necropolis was mostly used in the Roman period, especially in the 3rd century AD; about 90% of the graves come from that time.

Some of the most numerous finds in Malbork-Wielbark are the ornaments and parts of dress, including (so far at least) 48 eye brooches from 40 graves. Prussian series, comprising types A.57-61 (Almgren 1923, 29-32, Pl. 3: 57-61; Pfeiffer-Frohnert 1998; see also Twardo 2003; Chilińska-Früboes 2017) and being the subject of this analysis, is represented by 25 specimens from 21 graves (645/1929, 661/1929, 820/1929, 922, 924 or 925/1929 (2012), 935/1929 [x2] (2009), 962/1929 (2017), 971/1929 (2017), 1034/1929, 1694c/1932, 1694d/1932, 2008/18 [x2], 2010/19 [x2], 2012/52, 2012/66, 2019/22 [x2], 2019/34, 2019/43, 2019/59, 2021/6, 2021/25, 2021/43: Kleemann 2017, 17-200, 344, Pl. 68; Kleemann *et al.* 2013, 182, fig. 10; 2017, 240, fig. 12: 4; Kleemann and Münster 2011, 398, fig. 10; also unpublished materials from research in the years 2008-2021). The study of the chemical composition was conducted in the Bio- and Archaeometry Laboratory of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in Warsaw and involved eight brooches from five graves (Figs 1-3): 2008/18 (A.57 and A.61), 2019/22 (A.58 and A.60), 2019/34 (A.60), 2019/59 (a fragment of A.59) and 2019/43 (A.57 and a brooch of the main series A.53).

Brooches of the Prussian series constitute one of the elements of a stylistic community, comprising the areas of the Wielbark and Przeworsk cultures in the early Roman period; they are also abundant in the Balt cultures area. In recent years, more and more brooches of this type are being noted in the Lublin region (Niezabitowska 2005), which until recently had almost been a terra incognita on the map of heir distribution. Brooches of the Prussian series can also be found, though in lower numbers, in Scandinavia, Finland and Estonia (*cf.* Roxburgh and Olli 2019) to the north, to the west from the Oder river as well as in the Czech Basin and Slovakia (Pfeiffer-Frohnert 1998, 127-132, fig. 1-5; Zeman 2017b, 185); in the south, they occasionally occur in the Roman areas up to the Balkans

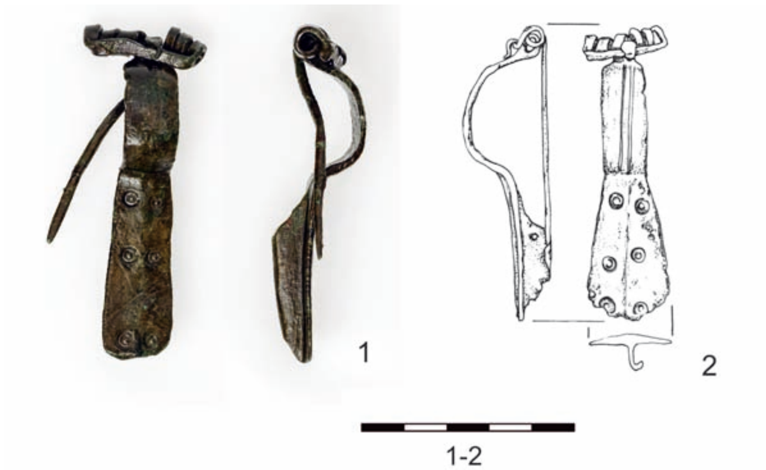

Fig. 1. Malbork-Wielbark, grave 2008/18 (1 – photograph by P. Maciuk; 2 – drawing by A. Kuzioła)

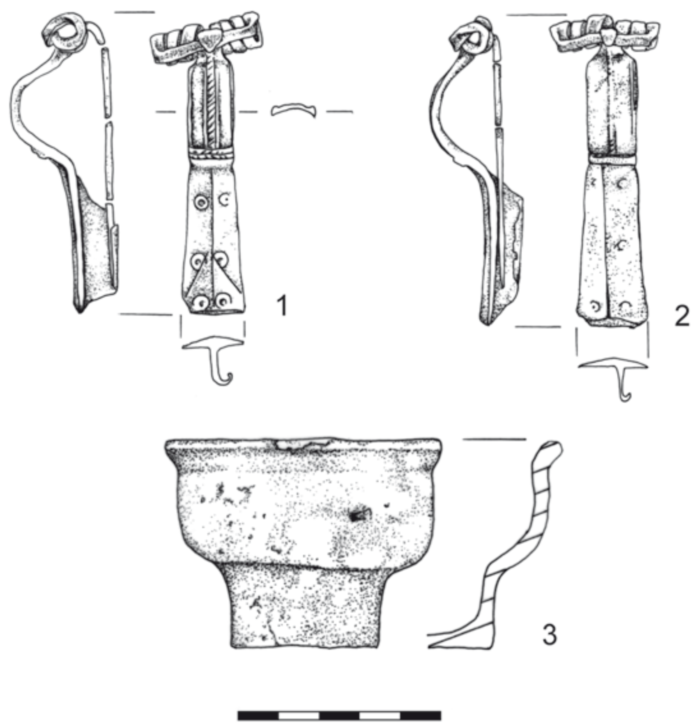

Fig. 2. Malbork-Wielbark, grave 2019/22 (Drawing by A. Kuzioła)

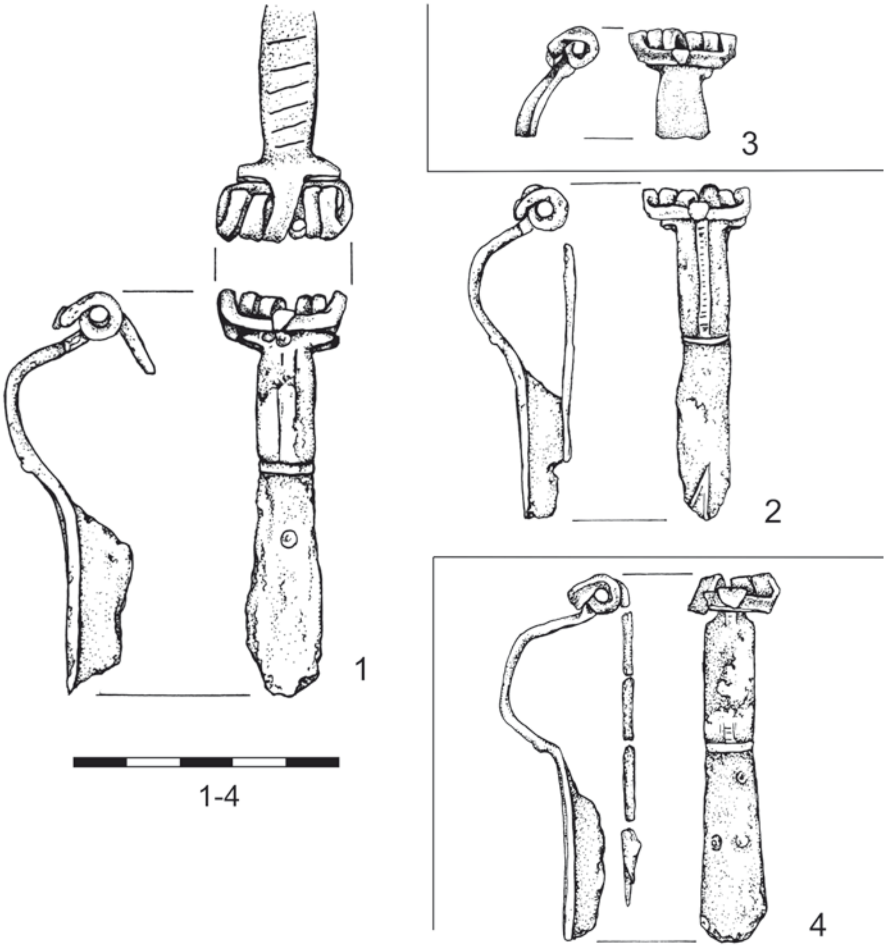

Fig. 3. Malbork-Wielbark. 1-2 – grave 2019/43; 3 – grave 2019/59; 4 – grave 2019/34 (Drawing by A. Kuzioła)

and in the east, up to Belarus and Ukraine (Haralambieva 2002; Beliavets 2014, 161-172, map 1, fig. 2).

Particular attention should be devoted to a very numerous group of the Prussian series eye brooches from Augsburg (*Augusta Vindelicorum*), the capital of the province of *Raetia* (Bakker 1993, 106; 2002, 263, 264, fig. 3; Voss 2008, 343-345, fig. 1). Altogether, 258 such brooches were found there, including particularly numerous semi-finished items. The spectrum of the types comprises forms ranging from A.57 to 61; apart from these, there are also earlier types, ranging from A.45 to A.53, indicating a long tradition of local manufacturing of those items.

The discussed brooches are one of the indicators of phase B2, especially its early stage (B2a), though in both the Wielbark culture and the east area of the Przeworsk culture, typologically younger forms (A.60 and 61) often appear together with artefacts typical of stage B2b (Pfeiffer-Frohnert 1998, 130-133; Andrzejowski 1998, 107; Cieśliński 2010, 55; Mączyńska 2011, 25; Chilińska-Früboes 2017, 57-59). The earliest type (A.57) appears already at the end of phase B1 (Pfeiffer-Frohnert 1998, 133; Cieśliński 2010, 55).

METALLURGICAL ANALYSES – GENERAL COMMENTS

Material research, taking the form of technological (Strobin 1995, 51-55; 2000, 231-252; 2018, 138-156; Natuniewicz-Sekuła 2017, 185-233), isotopic (Stos-Gale 1993; Voss *et al.* 1998, 164-176; Roxburgh and Olli 2019) or chemical analyses (Andrzejowski 1998, 125-130; Gan 2015; Gan and Hensel 2017), have been an integral part of the studies on the artefacts and manufacture from the Roman period for many years now. The published lists of analyses often comprise series amounting up to several hundred results. They serve as a basis for formulating both general and detailed conclusions on the manufacturing methods and techniques in the various areas of European *Barbaricum*, its organisation, genesis, external influences or raw material base (Niewęgłowski 1986, 322, 323; Hammer *et al.* 1997; Hammer and Voss 1998; Voss 2008; 2016; Voss *et al.* 1998; Droberjar and Frána 2004; Bayley and Butcher 2004; Fagner *et al.* 2015; Natuniewicz-Sekuła 2017, 217-220; Roxburgh and Olli 2019).

In the literature on the subject, a prevailing view is that the addition of zinc played a key role in the metallurgy of non-ferrous metals in the Roman Empire, as well as in the Wielbark and Przeworsk cultures (Niewęgłowski 1986, 319-323; Rehren and Martinón-Torres 2009, 170). In modern metallurgy, this alloy is referred to as brass; however, in antiquity it was called *aurichalcum* (Craddock 1978, 5-9; see also Voss *et al.* 1998, 276-286). In technological terms, it was an alloy of copper and zinc, which was absorbed into the metal in a specialist metallurgical process called cementation (Szmoniewski 2009, 118). The essence of this process was to heat a mixture of metallic copper and crushed zinc ore to the boiling point of zinc, that is 918°C in a closed crucible. The ore was added in the form of zinc oxide, sphalerite, or the so-called furnace calamine, *i.e.* zinc oxides obtained in the furnaces while smelting other metal ores. Modern experiments (Werner 1970; Haedecke 1973; *cf.* Voss *et al.* 1998, 118, 119) demonstrated that the cementation process takes place in a precise temperature range from 900°C to 1000°C; in the lower temperatures, zinc ore would not evaporate, while in the higher temperatures, the copper would begin to melt, thus reducing the absorption surface. The brass obtained in the Roman workshops could have contained from 22% to 28% of zinc (Hammer and Voss 2009, 202).

The upper limit of zinc content is a subject of discussion. The experiments conducted by Werner and Haedecke determined the limit of zinc content obtained through the cementation process as up to 28-32%. Nevertheless, it should be mentioned that there is a small number of chemical analyses of artefacts in which higher levels of zinc were found.

If another metal was used as a matrix, *e.g.* copper mixed with tin or with lead, hence obtained from scrap bronze, the absorption of zinc in the cementation process was reduced due to the lower melting point of copper. Therefore, the final content of zinc depended to a large degree on the temperature reached, the length of the process, the quality of the crucible, and even the thickness of the charcoal layer (Rehren 1999, 252).

Another significant characteristic of brass is related to oxidation, and its gradual reduction in the alloy by about 10% during further smelting. The zinc content in the ancient alloys is usually considered in three ranges (Craddock 1978, 11, 12). The first group comprises objects containing below 4% Zn, indicating the use of scrap brass or even its unintentional admixture related to the smelting of zinc oxide ore. The second group comprises objects with zinc content between 4% to 22%. This group varies the most in terms of its chemical composition, with significant admixtures of tin or lead; it is also the most frequently found. In the third group, there is brass with over 22% zinc content, which is directly related to the cementation process; apart from the copper contamination, there should not be other alloying additives.

Initially, brass was used in Rome for mostly military purposes and minting; only later was it also used for manufacturing ornaments and objects of everyday use. In the light of the description by Pliny the Elder (*Hist. Nat. XXXIV: 4*), the *aurichalcum* alloy was for Romans one of many different types of copper and was characterised by its outstanding technological properties, as well as its beautiful golden gloss. Its price was also relatively high. *Aurichalcum* production depended to a high degree on access to the ore, which was unfortunately limited; Pliny names a few already exploited deposits in Cyprus and Campania and mentions active mines providing similar 'copper' in Spain, Gaul and Germania. Pliny characterises different alloys used by Roman manufacturers: *campana* – for manufacturing vessels and items of everyday use; *tenerrima*– for making casting forms; *temperatura statuaria*– for casting statues; *ollaria*– for manufacturing vessels. For the purpose of future discussion, it is crucial to emphasise that, while doing so, Pliny names – apart from copper – three main ingredients of the alloys: *plumbum argentarium, plumbum nigrum* and *aes collectaneum*. While the latter two are unambiguously interpreted as lead and scrap bronze, the identification of *plumbum argentarium* is more tentative; it is understood as tin, an alloy of tin and lead, or lead being a by-product of silver metallurgy (Healy 1999, 325). Given all of the above, the variance in the chemical composition of the alloys used by Roman manufacturers must have been significant.

On the basis of the modern technical terminology, archeometry developed its own classifications of historical alloys, which use correlations between main alloying elements, *i.e.* tin, zinc and lead (Bayley 1991, 17, 18; Riederer 1998, 201, 202; Hammer *et al.* 1997, 102-114; Voss *et al.* 1998, 158-178, 276-286; Fagner *et al.* 2015, 337, fig. 2-4). Using the triangular graphs, the frequencies of occurrence of respective ingredients are distinguished rather clearly, while their position between the vertices of a triangle indicates the character and homogeneity of the alloy, specifying whether it is bronze, brass or gunmetal. This division can be subject to further classifications depending on the studied material or the results of chemical composition analysis, the studied series of products or chronology (Dungworth 1997, 906; Gan 2015, 179). Determining the chemical composition may also indicate the performance properties of the alloy as well as the way in which the finished products were manufactured. Tin bronze alloys are more resistant to stress and have higher durability than copper; they are also easier in casting, especially with the addition of lead. On the other hand, brass alloys were easier to forge than bronze. Due to their high fluidity and malleability, they could also be cast and, most significantly, they had a colour reminiscent of gold. The addition of lead lowered the melting point, thus increasing the casting properties, allowed better reproduction of the form, filled defects in the alloy and acted as a replacement for the less accessible tin. Simultaneously, due to the insolubility of copper, it decreased the plasticity of the alloy, making it more difficult to forge.

METALLURGICAL ANALYSES OF THE EYE BROOCHES FROM THE EASTERN PART OF *BARBARICUM* AND MANUFACTURING ISSUES

The eye brooches of the Prussian series from the cemetery in Malbork-Wielbark were incorporated into a database comprising the analyses of artefacts from burial grounds of the Wielbark and Przeworsk culture (in total, 114 brooches from 21 sites; Fig. 4; Tab. 1). Comparative material included the published analyses of analogous brooches from Moravia (Zeman 2017a, 306, tab. 1; 2017b, 185), from the eastern Baltic area (Estonia and northern Latvia: Roxburgh and Olli 2019, 21, -216, fig. 3, 221-226: 24 specimens), as well as parts of the materials (101 items) from the enormous group of Prussian series eye brooches from Augsburg (Riederer 2001, 233-235; 2002, 118-120; Hammer and Voss 2009, 202, footnote 1177; *cf.* Voss *et al.*1998, 176).

The analyses of the material from Malbork-Wielbark were conducted in the Bio- and Archaeometry Laboratory of the Institute of Archaeology and Ethnology PAN. The methods of X-ray spectroscopy were applied using the scanning electron microscope SEM-ECS with the following parameters: vacuum, time measurement 100 s, accelerating voltage 20 keV, spot size 250 mm^2. An Artax Brucker X-ray fluorescence spectrometer was also used with the accelerating voltage of 50 keV and time measurement of 100 s. Each measurement was taken on surfaces cleaned mechanically of corrosion products.

The chemical analyses (Tab. 2) indicated that the brooches from Wielbark were made from alloys of copper (Cu –79.05-86.48%) with zinc (Zn – 7.90-16.63%) and tin (Sn – 2.12-4.62%). The lower level of zinc in the analysis CL20802 (grave 2019/59) may be related to the significant corrosion of the preserved piece of the brooch. It may be assumed

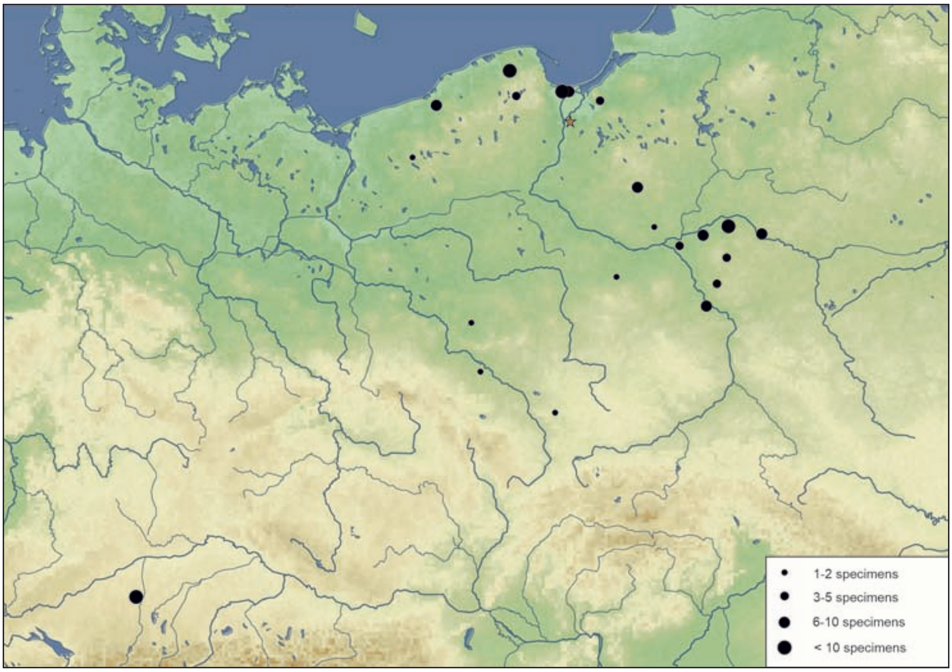

Fig. 4. Eye brooches of the Prussian series from the area of Wielbark and Przeworsk cultures subjected to metallographic study and included in Table 1 (also therein Augsburg). Asterisk: Malbork-Wielbark (graphics by A. Kuzioła)

that all brooches were manufactured with a similar brass alloy. In the analysis of the database, we applied statistical methods based on the principal component analysis (PCA) and the minimum spanning tree (MST) to rank spanning trees with the least distance – analysis with most similar factors. In Kaiser's methodology, the first two factors derived from the analysis are the most significant to determine the similarity of the analysed set, while the others are related to the level of internal differentiation. In the analyses was used free software *Past* (Hammer *et al.* 2001).

In the case of the analysed eye brooches, we used the results obtained for nine elements: Cu, Fe, Ni, Zn, As, Ag, Sn, Sb, Pb, reflecting the applied metallurgical technology and the profile of the deposit (Pernicka 2014, 253). All the data were normalised to reduce the weight of the main alloy ingredients. None of the factors stood out in particular; two factors with the highest correlation degree are responsible for 46% of all obtained variations. This result shows that most of the analyses point toward similar values, which are probably related to the way/technology of production that took place in large manufacturing centres. This suggests a significant centralisation of manufacturing. On the other hand, the analyses testify to a different raw material base and metallurgical technology, hence

Table 1. List of analysed metals from the Przeworsk and Wielbark cultures sites

Cl no.	Site	Contex	Type	Comments	Other	Literature
8313	Bieńkowice	stray find	A.60	Jamka 1964, 95: type A. 58 or 57.	MAW/III/124	Jamka 1964, 95 (earlier literature there)
7855	Brzeźce	grave 5	A.58/59		lack	Balke 1976, 41-42 fig. 10.
18591	Czarnówko	object R288	A.60		10/88 [36]	Gan 2015, 187-214.
18638	Czarnówko	object 402/09	A.60		863/09 [87]	
18642	Czarnówko	object 402/09	A.60		864/09 [90]	
18624	Czarnówko	object 529/09	A.60		1145/09 [73]	
18625	Czarnówko	object 529/09	A.60		1143/09 [74]	
18623	Czarnówko	object 530/09	A.57		1150/09 [72]	
18685	Czarnówko	object 900/10	A.60		1714/10 [140]	
18734	Czarnówko	object 1084A/10	A.60		2093/10 [196]	
18735	Czarnówko	object 1084A/10	A,57		2094/10 [197]	
18736	Czarnówko	object 1084A/10	A.60		2092/10 [198]	
18668	Czarnówko	object 1384/10	A.60		2653/10 [121]	
18670	Czarnówko	object 1384/10	A.60		2655/10 [124]	
18679	Czarnówko	object 1384/10	A.61		2654/10 [133]	
7757	Domaradzice	grave 83	A.58-60		1959:767	Kostrzewski 1954, 197-198 fig. 78: 6.
9163	Drawsko Pomorskie	grave III	A.59		R211/45	Chrupek 2019, 127, 206 fig. 6: 7 (with older literature).
9164	Drawsko Pomorskie	grave III	A.60		R212/45	Chrupek 2019, 127, 206 fig. 6: 6 (with older literature).
7020	Garwolin	grave 31	A.57-60		IV7097/43	Niewęgłowski 1991, 30-31 fig. 15: c
7027	Garwolin	grave 47	A.61			Niewęgłowski 1991, 41-44 fig. 27: a.
7032	Garwolin	grave 61	A.58		7097/87	Niewęgłowski 1991, 54-57 fig. 37: d.
12148	Grzybnica	barrow A, grave A	A.57		12896,00	Hahuła and Wołągiewicz 2001, 18, 104 pl. XVI: 1.
12162	Grzybnica	grave 19B	A.59	specimen 1	15038	Hahuła and Wołągiewicz 2001, 22-23, 123 pl. XXXV: 1.

Cl no.	Site	Contex	Type	Comments	Other	Literature
12163	Grzybnica	grave 19B	A.59	specimen 2	15039	Hahuła and Wołągiewicz 2001, 22-23, 123 pl. XXXV: 2.
12164,01	Grzybnica	grave 19B	A.59	upper part of bow, specimen 3	15040	Hahuła and Wołągiewicz 2001, 22-23, 123 pl. XXXV: 3.
12164,02	Grzybnica	grave 19B	A.59	spring, specimen 3, second analysis	15040	Hahuła and Wołągiewicz 2001, 22-23, 123 pl. XXXV: 3.
12166	Grzybnica	grave 19C	A.60		15049	Hahuła and Wołągiewicz 2001, 23, 124 pl. XXXV: 1.
12167	Grzybnica	grave 29	A.60	specimen 1	15070	Hahuła and Wołągiewicz 2001, 24, 129 pl. XLI: 1.
12168	Grzybnica	grave 29	A.60	specimen 2	15069	Hahuła and Wołągiewicz 2001, 24, 129 pl. XLI: 2.
12171	Grzybnica	grave 50	A.59		15084	Hahuła and Wołągiewicz 2001, 26-27, 137 pl. XLIX: 2
6854	Kamieńczyk	grave 12	A.60		IV/7368	Dąbrowska 1997, 13, 138 pl. VIII: 1.
6850	Kamieńczyk	grave 16	A.52/59	one of the two brooches shown on the pl. . IX/16: 1-2	IV/7368	Dąbrowska 1997, 14, 139 pl. IX/16: 1-2.
6855	Kamieńczyk	grave 52	A.61		244	Dąbrowska 1997, 20, 155 pl. XXV/52: 1.
6856,01	Kamieńczyk	grave 55	A.60		265	Dąbrowska 1997, 20-21, 156 pl. XXVI/55: 1.
6857,01	Kamieńczyk	grave 171	A.61		1001	Dąbrowska 1997, 42-43, 221 pl. XCI/171: 3.
6858	Kamieńczyk	grave 174	A.60-61			Dąbrowska 1997, 43, 223 pl. XCIII/174: 1.
9301	Karczewiec	grave 13	A.60-61		PMAIV/6557	Dąbrowska 1973, 389, 395 pl. III: 10.
9302	Karczewiec	grave 36	A.60?		PMAIV/6557	Dąbrowska 1973, 400, 405 pl. VI: 2.
9303	Karczewiec	grave 48b	A.61		PMAIV/6557	Dąbrowska 1973, 403, 408, 414 pl. IX: 10.
9304	Karczewiec	grave 48b	A.61		PMAIV/6557	Dąbrowska 1973, 403, 408, 414 pl. IX: 20.
9305	Karczewiec	grave 48b	A.61		PMAIV/6557	Dąbrowska 1973, 403, 408, 414 pl. IX: 21.
7682	Kołoząb	grave 153	A.60			Twardo 2003, 200 no. 12.1.
9523	Krupice	grave 3	A.57-61		MB/A/389	Jaskanis 2005, 12, 138 pl. II: 1.
9519	Krupice	grave 5	A.61		MB/A/389	Jaskanis 2005, 13, 140 pl. IV: 1.
9521	Krupice	grave 5	A.57-61		MB/A/389	Jaskanis 2005, 13, 140 pl. IV: 2.
9528	Krupice	grave 131A	A.60?		MB/A/389	Jaskanis 2005, 38, 173 pl. XXXVII/131A: 1.
9511	Krupice	grave 295	A.57 lub A.59		MB/A/613	Jaskanis 2005, 67, 210 pl. LXXIV/295: 1.

9510	Krupice	grave 328	A.60?		MB/A/615	Jaskanis 2005, 73, 220 pl. LXXXIV/328: 1.
9524	Krupice	grave 367	A.61		MB/A/615	Jaskanis 2005, 79, 231 pl. XCV/367: 1.
7107,1	Łajski	grave 93	A.60		705/78	Twardo 2003, 201 no. 13.3.
7107,2	Łajski	grave 93	A.60	the second sample from the same brooch	838/79	Twardo 2003, 201 no. 13.3.
7108	Łajski	grave 121	A.57-60		594/78	Twardo 2003, 201 no. 13.4.
7110	Łajski	grave 143	A.60		594/78	Twardo 2003, 202 no. 13.6.
19951	Malbork-Wielbark	grave 2008/18	A.57	upper part of bow		unpublished excavations J. Kleemann and P. Łuczkiewicz
19952	Malbork-Wielbark	grave 2008/18	A.61	upper part of bow		unpublished excavations J. Kleemann and P. Łuczkiewicz
20797	Malbork-Wielbark	grave 2019/22	A.58			unpublished excavations J. Kleemann and P. Łuczkiewicz
20798	Malbork-Wielbark	grave 2019/22	A.60			unpublished excavations J. Kleemann and P. Łuczkiewicz
20799	Malbork-Wielbark	grave 2019/34	A.60			unpublished excavations J. Kleemann and P. Łuczkiewicz
20800	Malbork-Wielbark	grave 2019/43	A.57			unpublished excavations J. Kleemann and P. Łuczkiewicz
20802	Malbork-Wielbark	grave 2019/59	A.59			unpublished excavations J. Kleemann and P. Łuczkiewicz
9779	Modła	grob 32/78 (75)	A.57	in parentheses the numbers of graves according to J. Andrzejowski	MZZ/A/459	Grzymkowski 1986, 235 fig. 11: c; Twardo 2003, 202 no. 14.1; Andrzejowski 2009, 108-108.
9781	Modła	grave 17/80 (114)	A.57		MZZ/A/528	Grzymkowski 1986, 238 fig. 14: d; Twardo 2003, 203 no. 14.5; Andrzejowski 2009, 132.
9784	Modła	grave 1/82 (186)	A.58-59?		MZZ/A/772	Andrzejowski 2009, 168.
9789	Modła	grave 3/82 (188)	A.58-59		MZZ/A/774	Twardo 2003, 203 no. 14.6; Andrzejowski 2009, 169.
9787	Modła	grave 50/82 (222)	A.57-60		MZZ/A/803	Twardo 2003, 204 no. 14.8; Andrzejowski 2009, 188.
9792	Modła	grave 1/84 (264)	A.60		MZZ/A/1070	Andrzejowski 2006, 26, 43 fig. 18: 1.

Cl no.	Site	Contex	Type	Comments	Other	Literature
8176	Nadkole	grob 22A-B	A.61?			Andrzejowski 1998, 21, 168 pl. XVII: 5.
8178	Nadkole	grave 24	A.60-61			Andrzejowski 1998, 21-22, 171 pl. XX: 4.
PS88	Nadkole	grave 26	A.60-61			Andrzejowski 1998, 22, 173 pl. XXII: 6.
PS89	Nadkole	grave 30	A.60			Andrzejowski 1998, 23, 174 pl. XXIII/30:6.
PS87	Nadkole	grave 56	A.57/58			Andrzejowski 1998, 30, 192 pl. XLI: 8.
8192	Nadkole	grave 57	A.60-61			Andrzejowski 1998, 30, 191 pl. XL/57: 4.
8193	Nadkole	grave 58A	A.60-61			Andrzejowski 1998, 30, 194 pl. XLIII/58A: 3.
8194	Nadkole	grave 58A	A.60-61			Andrzejowski 1998, 30, 194 pl. XLIII/58A: 4.
8195	Nadkole	grave 58A	A.60-61			Andrzejowski 1998, 30, 194 pl. XLIII/58A: 5.
8197	Nadkole	grave 59	A.61			Andrzejowski 1998, 31, 195 pl. XLIV/59: 5.
8204	Nadkole	grave 68	A.61			Andrzejowski 1998, 33, 196 pl. XLV/68: 7.
8207	Nadkole	grave 94	A.60-61			Andrzejowski 1998, 38, 210 pl. LIX/94: 8.
8216	Nadkole	grave 113	A.60			Andrzejowski 1998, 42, 219 pl. LXVIII/113: 9.
8217	Nadkole	grave 113	A.60			Andrzejowski 1998, 42, 219 pl. LXVIII/113: 10.
8224	Nadkole	grave 114	A.60			Andrzejowski 1998, 42-43, 221 pl. LXX/114: 5.
PS85	Nadkole	grave 114	A.60?			Andrzejowski 1998, 43, 221 pl. LXX/114: 6.
8225	Nadkole	grave 120	A.61			Andrzejowski 1998, 45, 222 pl. LXXI/120: 5.
8228	Nadkole	grave 124	A.61			Andrzejowski 1998, 46, 228 pl. LXXVII/124: 9.
ps135	Nadkole	grave 141B	A.58/59			Andrzejowski 1998, 49-50, 236 pl. LXXXV/141B: 3.
ps86/1	Nadkole	stray find	A.60-61			Andrzejowski 1998, 51, 129 nr 111-112.
12753	Oblin	grave 31	A.61			Czarnecka 2007, 18, 194 pl. XXX: 2.
12754	Oblin	grave 31	A.60			Czarnecka 2007, 18, 194 pl. XXX: 1.
12755	Oblin	grave 170	A.57-61			Czarnecka 2007, 47, 328 pl. CLXIV/170: 1.
12756	Oblin	grave 174	A.61			Czarnecka 2007, 47, 332 pl. CLXVIII/174: 1.
12757	Oblin	grave 174	A.61			Czarnecka 2007, 47, 332 pl. CLXVIII/174: 2.
12758	Oblin	grave 176a	A.59			Czarnecka 2007, 47-48, 331 pl. CLXVII/176a: 1.

8481	Pruszcz Gdański, site 7	grave 42	A.60/61		1984:39/82	unpublished, from research by M. Pietrzak and M. Tuszyńska, analyzes from the archives of CL IAE PAN.
8483	Pruszcz Gdański, site 7	grave 70	A.61		1984:39/150	
8488	Pruszcz Gdański, site 7	grave 89	A.60/61		1984:39/196	
8489	Pruszcz Gdański, site 7	grave 94	A.60/61		1984:39/216	
8490	Pruszcz Gdański, site 7	grave 127	A.60		1985:56/94	
8493	Pruszcz Gdański, site 7	grave 145a	A.61		1985:56/139	
8494	Pruszcz Gdański, site 7	grave 153	A.60		1985:56/126	
8499	Pruszcz Gdański, site 7	grave 159b	A.57	specimen 1	1985:56/229	
8500	Pruszcz Gdański, site 7	grave 159b	A.57	specimen 2	1985:56/230	
8506	Pruszcz Gdański, site 7	grave 279	A.57	specimen 1	1985:56/463	
8507	Pruszcz Gdański, site 7	grave 279	A.57	specimen 2	1985:56/464	

Cl no.	Site	Contex	Type	Comments	Other	Literature
7180,01	Pruszcz Gdański, site 10	grave 45A	A.59		1967:1/61	Pietrzak 1997, 16, 106 pl. VIII/45A: 2.
7182	Pruszcz Gdański, site 10	grave 75	A.59		1967:1/125	Pietrzak 1997, 20, 118 pl. XX/75: 1.
8474	Pruszcz Gdański, site 10	grave 291	A.59	one of the three brooches shown on the table CI/291: 2-4.	1969:27/274	Pietrzak 1997, 47, 199 pl. CI/291: 2-4.
9406	Przyrownica	stray find	A.60-61		MP/A/419	unpublished, analyzes from the archives of CL IAE PAN.
16208	Weklice	stray find	A.60		68/175	Natuniewicz 2000, 154, pl. III:10, fig. 5: 1; Natuniewicz 2017, pl. 3: 63.
16144	Weklice	grave 492	A.57		2527	Natuniewicz-Sekuła and Okulicz-Kozaryn 2011, 120, 405 pl. CCXIX: 1.
16219	Weklice	stray find	A.57		2902,00	Natuniewicz 2017, pl. 3: 73.
9743	Węsiory	barrow 4	A.60		1969:73	Kmieciński 1966, pl. XXXIX: 7.
9744	Węsiory	barrow 4	A.60		1969:73	Kmieciński 1966, pl. XXXIX: 5.
9751	Węsiory	barrow 13, grave 1	A.59/60		1969:73	Kmieciński 1966, pl. XXXIX: 1.
9752	Węsiory	barrow 13, grave 1	A.59/60		1969:73	Kmieciński 1966, pl. XXXIX: 2.

Table 2. Summary of the chemical analyses of the Prussian series eye brooches from the area of Wielbark and Przeworsk cultures. M, A, B – types of metals

Labora-tory no.	Site	Cu	Al	Cr	Mn	Fe	Ni	Zn	As	Ag	Sn	Sb	Pb	Au	Co	Bi	Re-marks	Metal
8313	Bieńkowice	85.00	0.08	0.09	0.01	1.20	0.08	10.00	0.11	0.62	2.70	0.07	0.35	0.00	0.01	0.00		M
7855	Brzeźce	80.54	0.75	0.22	0.00	2.30	0.04	15.00	0.03	0.07	0.54	0.07	0.45	0.00	0.00	0.00		M
18591	Czarnówko	80.15	0.28	0.02	0.00	0.28	0.18	15.20	0.00	0.03	2.95	0.35	0.28	0.14	0.00	0.00		M
18623	Czarnówko	81.60	0.16	0.05	0.10	0.60	0.07	16.33	0.00	0.14	0.50	0.00	0.27	0.00	0.00	0.00		M
18624	Czarnówko	82.74	0.11	0.00	0.02	0.38	0.03	14.85	0.00	0.23	1.46	0.00	0.00	0.00	0.00	0.00		M
18625	Czarnówko	82.08	0.02	0.02	0.06	0.10	0.01	14.41	0.00	0.00	3.05	0.00	0.19	0.00	0.00	0.00		M
18638	Czarnówko	82.97	0.14	0.01	0.01	0.22	0.27	9.43	0.39	0.00	5.76	0.45	0.00	0.00	0.00	0.00		A
18642	Czarnówko	81.61	0.08	0.04	0.01	0.29	0.17	15.86	0.46	0.12	1.13	0.20	0.02	0.00	0.00	0.00		M
18668	Czarnówko	80.89	0.08	0.00	0.12	0.17	0.03	16.06	0.00	0.00	2.35	0.24	0.00	0.00	0.00	0.00		M
18670	Czarnówko	82.66	0.02	0.08	0.00	0.29	0.07	13.74	0.15	0.09	2.32	0.32	0.26	0.00	0.00	0.00		M
18679	Czarnówko	82.47	0.06	0.01	0.02	0.40	0.13	14.55	0.23	0.03	1.46	0.28	0.18	0.00	0.00	0.00		M
18685	Czarnówko	78.65	0.02	0.00	0.00	0.36	0.39	12.64	0.28	0.10	6.06	0.15	0.95	0.00	0.00	0.00		M
18734	Czarnówko	82.04	0.17	0.00	0.00	0.20	0.00	15.26	0.00	0.00	2.03	0.07	0.06	0.00	0.00	0.00		M
18735	Czarnówko	82.11	0.09	0.05	0.20	0.20	0.09	13.91	0.00	0.07	2.87	0.00	0.16	0.00	0.00	0.00		M
18736	Czarnówko	78.96	0.09	0.00	0.09	0.25	0.30	17.14	0.16	0.00	2.64	0.29	0.05	0.00	0.00	0.00		M
7757	Domaradzice	85.03	0.68	0.10	0.00	0.65	0.03	9.50	0.08	0.05	3.00	0.18	0.70	0.00	0.00	0.00		A
9163	Drawsko Pomorskie	77.25	0.38	0.23	0.01	2.20	0.03	18.00	0.08	0.06	1.50	0.09	0.16	0.00	0.01	0.00		M
9164	Drawsko Pomorskie	78.07	0.45	0.16	0.01	1.60	0.02	17.00	0.08	0.08	2.30	0.08	0.15	0.00	0.00	0.00		M
7020	Garwolin	90.66	0.42	0.00	0.00	0.62	0.04	4.20	0.07	0.10	3.50	0.04	0.35	0.00	0.00	0.00		A
7027	Garwolin	87.02	0.35	0.00	0.01	1.30	0.05	8.00	0.06	0.05	2.70	0.11	0.16	0.00	0.00	0.00		A
7032	Garwolin	90.58	0.85	0.00	0.01	1.10	0.06	6.00	0.04	0.06	1.20	0.04	0.08	0.00	0.00	0.00		A
12148	Grzybnica	77.41	0.00	0.00	0.00	0.19	0.09	20.89	0.00	0.08	0.73	0.00	0.30	0.00			Si 0.30	B
12162	Grzybnica	78.66	0.00	0.00	0.04	0.22	0.14	18.10	0.00	0.18	2.26	0.00	0.20	0.00			Si 0.20	B

Labora-tory no.	Site	Cu	Al	Cr	Mn	Fe	Ni	Zn	As	Ag	Sn	Sb	Pb	Au	Co	Bi	Re-marks	Metal
12163	Grzybnica	78.47	0.00	0.00	0.05	0.21	0.14	18.21	0.00	0.14	2.32	0.00	0.15	0.00			Si 0.32	B
12164.01	Grzybnica	80.66	0.00	0.00	0.00	0.15	0.00	16.71	0.00	0.74	1.51	0.00	0.00	0.00			Si 0.24	B
12164.02	Grzybnica	80.92	0.00	0.00	0.00	0.11	0.11	16.27	0.00	0.05	2.12	0.00	0.14	0.00			Si 0.27	M
12166	Grzybnica	81.45	0.00	0.00	0.00	0.34	0.18	15.20	0.00	0.11	1.81	0.00	0.69	0.00			0.22	B
12167	Grzybnica	79.26	0.00	0.00	0.00	0.14	0.10	17.47	0.00	0.09	2.43	0.00	0.17	0.00			Si 0.33	B
12168	Grzybnica	81.50	0.00	0.00	0.00	0.08	0.03	15.29	0.00	0.14	2.39	0.00	0.33	0.00			Si 0.24	M
12171	Grzybnica	77.85	0.00	0.00	0.02	0.16	0.14	20.04	0.00	0.12	1.14	0.00	0.28	0.00			Si 0.26	B
6854	Kamieńczyk	88.41	1.30		0.00	1.10	0.06	7.50	0.03	0.05	1.05	0.07	0.44	0.00	0.00	0.00		A
6850	Kamieńczyk	86.88	0.44		0.00	0.65	0.03	11.00	0.04	0.04	0.48	0.04	0.40	0.00	0.00	0.00		A
6855	Kamieńczyk	80.43	0.85		0.00	1.45	0.05	16.00	0.08	0.06	0.65	0.08	0.35	0.00	0.00	0.00		M
6856.01	Kamieńczyk	87.30	0.23		0.00	1.40	0.02	9.00	0.05	0.05	1.25	0.07	0.62	0.00	0.00	0.00		A
6856.02	Kamieńczyk	89.06	0.28		0.00	0.80	0.02	8.00	0.03	0.06	1.15	0.06	0.55	0.00	0.00	0.00		A
6857.01	Kamieńczyk	88.52	0.35		0.00	0.90	0.03	9.00	0.04	0.05	0.80	0.06	0.24	0.00	0.00	0.00		A
6857.02	Kamieńczyk	86.38	0.62		0.00	0.90	0.04	10.00	0.04	0.09	1.15	0.14	0.65	0.00	0.00	0.00		M
6858	Kamieńczyk	80.80	1.15		0.00	0.90	0.03	16.00	0.06	0.06	0.75	0.08	0.18	0.00	0.00	0.00		M
9301	Karczewiec	86.55	0.50	0.12	0.01	0.95	0.01	9.50	0.04	0.06	2.10	0.05	0.12	0.00	0.00	0.00		A
9302	Karczewiec	85.10	1.20	0.35	0.02	1.90	0.03	9.00	0.03	0.05	2.20	0.05	0.07	0.00	0.01	0.00		A
9303	Karczewiec	86.72	0.38	0.35	0.02	2.10	0.02	8.50	0.03	0.05	1.60	0.07	0.16	0.00	0.00	0.00		A
9304	Karczewiec	86.81	0.48	0.17	0.00	1.20	0.01	8.50	0.02	0.04	2.50	0.06	0.20	0.00	0.00	0.00		A
9305	Karczewiec	67.61	0.90	0.50	0.06	4.00	0.03	25.00	0.04	0.22	1.20	0.11	0.32	0.00	0.01	0.00		B
7682	Kołoząb	82.30	0.50	0.30	0.00	2.20	0.04	10.00	0.07	0.12	3.60	0.18	0.70	0.00	0.00	0.00		A
9510	Krupice	81.49	0.32	0.25	0.01	1.80	0.02	14.00	0.03	0.05	1.80	0.06	0.18	0.00	0.01	0.00		M
9511	Krupice	78.93	0.50	0.22	0.01	1.60	0.01	15.50	0.03	0.06	2.80	0.08	0.26	0.00	0.00	0.00		M
9519	Krupice	82.27	0.12	0.20	0.01	1.30	0.01	14.00	0.02	0.05	1.80	0.07	0.15	0.00	0.00	0.00		M
9521	Krupice	80.54	0.13	0.25	0.13	1.50	0.02	16.00	0.04	0.05	1.20	0.05	0.11	0.00	0.01	0.00		M
9523	Krupice	82.23	0.05	0.10	0.00	1.10	0.01	14.00	0.06	0.04	2.10	0.07	0.25	0.00	0.00	0.00		M

9524	Krupice	84.12	0.13	0.22	0.01	1.40	0.01	13.00	0.03	0.04	0.90	0.06	0.08	0.00	0.01	0.00		M
9528	Krupice	76.53	0.05	0.10	0.00	0.95	0.01	20.00	0.05	0.06	2.00	0.09	0.15	0.00	0.00	0.00		B
7107.1	Łajski	88.22	0.65	0.04	0.00	1.40	0.03	7.00	0.06	0.04	1.90	0.06	0.60	0.00	0.00	0.00		A
7107.2	Łajski	89.13	0.60	0.08	0.00	1.40	0.03	6.50	0.09	0.04	1.80	0.09	0.25	0.00	0.00	0.00		A
7108	Łajski	86.24	0.65	0.12	0.00	0.65	0.05	8.00	0.18	0.10	3.30	0.15	0.56	0.00	0.00	0.00		A
7110	Łajski	84.03	0.40	0.20	0.00	0.90	0.04	8.50	0.19	0.06	4.40	0.18	1.10	0.00	0.00	0.00		A
19951	Malbork-Wielbark	81.06	0.07	0.01	0.02	0.33	0.03	15.05	0.21	0.12	2.54	0.07	0.39	0.00			Si 0.07; Ti 0.03	M
19952	Malbork-Wielbark	79.05	0.20	0.04	0.07	0.12	0.37	16.63	0.00	0.08	2.12	0.38	0.94	0.00				M
20797	Malbork-Wielbark	82.61	0.18		0.03	0.31	0.02	12.25	0.02	0.00	3.28	0.20	0.09				Si 0.22	M
20798	Malbork-Wielbark	84.12	0.29		0.03	0.36	0.04	11.04	0.03	0.04	3.89	0.06	0.10					M
20799	Malbork-Wielbark	83.84			0.03	0.28	0.02	11.16	0.04	0.03	4.22	0.24	0.13					A
20800	Malbork-Wielbark	83.82	0.32		0.03	0.14	0.00	11.14	0.01	0.04	3.70	0.16	0.10				Si 0.27; S 0.27	M
20802	Malbork-Wielbark	86.48			0.05	0.14	0.01	7.90	0.04	0.00	4.62	0.17	0.13				Si 0.21; S 0.26	A
9779	Modła	81.57	0.42	0.27	0.02	2.00	0.01	13.50	0.09	0.05	1.70	0.06	0.30	0.00	0.00	0.00		M
9781	Modła	85.18	0.25	0.22	0.01	1.60	0.01	11.00	0.00	0.05	1.50	0.04	0.13	0.00	0.00	0.00		M
9784	Modła	82.91	0.35	0.27	0.00	2.20	0.01	12.50	0.00	0.05	1.40	0.05	0.25	0.00	0.01	0.00		M
9787	Modła	84.86	0.32	0.30	0.02	2.50	0.01	10.00	0.05	0.05	1.80	0.06	0.03	0.00	0.01	0.00		A
9789	Modła	84.56	0.30	0.22	0.01	1.70	0.03	11.50	0.08	0.11	1.20	0.05	0.24	0.00	0.00	0.00		M
9792	Modła	84.52	0.38	0.27	0.02	2.30	0.02	10.00	0.04	0.04	2.00	0.06	0.35	0.00	0.01	0.00		A
8176	Nadkole	86.65	0.35	0.15	0.01	1.60	0.05	9.00	0.14	0.06	1.70	0.12	0.16	0.00	0.00	0.00		A

Labora-tory no.	Site	Cu	Al	Cr	Mn	Fe	Ni	Zn	As	Ag	Sn	Sb	Pb	Au	Co	Bi	Re-marks	Metal
8178	Nadkole	85.35	0.47	0.11	0.01	1.35	0.05	10.00	0.14	0.07	2.10	0.13	0.22	0.00	0.00	0.00		A
8192	Nadkole	84.85	0.26	0.26	0.02	2.10	0.08	10.00	0.10	0.11	1.80	0.22	0.20	0.00	0.01	0.00		A
8193	Nadkole	84.84	0.16	0.11	0.01	1.20	0.06	7.80	0.06	0.09	5.30	0.15	0.23	0.00	0.00	0.00		A
8194	Nadkole	83.50	0.52	0.17	0.01	1.40	0.06	11.00	0.05	0.09	3.00	0.13	0.09	0.00	0.00	0.00		M
8195	Nadkole	85.08	0.16	0.09	0.01	0.90	0.07	9.20	0.06	0.06	4.00	0.15	0.24	0.00	0.00	0.00		A
8197	Nadkole	87.15	0.52	0.27	0.03	2.30	0.08	8.50	0.06	0.12	0.62	0.11	0.24	0.00	0.01	0.00		A
8204	Nadkole	85.00	0.32	0.25	0.02	1.65	0.06	10.00	0.03	0.08	2.00	0.12	0.16	0.00	0.00	0.00		M
8207	Nadkole	84.29	0.27	0.16	0.01	1.70	0.06	10.00	0.06	0.05	3.00	0.12	0.28	0.00	0.00	0.00		A
8216	Nadkole	85.46	0.42	0.16	0.04	1.80	0.05	8.00	0.11	0.10	3.50	0.13	0.23	0.00	0.01	0.00		A
8217	Nadkole	87.19	0.18	0.10	0.01	1.05	0.05	8.20	0.04	0.06	2.70	0.11	0.32	0.00	0.00	0.00		A
8224	Nadkole	82.00	0.30	0.07	0.01	1.05	0.05	11.00	0.03	0.05	5.00	0.11	0.30	0.00	0.00	0.00		M
8225	Nadkole	84.00	0.62	0.09	0.01	1.15	0.06	11.00	0.04	0.08	2.60	0.14	0.30	0.00	0.00	0.00		M
8228.00	Nadkole	83.00	0.52	0.22	0.01	1.70	0.04	12.00	0.03	0.09	2.10	0.15	0.15	0.00	0.00	0.00		M
ps135	Nadkole	79.62	0.01	0.02	0.00	0.40	0.04	18.00	0.07	0.06	1.40	0.11	0.28	0.00	0.00	0.00		M
ps85	Nadkole	58.00	0.14	0.01	0.00	0.05	0.03	35.00	0.05	0.15	4.50	0.18	1.00	0.00	0.00	0.00		B
ps86.1	Nadkole	63.00	0.11	0.03	0.00	0.90	0.02	35.00	0.02	0.11	0.40	0.08	0.38	0.00	0.00	0.00		B
ps86.2	Nadkole	61.00	0.05	0.02		0.28	0.02	35.00	0.04	0.22	2.80	0.07	0.23	0.00	0.00	0.00		B
ps87	Nadkole	72.15	0.03	0.13		0.30	0.06	27.00	0.04	0.15	0.03	0.04	0.24	0.00		0.00		B
ps88	Nadkole	71.67	0.28	0.02		0.38	0.21	25.00	0.05	0.09	2.40	0.12	0.23	0.00	0.01	0.01		B
ps89	Nadkole	79.77	0.02	0.00		0.30	0.09	18.00	0.03	0.10	1.60	0.04	0.13	0.00				B
12753	Oblin	80.78	0.00	0.00	0.00	0.38	0.12	14.81	0.00	0.04	3.07	0.00	0.58	0.00		0.00		M
12754	Oblin	79.42	0.00	0.00	0.00	0.31	0.19	17.14	0.00	0.00	2.54	0.00	0.29	0.00		0.00		B
12755	Oblin	83.04	0.29	0.00	0.03	0.27	0.22	12.20	0.00	0.00	3.49	0.00	0.07	0.00		0.00		M
12756	Oblin	78.78	0.31	0.00	0.00	0.11	0.08	16.85	0.00	0.08	3.19	0.00	0.27	0.00		0.00		B
12757	Oblin	79.51	0.00	0.00	0.01	0.22	0.14	17.57	0.00	0.00	1.97	0.00	0.56	0.00		0.00		B
12758	Oblin	79.12	0.00	0.00	0.05	0.23	0.07	19.32	0.00	0.05	0.43	0.00	0.39	0.00		0.00		B

7180.01	Pruszcz Gdański 10	85.72	0.90	0.08	0.00	1.10	0.02	11.50	0.07	0.06	0.05	0.13	0.38	0.00	0.00	0.00		M
7180.02	Pruszcz Gdański 10	84.95	0.85	0.10	0.00	1.40	0.02	12.00	0.10	0.06	0.05	0.13	0.35	0.00	0.00	0.00		M
7182	Pruszcz Gdański 10	83.56	0.87	0.11	0.00	1.50	0.04	11.00	0.10	0.04	2.30	0.13	0.36	0.00	0.00	0.00		M
8474	Pruszcz Gdański 10	80.00	0.22	0.80	0.03	2.20	0.08	13.00	0.07	0.07	2.80	0.11	0.25	0.00	0.01	0.00		M
8481	Pruszcz Gdański 7	80.00	0.21	0.60	0.02	2.00	0.06	15.00	0.07	0.07	1.50	0.14	0.40	0.00	0.01	0.00		M
8483	Pruszcz Gdański 7	82.00	0.18	0.50	0.02	2.00	0.06	12.00	0.08	0.09	2.40	0.12	0.28	0.00	0.01	0.00		M
8488	Pruszcz Gdański 7	78.00	0.16	0.80	0.03	2.50	0.06	15.00	0.08	0.04	2.30	0.11	0.50	0.00	0.01	0.00		M
8489	Pruszcz Gdański 7	83.00	0.14	0.50	0.02	1.60	0.06	12.00	0.09	0.05	2.30	0.23	0.12	0.00	0.01	0.00		M
8490	Pruszcz Gdański 7	83.00	0.12	0.60	0.02	1.80	0.05	13.00	0.08	0.05	0.65	0.11	0.38	0.00	0.01	0.00		M
8493	Pruszcz Gdański 7	83.00	0.16	0.50	0.02	1.70	0.07	10.00	0.07	0.04	3.50	0.15	0.55	0.00	0.01	0.00		A
8494	Pruszcz Gdański 7	81.00	0.11	0.80	0.03	2.00	0.08	12.00	0.07	0.04	3.20	0.27	0.65	0.00	0.02	0.00		A
8499	Pruszcz Gdański 7	82.00	0.13	0.70	0.03	1.80	0.04	13.00	0.06	0.04	1.50	0.13	0.18	0.00	0.01	0.00		M
8500	Pruszcz Gdański 7	81.00	0.12	0.70	0.03	1.70	0.05	14.00	0.06	0.04	1.50	0.20	0.22	0.00	0.01	0.00		M
8506	Pruszcz Gdański 7	81.00	0.10	0.50	0.03	1.90	0.06	13.00	0.06	0.28	2.00	0.28	0.42	0.00	0.01	0.00		M
8507	Pruszcz Gdański 7	83.00	0.12	0.70	0.03	2.20	0.05	12.00	0.04	0.10	1.80	0.32	0.11	0.00	0.01	0.00		A
9406	Przyrownica	73.94	0.70	0.14	0.01	2.20	0.03	22.00	0.04	0.06	0.46	0.10	0.32	0.00	0.00	0.00		B

Laboratory no.	Site	Cu	Al	Cr	Mn	Fe	Ni	Zn	As	Ag	Sn	Sb	Pb	Au	Co	Bi	Remarks	Metal
16144	Weklice	76.85	0.15	0.08	0.02	0.22	0.00	21.28	0.30	0.00	0.55	0.00	0.53	0.00	0.00		S 0.02	B
16208	Weklice	78.93	0.13	0.02	0.04	0.16	0.03	20.06	0.00	0.00	0.37	0.00	0.00	0.16	0.00		Si 0.07; S 0.02	B
16219	Weklice	75.41	0.04	0.03	0.10	0.37	0.07	22.52	0.24	0.00	0.66	0.03	0.31	0.00	0.00		Si 0.07; Ti 0.07; S 0.07	B
9743	Węsiory	84.10	0.35	0.12	0.01	1.90	0.01	11.50	0.08	0.05	1.50	0.10	0.28	0.00	0.01	0.00		M
9744	Węsiory	82.30	0.22	0.03	0.01	1.50	0.01	15.00	0.04	0.04	0.60	0.05	0.20	0.00	0.01	0.00		M
9751	Węsiory	83.65	0.13	0.25	0.01	1.40	0.01	11.50	0.02	0.03	2.60	0.04	0.36	0.00	0.00	0.00		M
9752	Węsiory	81.39	0.18	0.18	0.00	1.30	0.01	12.50	0.03	0.03	4.00	0.05	0.42	0.00	0.00	0.00		M

they may indicate local manufacturing. The series of strong correlations between resources allow to indicate similar raw materials, show their regional nature as well as possible connections.

The first distinguished factor has the strongest correlation with Cu, Sn, Pb, As and Sb, and a highly negative correlation with Zn (Fig. 5). This confirms that brass was obtained in the cementation process, by adding a separate zinc oxide ore to copper. The closeness between Sb and As indicates a common nature of the material, which is probably related to the contamination of copper. A similar contamination profile also characterises commonly occurring tennantite-tetrahedrite sulphide copper ore, which was already in use in the Bronze Age. The second factor emphasises the relevance of Ni and As and strengthens the correlation between Sn, Sb, and Pb. The third factor has the strongest correlation with Fe. Iron may contaminate zinc oxide ore, which would indicate that it originated from carbonate ore. They do not require initial processing in the metallurgical works, hence the contaminations may migrate to brass. Brass production in Roman metallurgy was based on such ore deposits located in Western Europe (Ponting 1999, 1317, 1318).

In order to distinguish groups with the most similar specimens, we used an additional statistical method of a minimum spanning tree, which connects points of similar weight. The emerging sequences were verified through the observation of further factors; in the end, the distinguished artefacts were required to display distinctiveness in terms of the manufacturing location or chemical composition in several generated diagrams. For clarity and to highlight the potential differences, a group of analyses was dedicated to the range -1/1 of the x-axis, where more than a half of the analysed brooches were assigned (Fig. 6). Such a high number indicates an existing strong relationship in both metallurgical and chronological terms. This particular type of metal was identified in material from nearly all of the researched burial grounds. The average content of the elements amounted to: 82.0% for Cu (reference range 77.3-86.4%); 1.1% for Fe (reference range 0.1-2.5%); 13.6% for Zn (reference range 10.0-18.0%); 2.1% for Sn (reference range 0.1-6.1%); 0.3% for Pb (reference range 0-1%); 0.1% for As (reference range 0-0.5%); 0.1% for Sb (reference range 0-0.4%). These values are virtually identical with the average references for the whole analysed data set. Hence, it may be assumed that they reflect the prevailing mode of manufacturing, indicating a particular type of metal, which could be related to the common raw materials inflow or the same manufacturing centre. The zinc content amounting to 13% was the most frequent in Roman metallurgy; according to Craddock (1979, 12), it is the result of mixing new pure brass with scrap bronze. This somewhat classical alloy was named type M (middle).

There is no visible correlation between the type M metal and specific types of brooches (*cf.* Table 3). However, it should be emphasised that 69% of the analysed brooches type A.57 and around 50% of type A.60 and A.61 were made of this metal. This alloy also prevails in the analysed artefacts from the burial grounds in Czarnówko (92% brooches out of 13 samples) and Krupice (86% out of 7 brooches). In Pruszcz Gdański (site 7), Malbork-

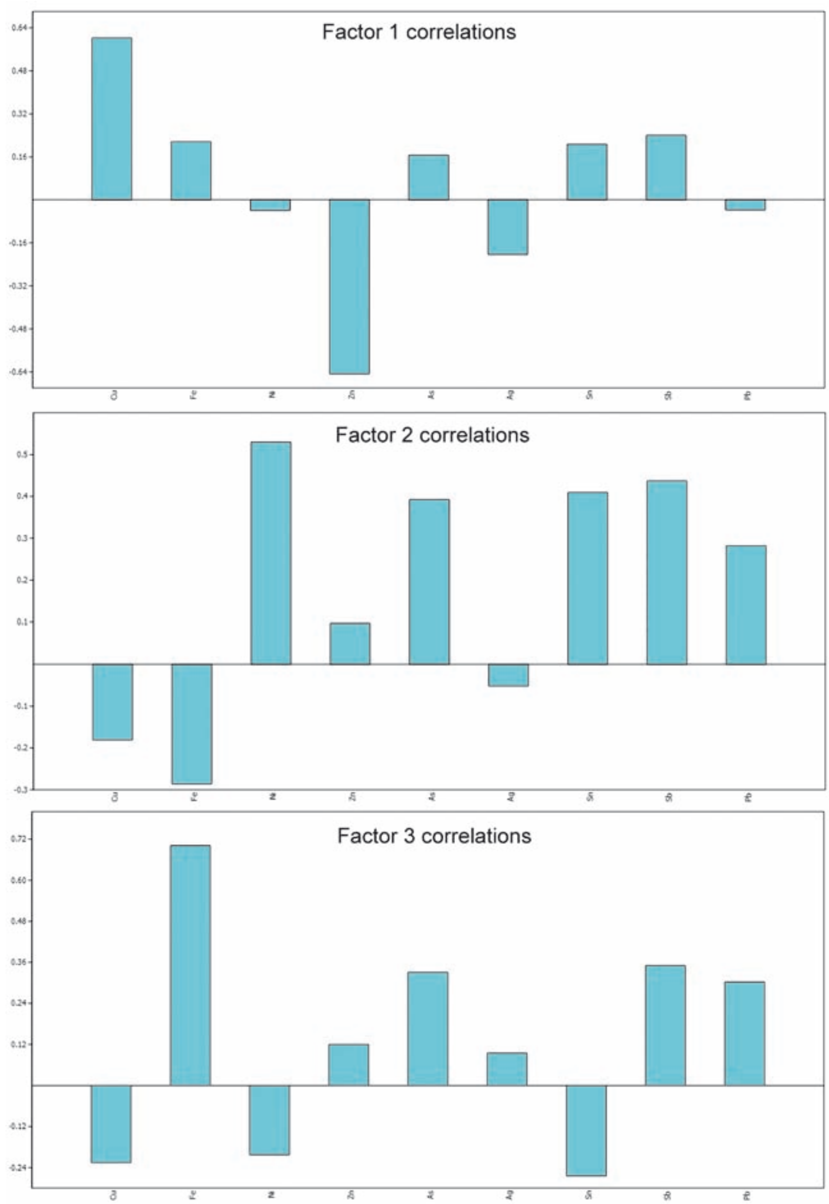

Fig. 5. The results of statistical analysis for the chemical profiles. Correlations between factors 1-3 and elements

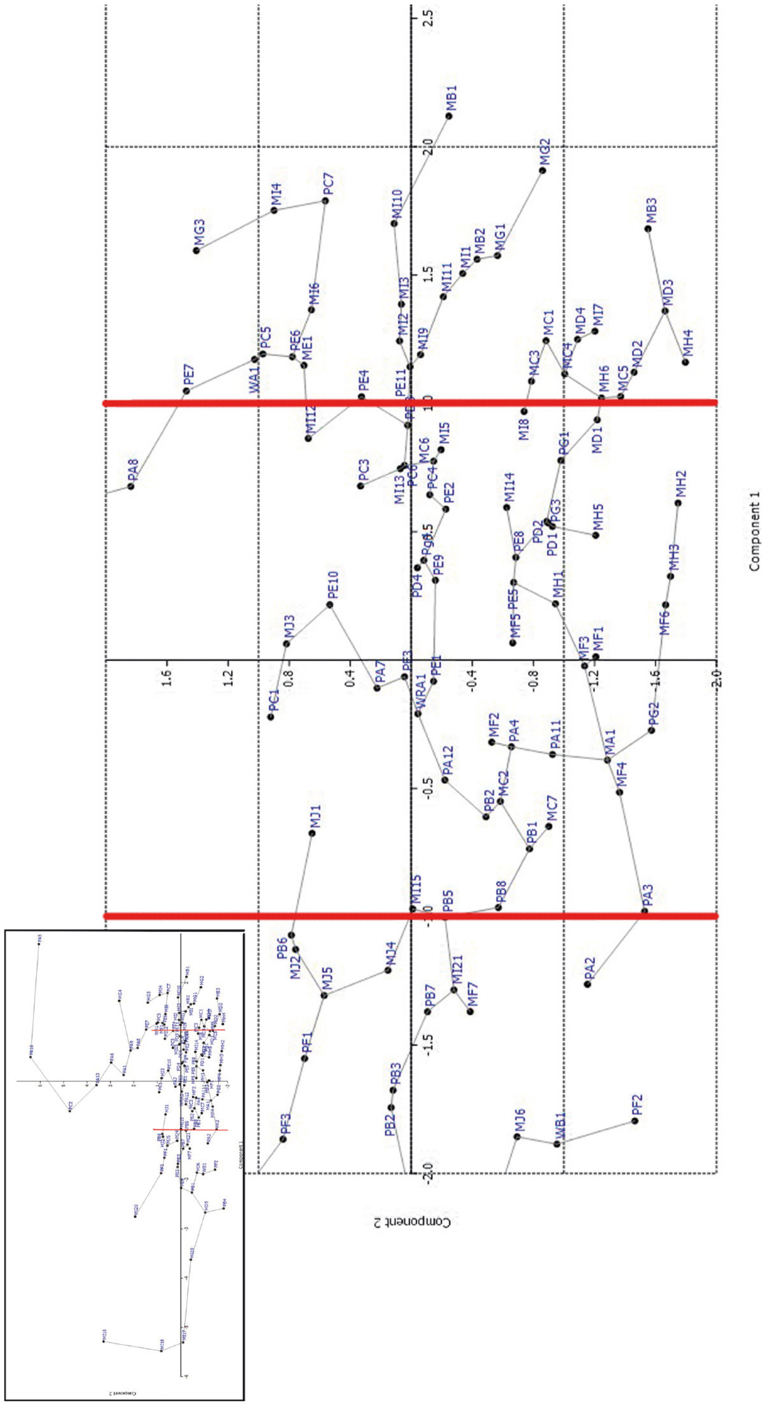

Fig. 6. The results of PCA analysis. Scatter plot of factors 1 and 2 with results between -1/1 on X-axis (type M metal). In the left corner, separate diagram with all results

Table 3. Tabular summary of the distinguished types of metals (M, A, B) in terms of numbers and percentages against the background of archaeological sites and typological findings

Almgren typology	**Number of chemical profiles on the sites**																					number of analyzes by type	M-type metal – according typology	A-type metal – acording typology	B-type metal – acording typology	% M	% A	% B
	Czarnówko	Pruszcz Gd. 7	Oblin	Malbork-Wielbark	Grzybnica	Krupice	Weklice	Garwolin	Pruszcz Gd.10	Drawsko	Bieńkowice	Kamieńczyk	Kołoząb	Karczewiec	Łajski	Modla	Nadkole	Węsiory	Przyrownica	Domaradzice	Brzeźce							
A57	2	4		2	1		2									2						**13**	9	1	3	69	8	23
A58				1				1														**2**	1	1	0	50	50	
A59			1	1	5				4	1												**12**	6	1	5	50	8	42
A60	10	2	1	2	3	2	1			1	1	3	1	1	3	1	5	2				**39**	19	14	6	49	36	15
A61	1	2	3	1		2		1				3		3			5					**21**	10	7	4	48	33	19
A60/61		3										1		1			9		1			**15**	5	6	4	33	40	27
A57-59-51			1			3		1							1	1	1					**8**	4	3	1	50	38	13
A58/59																2	1			1	1	**5**	4	1	0	80	20	
A59/60																		2				**2**	2	0	0	100		
52/57												1										**1**	0	1	0		100	
Sum	**13**	**11**	**6**	**7**	**9**	**7**	**3**	**3**	**4**	**2**	**1**	**8**	**1**	**5**	**4**	**6**	**21**	**4**	**1**	**1**	**1**	**118**	**59**	**35**	**23**	50	30	19
M-type metal on the site	12	8	2	5	2	6	0	0	4	2	1	3	0	0	0	4	6	4	0	0	1							
A-type metal on the site	1	3	0	2	0	0	0	3	0	0	0	5	1	4	4	2	9	0	0	1	0							
B-type metal on the site	0	0	4	0	7	1	3	0	0	0	0	0	0	1	0	0	6	0	1	0	0							
% M	92	73	33	71	22	86	0	0	100	100	100	38	0	0	0	67	29	100	0	0	100							
% A	8	27	0	29	0	0	0	100	0	0	0	63	100	80	100	33	43	0	0	100	0							
% B	0	0	67	0	78	14	100	0	0	0	0	0	0	20	0	0	29	0	100	0	0							

Wielbark and Modła, it was found in 70% of the artefacts. In some sites (Węsiory, Drawsko Pomorskie, Pruszcz Gdański, site 10, Brzeźce), this metal was found in even up to 100% of eye brooches; nevertheless, this score is relativised by a low number of the studied artefacts from these burial grounds.

The remaining 58 standing out analyses indicate a significantly higher zinc content, which may testify to the use of non-mixed brass (metal high in zinc – type B), or quite the opposite, they are characterised by a lower zinc content, which may imply further metallurgical works being conducted, perhaps related to the local manufacturing. This mixed alloy with lower zinc content was named type A. Detailed inspection of group A allows us to distinguish several raw material sequences, which show a tin content increasing from 0.6% to 5%, with an average zinc content not exceeding 9.6%. However, generally speaking, the chemical composition is very similar and any attempts of further categorisation do not provide significant information.

Most of the brooches made from metal A (28 out of 35 analysed) are from Mazovian sites. In Garwolin, Łajski and Karczewiec, all or nearly all of the investigated brooches were made from this metal. On the other hand, in Kamieńczyk, Nadkole and Modła, it was found in 63%, 43% and 33% of the brooches respectively. The mixed metal occurred definitely less often in the Pomeranian sites: in Pruszcz Gdański, site 7, and Malbork-Wielbark, it was found in only 30% of the artefacts. Considering the typology, the discussed set comprises only a few examples of types A.57 (Pruszcz Gdański, site 7, grave 279, CL8507), A.58 (Garwolin, grave 61, CL7032) and A.59 (Malbork-Wielbark, grave 2019/59, CL20802 – in this case the low amount of zinc could also be the result of the strong corrosion of this object); the percentage share of the types A.60 and A.61 amounts to *circa* 30%. Therefore, it can be assumed that the chronologically more recent types of eye brooches could have been manufactured in the local workshops on the basis of earlier stylistic patterns and made from an available, processed raw material – scrap. However, earlier local production may be indicated by hybrid brooch A.52/59 from Kamieńczyk, grave 16 (CL6850 analysis) which was also made from such processed raw material.

At least two groups/accumulations of raw material emerge within the brooches with a high amount of zinc (type B metal), in which the minimal zinc content exceeds 15%. The most prominent is a two-element CuZn compound and it comprises two brooches from Nadkole (grave 56, analysis PS87 and a loose artefact PS86/1) as well as one artefact from Oblin (grave 176a, analysis CL12758) and Przyrownica and all three analysed items from Weklice and its surrounding. However, a pair of A.57 brooches from Weklice (grave 492), accompanied by an A.53 brooch, would actually have to be described as a main series of the eye brooches in regard of their springs made of wire with a round section.

The group CuZnSn, characterised by a higher admixture of tin (reference range 1.14-4.50%), is undoubtedly bigger. It involves items from Grzybnica (graves 19B, 19C, 29, 50), Krupice (grave 131A), Karczewiec (grave 48b), Nadkole (graves 26, 30, 114), Oblin (graves 31, 174). Grave 19B in Grzybnica contained two A.59 brooches and one A.58; one of the

A.59 brooches was made from both type B metal (its bow) and type M metal (its spring), which means that the proportion of components could vary even within one object. Both of the brooches were covered by the same barrow as grave 19C with an A.60 brooch; grave 29 contained two brooches A.58 made from different brass and containing an average or high ratio of zinc, which might have been a secondary composed pair of brooches.

Both groups may be linked to the primary cementation process. In the first group, contaminated copper was used, whereas in the second – scrap bronze. It should be noted that artefacts high in zinc content constitute the smallest group in the whole analysed data set of eye brooches, amounting to only 19% of all items. In regard to the specific types of eye brooches, they constitute 23% of type A.57 and 42% of type A.59; their share did not exceed 20% in the case of the younger types A.60 and A.61.

It is worth mentioning the diversified distribution of the metal found in larger and more thoroughly researched burial grounds. All discussed metal types were identified only at the site in Nadkole. There were no items high in zinc (type B metal) found in Kamieńczyk, Modła, Czarnówko, Malbork-Wielbark and Pruszcz Gdański, site 7. On the other hand, in Oblin, Krupice and Grzybnica, both metal types M and B were found. The diversification in the findings may result from the access to the raw material as well as reflect the chronological differentiation of sites and the varying frequency of brooch types.

The juxtaposition of the results from the analyses of findings from eastern *Barbaricum* with the analyses of eye brooches from Augsburg, the eastern Baltic area and Moravia (see Riederer 2001, 233-235; 2002, 118-120; Roxburgh and Olli 2019; Zeman 2017a, 305-308, tab. 1; 2017b, 185) shows symptomatic differences. In Augsburg, there were virtually no artefacts low in zinc content. The reference range for Zn obtained from 59 artefacts was 11.04% to 30.95%; moreover, there were 12 brooches made of bronze with the admixture of tin and with the zinc content not exceeding 1%. Finally, one brooch was made of copper and one of *tenerrima*, an alloy of CuSnZnPb. Thus, that production was based on unlimited access to high-quality raw material and it was not necessary to use remelted metal (metal scrap). On the other hand, such recycling can be observed in the case of metal A findings from the burial grounds in Mazovia. A small group of the Prussian series eye brooches from Moravia is similar in this regard to the Mazovian findings. They are lower in zinc content, tin is present in the alloy, and for the first time, there is a significant admixture of lead (>2%) in one brooch type A.61 from Vesela (it must be noted that this data set must be viewed with caution due to the fact that the measurements were taken on the uncleaned surface of the objects and, therefore, contain up to 35% of silicon; the absolute percent values of the components are not recalculated concerning the metal, but including all corrosion products as well as the surrounding soil). This may testify to the existence of local workshops in the area of Mazovia and Moravia. However, there is no basis for the assumption that a proportionally high share of brooches made from metal types M or B found in Oblin and Krupice means their local manufacturing and the existence of specialised workshops in the area. The artefacts from these cemeteries were probably imported from other workshops. Other sites with lone items made from metal types M or B could be subject to a similar interpretation.

The results of the analyses of the eye brooches from Latvia and Estonia should be treated with caution too. As the authors of the analyses indicate themselves, the surface analysis is not a proper method of classification; it might only signal what the prevailing trends were regarding the selected alloys (Roxburgh and Olli 2019, 218). The results are distorted due to patina, corrosion, decuprification and dezincification. It should be emphasised that the corrosion phenomena include also surface enrichment/pushing the compounds of tin and lead to the surface of the manufactured item (Janowski *et al.* 2019, 389-395). Hence, a direct comparative analysis of the received results is not possible and the suggested differences in the selection of gunmetal alloy for the brooches type A.60 and the brass alloy for the brooches type A.61 found among Estonian artefacts require further verification, especially considering that different types of metal were identified in both typological groups. Brooches A.61 (11 specimens in total) were mostly made from a metal designated by the authors as "brass," which seems to be similar to the metal type A – an alloy that was probably common in local workshops located in *Barbaricum*. There is only one brooch that is related to the M metal, with no addition of tin or lead. Another brooch was made of an alloy with high content of tin (18%) and the addition of zinc (3%) and lead (4%), which would indicate a different tradition or raw material. Such alloys are virtually non-existent in Roman metallurgy.

The similar metal was also noted among of brooches type A.60 (13 analyses in total). The remaining brooches were mostly manufactured with the quadruple alloy CuZnSnPb, containing an equal amount of Zn and Sn. Such metal, characterised by no visible extremes, was typical for some elements of Roman military equipment in the 2^{nd} and 3^{rd} centuries AD (Dungworth 1997, 906); hence, it should be linked to the reuse of raw material. Moreover, the group of type A.60 brooches from Latvia and Estonia include one specimen each corresponding to the metals types M and A distinguished here. Hence, we can assume that there are some links, yet there are significantly more differences, which are the result of geographical distance, slightly later chronological dating, but mostly different methods of analytical research, influencing the accuracy of measurements.

A stepping stone towards the identification of manufacturing centres in *Barbaricum* may undoubtedly be the presence of brooches made from raw material low in zinc with the simultaneous occurrence of brooches characterised by average and high zinc content. This was the case in the burial grounds in Malbork-Wielbark, Czarnówko, Pruszcz Gdański, site 7, Kamieńczyk, Modła, and Nadkole. Surely, this does not provide sufficient evidence that there was a local workshop near each of these cemeteries. These communities could have used the services of the same, larger centre. However, one should not exclude the existence of smaller, local workshops, such as Garwolin or Łajski, in the burial grounds at which only artefacts low in zinc content (metal A) were identified.

The material (chemical composition) differentiation visible in the analysed materials from the eastern part of *Barbaricum* corresponds with the morphological differentiation.

Even though the typological unification is quite considerable, 'hybrid' forms that blend the properties of several types are not that rare. Hence, the 'morphological' arguments might support the suppositions of dispersed manufacturing in many local centres, performed by artisans possessing various skills. The inventory of grave 34 from the burial ground in Kołacz (Dąbrowska 2002, 226, 234, 252, tab. 10: 1-4) might be a good example thereof. Two brooches, only small parts of which were preserved, must be classified as belonging to the Prussian series. The shape of one of the other brooches is reminiscent of the Prussian series; and so are the cord and the spring made of wire with rectangular cross-section, as well as a ladder ornamenton on the frontal part of the bow. However, the middle and the lower parts of the bow show highly unusual ornamentation with vertical grooves, which are bounded by horizontal grooves. There were probably two brooches constituting a pair, made in one workshop (or by one artisan). The second, poorly preserved specimen is also decorated with vertical grooves, which are bounded by horizontal grooves; however, it has a more fan-like shape. The horizontal grooves placed between the bow and the foot on both specimens, can be considered an imitation of a crest. The lack of a crest, as well as the narrowing of the upper part of the bow are characteristic for type A.61 brooches, which are the latest specimens of the Prussian series. By contrast, the non-decorated and plain foot is reminiscent of the main series of brooches, especially types A.52 and 53, which were not characterised by a widened foot as type A.61 and these examples. Both brooches from Kołacz should be considered as local products, which could have been inspired not only by eye brooches but also by the bow ornamentation of crest brooches from the area of the Bogaczewo culture.

In theory, grave 16 in Kamieńczyk (Dąbrowska 1997, 14, 139, tab. IX/16: 1-3) seems to confirm similar experiments. There were three eye brooches. On the basis of the eyes on the bow, two of them should be determined as type A.52; however, the bow ornamentation is reminiscent of type A.59. The third brooch blends the properties of types A.53 and few properties of A.57 (bow ornamentation) as well as A.52 (foot). The blending of types probably excludes a specialised workshop (*e.g.*, similar to the Augsburg manufacture) and points towards a smaller, local manufacturer who possessed only general knowledge regarding the features of this type of brooches. More so, one of these A.52/59 hybrids (analysis CL6850) was made of processed alloy with low zinc content (type A metal).

Both mentioned inventories (Kołacz and Kamieńczyk) are from the eastern part of Mazovia, which could suggest—along with the chemical analyses—the existence of some local workshop (or workshops). This particular mix of types and unusual ornamentation could have been the result of following the local tastes or independent experiments of the craftsman (or craftsmen).

Dispersed manufacturing, taking place in various local centres, might also be evidenced by a brooch from Husynne in Eastern Poland (Hrubieszów Basin). This loose artefact is most similar to the types A.62-63; however, the ornamentation of the bow and the foot is more reminiscent of the brooches from Almgren Group II (so-called spring-cover brooches/

Rollenkappenfibeln). The manner in which the cord of the spring is fastened is also quite unusual: with two cord-hooks made of thin metal strips and placed near the outer edges of the bow, which probably was not the result of a non-professional attachment (Niezabitowska 2005, 490-492, fig. 1: 1).

MANUFACTURING RESOURCES

Metallurgical analyses indicate that, in terms of the alloy composition, the artefacts found in the eastern areas of *Barbaricum* largely correspond to the Roman categories of alloys known, for example, from Augsburg. Is also confirmed that in the 1st century, a significant part of *sestertii* was made of fresh brass obtained through the cementation process (Craddock 1979, 13). Freely mixed (*i.e.* recycled) alloys were also quite relevant; they were obtained through melting together various raw materials. It is assumed that Germanic artisans used mostly Roman vessels and 'bronze'/*aes* coins as the main source of the raw materials in manufacturing (see Voss *et al.* 1998, 290, 291; Voss 2016, 141-145; also Fagner *et al.* 2015, 339). The same conclusions can be drawn from the data set of Moravian metal vessels (Zeman 2017a, 306, tab. 1). In Germania, there is no evidence from the Roman period that would confirm independent copper extraction and smelting. In this context, it is worth mentioning the calculations by E. Droberjar and J. Frána (2004, 457-459) that use the weight of the artefacts from the burial ground in Dobřichov-Pičhora. These indicate that from one Östland bucket (E.38 – 1.150 kg; E.39 – 1.518 kg), it was possible to make from 40 to 52 so-called spring-cover brooches (medium weight: 29 g), whereas from a situla (E.18b from grave II; 1.871 kg) – even up to 65 such brooches. Nevertheless, the composition of the alloys used for the manufacturing of metal vessels is unclear; the same is true for the mentioned group of the brooches. However, the question arises of how this can be related to the situation in the eastern areas of *Barbaricum*. In this area, bronze vessels occur essentially only in graves such as in Lubieszewo/Lübsow (*cf.* Schuster 2010), whose exceptionality and elitism is defined precisely based on the presence of such vessels. Therefore, local elites surely had access to imported goods. However, a further question should be posed as to whether the import was a scale large (and stable) enough for the elites to redistribute a part of these social status markers or to use them as a source of raw material for the production of significantly less prestigious ornaments. Moreover, east of the Odra river, *aes* coins do not occur in any considerable number. Hence, these two categories of sources should be excluded at least in relation to the Wielbark and Przeworsk culture.

For the same reasons, a theoretically sound example of the late Roman hoards from the Rhine such as in Neupotz should probably be discarded. This deposit (Künzl 1993) comprising over 10 kg of silver, nearly 200 kg of *aes*, nearly 1.5 kg of tin as well as almost 220 kg of iron; there is also a deposit of late Roman bronze vessels from the Elbe in the village of Grieben (Voss 2016, 141, fig. 1, see earlier literature there). However, no examples of such deposits are present in the area of the Wielbark and Przeworsk culture in the 1st and 2nd century AD.

There is also another alternative possibility, namely a type of recycling, which is indicated by the hoard from Łubiana (Mączyńska 2011), containing nearly 14 kg of bronze artefacts robbed from numerous burial grounds of the Przeworsk and Wielbark culture. The deposit probably functioned as storage for raw materials designated for further remelting. It is also dated much later, i.e. to the beginning of the 5th century.

Perhaps vessels and coins were not the only sources of raw material in *Barbaricum*. There is a find from the grave 202 at the burial ground in Třebusice, Czechia (Droberjar and Frána 2004, 457-459, figs 6, 7), dated to the regional phase B1b on the basis of two brooches type A.45b and A.19aII, which might serve as a hint. A rectangular piece of brass sheet (4.6 x 2.2 cm; weight: 13.04 g; gauge: 2 mm) was found in the cinerary urn. It was very high in zinc content (31.3%), meaning it was of very high quality. This sheet, which had visible signs of cutting on three of its edges, was definitely not a part of a vessel or fitting but rather a supply of material for further manufacturing. Unless it was produced in the area or generally in *Barbaricum*, which would be contradicted by the zinc content being so high, this could be a hint regarding the influx (perhaps export or trade) of raw brass material (half-products) into *Barbaricum* that was not limited to ready-made dress accessories, vessels and coins. However, this example comes from a period that is slightly earlier than the one when the discussed eye brooches of the Prussian series were used.

SUMMARY AND CONCLUSION

The issue of whether eye brooches are the product of Germanic or Roman workshops is being constantly raised in the literature (lately: Steidl 2013, in relation to the earlier brooches A.45-46). The series of Prussian series eye brooches from Augsburg (*Augusta Vindelicum*) plays a particular role here. Their interpretations in terms of manufacturing, trade and use are widely different. Some presume that the brooches were manufactured by Provincial Roman artisans to be exported to the 'amber coast' (*e.g.*, Voss 2008, 343-345, fig. 1), similarly to the glass beads that served as the subject of exchange (*cf.* Łuczkiewicz *et al.* 2021). Others speculate that they were manufactured for export to Germania by Germanic specialists located in Augsburg (*e.g.,* Mączyńska 2011, 27) who were perhaps coming from the eastern part of the Elbian Circle (Bakker 1993, 106; 2002, 263, 264, fig. 3), though the latter supposition seems to be discredited by the fact that the Prussian series occurred mostly in the areas of the Wielbark and Przeworsk culture, which are located much further to the east.

As shown by M. Pauli's research, these brooches were certainly manufactured in Augsburg and decorated using identical stamps. At least one workshop, or many workshops, since the discussed brooches were also found in other places and not only in one centre, functioned in the artisan district located in the south-western part of the *vicus*, while the manufacturing process was perhaps conducted by Germanic artisans. A relatively high percentage of repaired specimens as well as those showing evidence of having been used indicates that they were also worn by the local population. However, brooches found in one basement of a house that was destroyed in 69/70 AD show that late eye brooches of the main series, as well as early ones of the so-called Prussian series, were only a minority in the stock of wares at that time.

This case may not be proof of a presumed presence of Germanic traders in Augsburg; perhaps a minority of the brooches were worn by the presumed local Germanic population. They could have been the second or third generation (as indicated by the local occurrence of older and younger forms of eye brooches from the main series) of the descendants of Germanic *auxilia* stationed in the *castellum*, which was destroyed during the civil war in 69/70 AD. However, another possibility cannot be definitively ruled out, that the non-Roman inhumation graves with horse burials in the south-western part of the necropolis belong to Thracians rather than Germans in the *auxilia* (Bakker 2000, 89, 90).

There is also another (though quite similar) interpretation. Admittedly, there is no epigraphic evidence confirming that the Germanic – or, all the more, 'East-Germanic' – *auxilia* were stationed in Augsburg, or in the province of *Raetia*, or on the Danubian *Limes* in the 2nd century; neither there is evidence of tribal contingents. However, the discovered fittings of drinking horns, which are not that rare in *Raetia*, may be connected with the presence of 'Germanic' warriors. Such fittings are also found in grave inventories containing militaria, for instance, grave 17 in Wehringen with a ring pommel sword, lance point and conical shield boss (Maier 1985, 54, 55; Nuber 1985, 52, 53; see also Steidl 2013, 162-165, regarding the so-called Germanic discoveries from the phase B1). In this context, it also seems important to mention the so-called ring pommel swords from this and another grave in Wehringen, which are dated in the late 2nd century; nevertheless, this type of swords, though not foreign to the Roman military tradition, may not be linked solely to the 'Germanic' people (Miks 2007, 177-187, 758, pl. 47, A775). Perhaps the entire manufacturing of the eye brooches in Augsburg was not meant to partly satisfy the local needs and partly be distributed into the *Barbaricum*, including its east ends; instead, they were made for the 'Germanic' *auxilia*, since at least some of them were found in the area of the destroyed former *castellum*. The connection with the provincial burials in Wehringen that took place nearly a hundred years later seems very curious. Moreover, the eye brooches were never found in graves that could be in any sense connected with 'Germanic' *auxilia*. It does not appear to be provable that the 'Germanic' artisans had been living in Augsburg due to their kinsmen stationed in the province. However, the mass scale of this production, far exceeding the needs of *auxilia*, should be mentioned here as a counter-argument.

In the literature, it is also hypothesised (Roxburgh and Olli 2019, 226) that the brooches were manufactured for the Germanic soldiers serving in the Roman army, who would take them back home after finishing military service. It should be remembered, however, that the eye brooches of the Prussian series were used by men (*e.g.*, Nadkole, graves 38, 57, 86: Andrzejowski 1998; Kamieńczyk, graves 92, 352: Dąbrowska 1997; Oblin, grave 176a: Czarnecka 2007), but were also commonly found in *Barbaricum* in female graves (*e.g.*, Nadkole, graves 36, 80A, 94: Andrzejowski 1998; Kamieńczyk, graves 55, 111, 174, 272: Dąbrowska 1997).

The models of production that emerge from the chemical analyses of the Prussian series eye brooches from the eastern part of *Barbaricum*, are highly diversified. More than half of the artefacts probably came from large centres, as they were made of a chemically homogeneous Roman raw material. This naturally evokes an analogy with Augsburg; it may be suspected that such a workshop (or workshops) was located outside of *Barbaricum*, in the Empire (*cf.* similar comments by Roxburgh and Olli 2019, 225-227, on the basis of the results of the alloys analysis of the typologically late eye brooches of the Prussian series, mostly A.61, found in Latvia and Estonia). However, high-quality raw material in the form of coins and vessels (and perhaps brooches too) was transported into *Barbaricum*; thus the possibility that there were large manufacturing centres operating also in *Barbaricum* cannot be fully excluded (this may also refer to late eye brooches of the Prussian series from Latvia and Estonia: Roxburgh and Olli 2019, 225-227). Nonetheless, this statement is relativised by a general lack of bronze coins as well as the fact that metal vessels occur in the researched area only in the elite graves from the older Roman Period. These potentially existing supra-regional workshops would have required the functioning of a wide network for the distribution by ware-exchange since these chemically homogeneous products were found in the burial grounds of both the Wielbark and Przeworsk cultures. Moreover, the fact that, so far, such a centre in these areas has not been discovered is not a strong argument in favour of this notion, regarding the present low state of research on the settlements, especially on the Wielbark culture.

The lack of a clear correlation between the typological classification of the analysed group of brooches and the type of the alloy, as well as the observed wide array of alloying additives, lead us to the conclusion that a significant number of the brooches was manufactured from a raw material that was accessible at the given time through mixing or recycling. Surely, some of the demand was also satisfied by small workshops that manufactured goods for a narrow circle of local consumers. An excellent example thereof is an increased presence of brooches made of mixed metal (type A) in the burial grounds of Mazovia. In Kamieńczyk and Modła (8 and 6 analyses respectively), no products with high zinc content (type B metal) were found; however, in the necropolis of Nadkole, which is the source for the most analyses from Mazovian burial grounds, both original Roman alloys (type M and type B) occur in considerable numbers of samples analysed.

A low number of brooches made from the mixed alloy (type A) or a complete absence of items with high zinc content (type B) in large Pomeranian burial grounds (Pruszcz Gdański, site 7, Malbork-Wielbark and, first and foremost, Czarnówko), where the original

Roman alloy (type M) prevails, poses the question regarding the possible differences in the patterns of distribution (and influx) of the brooches between the Przeworsk and the Wielbark culture. The communities of the Wielbark culture, or at least their part living in the bustling settlement microregions where the analysed cemeteries were located may have mostly received the products from large, supra-regional manufacturing centres, whose location cannot be clearly determined. Hypothetically, these might have been workshops in the Empire; it is not completely excluded that they could have functioned in *Barbaricum*, though they would have needed constant access to large quantities of high-quality raw material. For the most part, the population from the eastern Mazovian area of the Przeworsk culture might have supplied themselves through local workshops, yet the brooches made of the Roman alloy (type M) were also not rare there. This implies slightly different networks of (possibly external) relations existing in the two cultures. These hypotheses are, however, relativised by the partial nature of the resource base at our disposal (*cf*. Fig. 4 and Tab. 1).

In the light of the conducted chemical composition analyses of the artefacts from *Barbaricum*, it is not possible to unanimously answer the question of whether the eye brooches of the Prussian series were manufactured by Germanic or Roman workshops. However, a different question should be posed instead: how many of the analysed brooches were made in large, supra-regional workshops? And where were those workshops located? It has been proven that some of the workshops were located in Augsburg. However, our considerations should include the regions of *Barbaricum* which had close contact with the Empire and, above all, were able to secure a steady influx of Roman resources. On the other hand, it has also been demonstrated that there were smaller workshops using scrap metal as the source of their raw material,which could have been located anywhere in the *Barbaricum*. As evidenced by the occurrence in Kamieńczyk grave 16, these local or regional workshops in *Barbaricum* started their production along with the production of younger eye brooches of the main series such as A.52-53 at the latest. Therefore, in further research, the metal composition of the eye brooches of the main series in both the Empire and *Barbaricum* should be comparatively examined in order to investigate the beginning of this local production more closely. Afterwards, an investigation should be conducted of the metal composition of the spring-cover brooches simultaneously competing on the 'market' with the eye brooches of the Prussian series, in the Wielbark culture especially A.38 and A.42, as well as the secondary brooches from Almgren group V such as A.110, A.120 or A.148/150. This could broaden our understanding of the production structures at that time. Therefore, the analyses presented here can only be viewed as a contribution to further research.

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DOWN BY THE RIVER TO THE MIDDLE OF NOWHERE? AVAR-PERIOD METAL ARTEFACTS DISCOVERED IN JANOWIEC, SITE 3, PUŁAWY DISTRICT

ABSTRACT

Kuś G., Trzeciecki M. and Gan P. 2022. Down by the river to the middle of nowhere? Avar-period metal artefacts discovered in Janowiec, site 3, Puławy district. *Sprawozdania Archeologiczne* 74/2, 289-316.

The text discusses the results of typological and metallographic analyses of metal objects dated to the 7th-8th centuries from Janowiec on the Vistula River, including five bronze strap fittings, two silver bracelets with trumpet-like endings, two bronze bars, and lumps of melted metal. The analyses of the fittings indicate their direct associations with the Avar Kaganate. Currently, the fittings from Janowiec comprise the most numerous assemblage of Avar imports from Polish lands. The form and technology of manufacture of the bracelets is typical for the area between the middle Dnipro and the middle Danube, while their decorative patterns refer to the art of the Avars. Interestingly, such an assemblage was discovered in the territory currently regarded as peripherical or even wholly uninhabited. The finds from Janowiec document contacts between the emerging “tribal” elites of northern and north-eastern Lesser Poland and the Transcarpathian areas and indicate the role of the Vistula as a communicational axis.

Keywords: Early Middle Ages, Lesser Poland, interregional contacts, Avar belt, metallographic analysis
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1. INTRODUCTION

Until recently, the territory between the middle Vistula and the Pilica rivers has not aroused much interest in researchers studying the history of Polish lands in late Antiquity and the early Middle Ages. Maps illustrating the ranges of settled zones, strongholds location, or imports distribution show an uninhabited zone between culture-forming centres and emerging political structures (see *e.g.*: Poleski 2013a, 323-324, fig. 3). However, investigations and discoveries of recent years prove that the "no man's land" on the middle Vistula can instead be regarded as an "unknown land", awaiting its discoverers. The finds from Site 3 in Janowiec on the Vistula River presented in this text prove such a thesis. The group of metal objects of southern and south-eastern provenance discussed here, generally dated to the Late Avar period, shows surprisingly extensive interregional contacts between communities living in the region discussed here, long before it became part of the early Piast state.

Site 3 (AZP 76-75/47) in Janowiec, Puławy district, is located on the sandy terrace's gently sloping edge, closing the Vistula valley from the northwest. The current river bed is approximately two kilometers from the site (Fig. 1). The valley partly serves for agricultural purposes, partly is wetland, with a network of canals accompanying ponds. The partially canalized Plewka river flows at the foot of the terrace and falls into the Vistula above Janowiec. Geographically, the site is located on the border of two Mezoregions – the

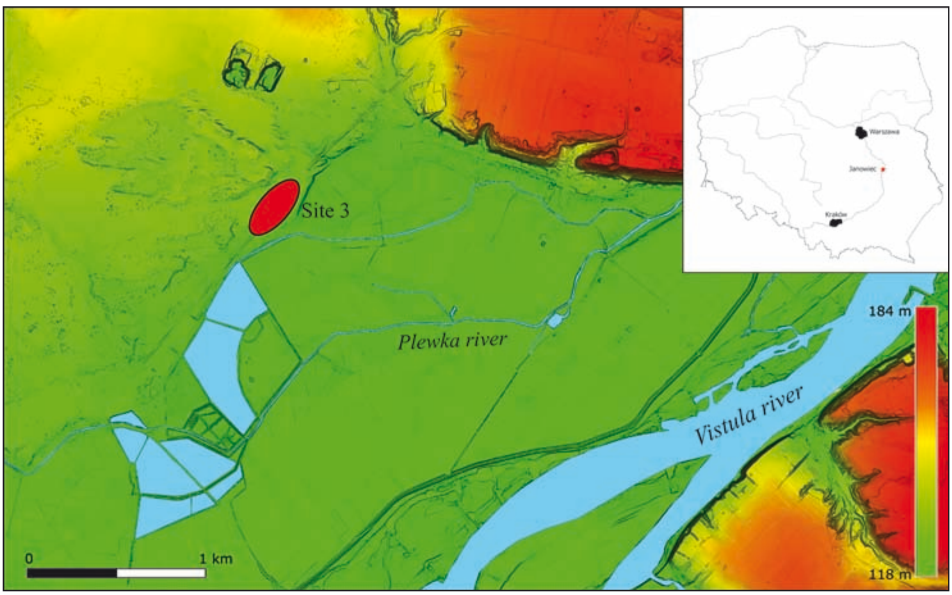

Fig. 1. Location of Site 3 in Janowiec, Puławy district. Prepared by G. Kuś

Radom Plain and the Małopolska Gap of the Vistula River (Solon *et al.* 2018). The site was discovered in 1981 during surveys carried out as part of the Polish Archaeological Record project (Bargieł and Zakościelna 1995, 318), excavation work, and surface prospection have been carried out here since 2017. So far, excavations have covered an area of only 1.8 ares. More than 40 archaeological features were discovered, the majority of them dated back to the Roman period. A relatively small number of Early Medieval features have been discovered there so far. Their chronology refers to the 11th-12th centuries AD, with the exception of one pit containing sherds of handmade vessels dated preliminarily to the 7th-8th centuries AD. A detailed surface survey with metal detectors, repeated every year, has covered an area of approximately 3 hectares. It provided a set of finds relatively widely dated – from the Bronze Age to the Post-medieval period. The most numerous are artefacts from the Roman and Post-medieval periods. Fragments of two Migration period fibulae of Baltic provenance are also worth mentioning (Kuś 2021), along with objects discussed here, dated to the earlier phases of the Early Middle Ages.

The following text is – as already mentioned – a presentation of a selected group of finds, along with typological and chronological analysis, supported by the results of laboratory tests carried out in the Central Laboratory of Bio- and Archaeometry IAE PAN. Given the initial state of investigation of the site, conclusions regarding the provenance of objects and roles they may have played in local socio-cultural contexts are preliminary. They indicate, however, the potential of future studies on the Early Medieval history of this region, overlooked until recently.

2. THE FINDS

The collection of artefacts discussed here includes five strap fittings made of copper alloy, fragments of two silver bracelets, along with two metal bars and an object interpreted as a negative of the pouring channel of a casting mould. The fittings (No. 1-5, 11) along with one bracelet (No. 6), alleged bars of raw material (No 8, 9), and a negative of the pouring channel (No. 10), have been acquired in the course of metal detector surveys, from the contemporary humus. Fittings No. 2-5 were discovered in the north-eastern part of the site, in a small cluster not exceeding 20 m^2. Fitting No. 1 and a lump of metal (No. 11) were found in the eastern part of the investigated area, about 40 m from the cluster described above. Bracelet No. 6, metal bars, and pouring channel (No. 8-10) occurred in the southern part of the site. Another bracelet fragment (No. 7) was discovered in the archaeological trench located in the southern part of the site. It was found in a pit (Feature 28), preliminarily dated to the 11th-12th century. The bracelet fragment was lying at the interface between the contemporary humus layer and the filling of the pit. It is worth noting that the distance between the finds of both bracelets is 17 m in a straight line, while the extreme distance between the finds is 186 m (Fig. 2).

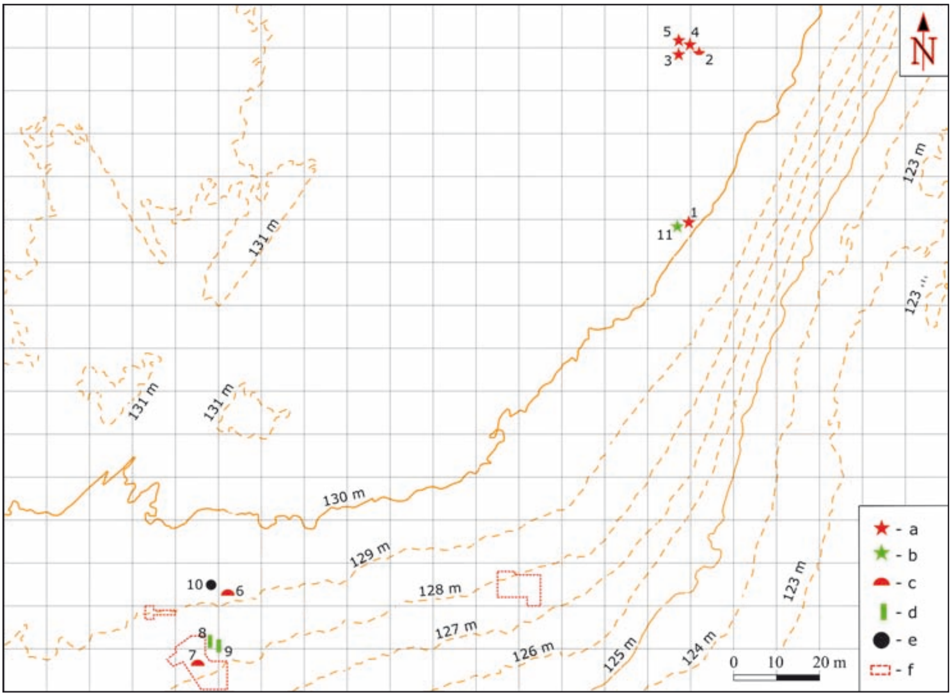

Fig. 2. Janowiec, Site 3, location of the discussed finds, numbered as in catalogue. Legend: a – Avar strap fittings; b – a probably strap fitting; c – bracelets; d – bars of raw material; e – a negative of the pouring channel of a casting mould; f – archaeological trenches. Prepared by. G. Kuś

1. Bipartite strap fitting (Fig. 3: 1; sample number: CL20883). The upper plaque has a form of an inverted shield, 27 mm high and a maximum width of 19 mm. In the outer frame, 3 mm thick, an openwork relief in the form of two strongly geometrized plant motifs located on both sides of the vertical axis of symmetry of the shield is closed. Two holes with rivets 5 mm long and 1 mm in diameter are placed on the axis of symmetry of the plaque. A pad strengthening the attachment to the belt is preserved on the lower rivet. The plate ends with two holders supporting an iron axis to which a movable lower part of the application is attached. Apparently, it could have had the form of a highly simplified palmette, of which only the supporting volutes are preserved. The weight of the fitting (after conservation) is 7 g.

2. Strap end (Fig. 3: 2; sample number: CL20884). Massive (weight after conservation 11.76 g), hollow U-shaped plate, 27 mm high and maximum 15 mm wide. Both sides are decorated with openwork, a strongly geometric floral motif, closed in a wide frame with transverse cuts around the perimeter. The images differ in details. Two pairs of eyelets are located on the upper edge. They have the form of strongly profiled triangles. Rivets to fix the fitting at the end of the strap are still in place.

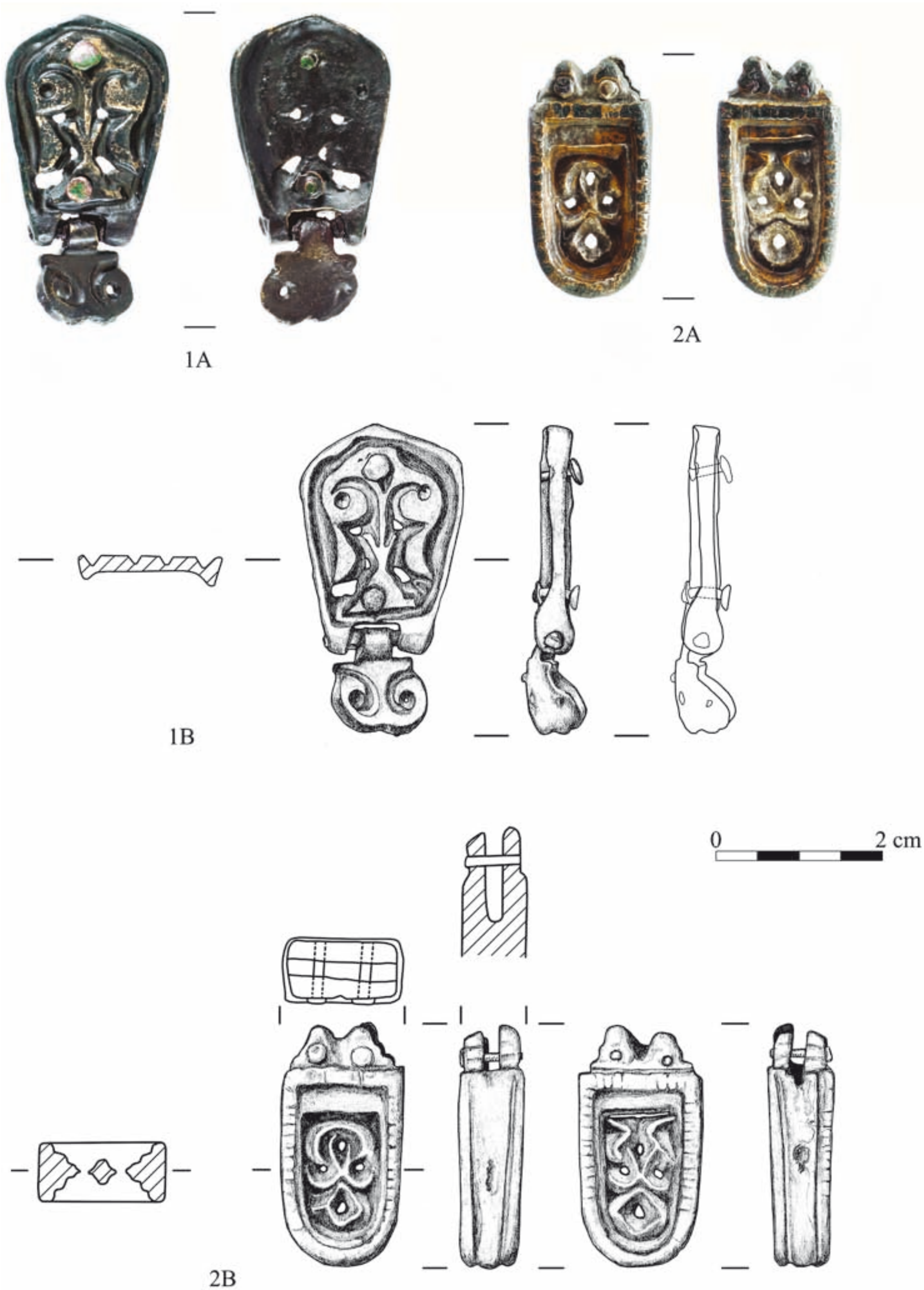

Fig. 3. Janowiec, Site 3, strap fittings. Drawn by A. Łyszkowicz, photo G. Kuś

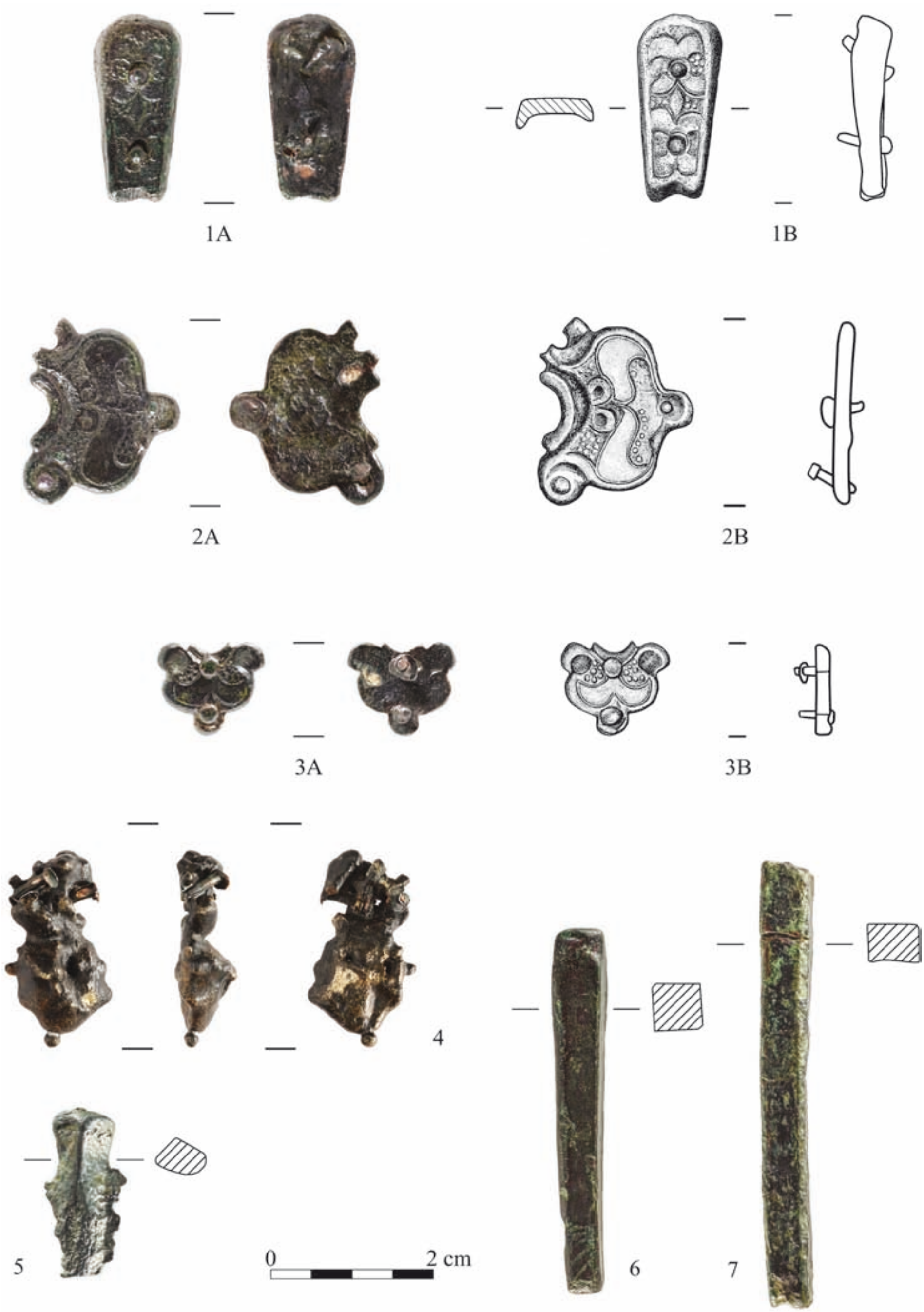

Fig. 4. Janowiec, Site 3, strap fittings (1-3), melted fitting (4), negative of a pouring channel (5), bars of bronze (6, 7). Drawn by A. Łyszkowicz, photo G. Kuś

3. Fragment of strap fitting (Fig. 4: 1; sample number: CL20891) in the form of an elongated plate, slightly narrowing towards one of the ends, 22 mm long, maximum 10 mm wide, and weighing 3 g. The inner surface is slightly concave. The flat outer surface is decorated with an engraved floral motif composed of two palmettes, integrated into the background partially covered with a stamped ornament imitating granulation. Along the vertical axis of symmetry, both ends of the shield are provided with two holes holding rivets, each about 1 mm in diameter and about 5 mm long. A pad strengthening the attachment to the strap is preserved on one of the rivets. The lower edge of the shield shows signs of damage and, unfortunately, is severely damaged. This hinders determining whether the object in question is a fragment of a single or bipartite fitting.

4. Strap fitting in the form of a flat, heart-shaped shield with three oval protrusions (Fig. 3: 2; sample number: CL20893), width 22 mm, height 18 mm, thickness 2 mm, weight 2.88 g. The outer surface is decorated with an engraved floral motif of symmetrically arranged stylized leaves, surrounded by a stamped ornament imitating granulation. Rivet holes are placed in the protrusions, with two preserved rivets, each with a diameter of 1 mm and of length 5 mm. Remains of a pad are visible at the end of one of them. The third protrusion is partially damaged.

5. Strap fitting in the form of a flat, heart-shaped shield with three oval protrusions (Fig. 3: 3; sample number: CL20892), width 12.5 mm, height 11 mm, thickness 2 mm, weight 1.26 g. The outer surface is decorated with an engraved floral motif of symmetrically arranged stylized leaves, surrounded by a stamped ornament imitating granulation. Rivet holes are placed along the symmetry axis, at the upper and lower edge of the plaque. The rivets, each with a diameter of 1 mm and length of 5 mm, are preserved. Remains of a pad are visible at the end of one of them.

6. Fragment of a bracelet made of a circular silver bar with a diameter of 3.4 mm, with a thickened ending with a diameter of 11.5 mm (Fig. 5: 1; sample number: CL20886). The length, measured along the outer circumference, is 55 mm, the weight is 16.72 g. The decorated strand at the ending is about 13 mm wide. It does not cover the entire circumference of the bracelet. The ornament includes three horizontal stripes filled with S-shaped stamp impressions, sometimes not very carefully printed, separated by single engraved lines. The decorated zone is closed at the top and bottom with double engraved lines. Numerous irregularities and single cracks are visible on the surface, presumably due to a lack of final finishing or the influence of high temperature on the finished product.

7. Fragment of a bracelet made of a circular silver bar with a diameter of 3.5 mm, with a thickened ending with a diameter of 15 mm (Fig. 5: 2; sample number: CL20885). The length, measured along the outer circumference, is 69 mm, the weight is 20.39 g. The decorated strand at the ending is about 12 mm wide. It does not cover the entire circumference of the bracelet. The ornament consists of three horizontal stripes of stamped decoration imitating granulation separated by undecorated belts and limited at the bottom by a single

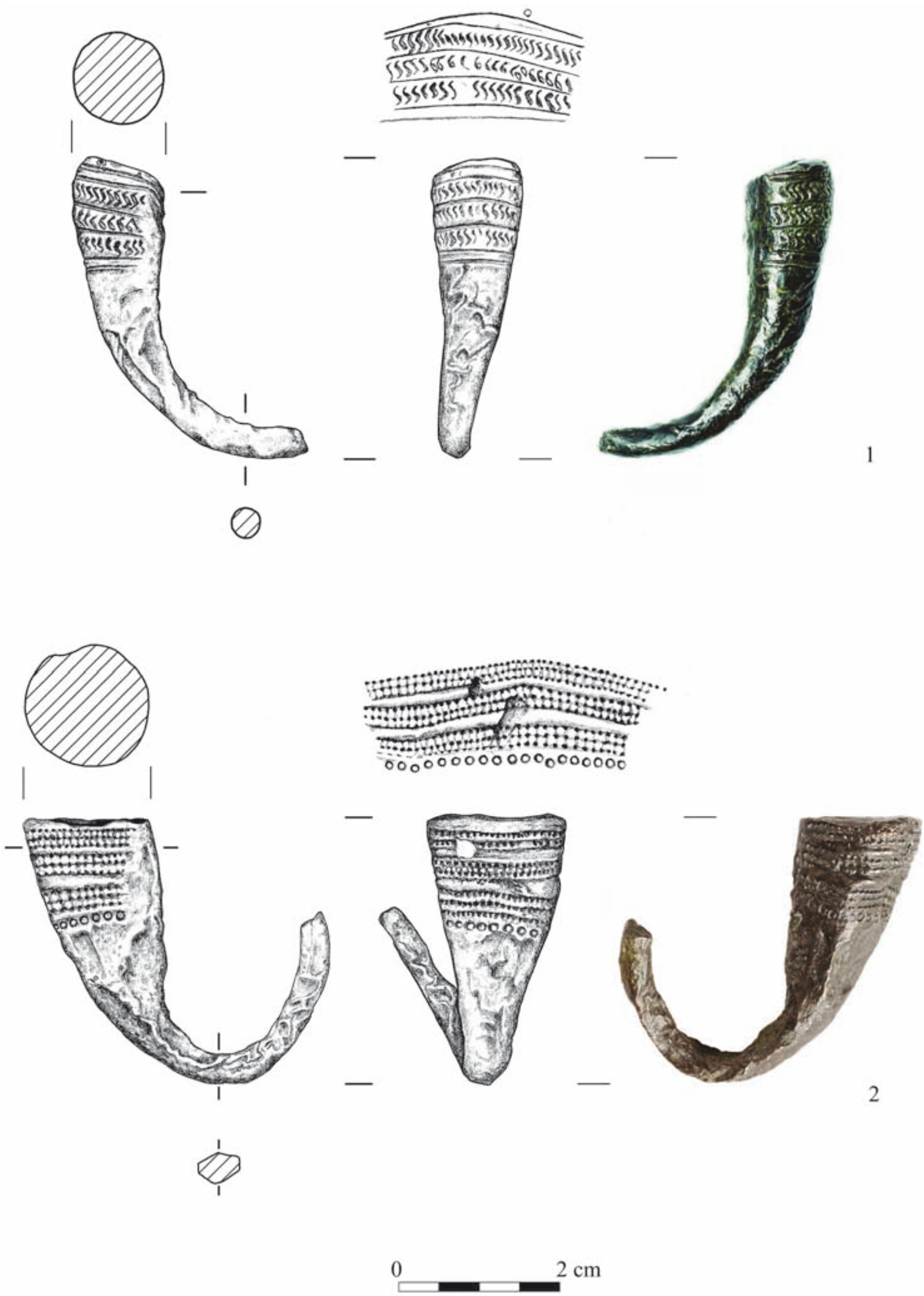

Fig. 5. Janowiec, Site 3, fragments of bracelets. Drawn by A. Łyszkowicz, photo G. Kuś

line of stamped circles. As in the case of the previously described item, the surface of the preserved fragment is deformed.

The survey also produced a group of copper alloy objects, probably related to the on-site processing of the raw material. Although there is no stratigraphic data unambiguously linking the finds with the artefacts described above, we included them in chemical analyses for comparative purposes. The assemblage encompasses:

8. A bar of raw material, square in cross-section, length 45 mm, width 6 mm, weight 9.57 g (Fig. 4: 6; sample number: CL20922).

9. A bar of raw material, rectangular in cross-section, length 55 mm, width 6 × 5 mm, weight 9.92 g. (Fig. 4: 7; sample number: CL20923).

10. A cast of the pouring channel of a mould, 21 mm high, with irregular protrusions at the edges. Weight 3.12 g. (Fig. 4: 5; sample number: CL20924).

11. An irregular piece of melted metal, probably strap fitting, maximum dimensions of 24 × 13 × 8 mm, the weight of 4.85 g. Two partly melted rivets approximately 7 mm long and 1 mm in diameter are visible at one end (Fig. 4:4; sample number: CL20887).

3. TYPOLOGY AND CHRONOLOGY

The strap fittings described above can be recognized as elements of the so-called belt sets, characteristic of the material culture of the Avars (*cf*. Szőke 2008, further literature there). Fitting No. 1 is a metal element of the main belt. It served for attaching an additional vertical strap. Numerous applications of similar forms and decorative patterns occur in most of the Late Avar cemeteries in the territory of today's Hungary. The set of seven fittings from Grave 491 in the cemetery in Székkutas, Csongrad county (Nagy 2003, 64, 65, fig. 175: 6-12), along with five appliqués from Grave 5 in the Atokháza-Bilisics cemetery in Ásotthalom, Csongrad county (Csallány 1957, 15-116, 128, fig. 5, Pl. 29: 1-5) should be mentioned here. They differ only in minor details from the fitting from Janowiec. Similar fittings occur also at cemeteries in the Somogy county: Fészerlak-puszta (today part of Kaposvár; Szimonova 1972, 161-163, fig. 61) and Zamárdi-Rétiföldek (Bárdos, Garam 2014, 36-37, 70, 71-74, fig. 183, 204, 206). A strap fitting from Grave 79 in the Szob-Homokok-dűlő cemetery, Pest county, near today's Hungarian-Slovak border is also worth mentioning (Kovrig 1975, 178, 179, fig. 8: 79:10). Among the closest analogies, one can also point to the fitting found in a Late Avar cemetery in Edelstal, in Austrian Burgenland (Hampel 1894, 141, 142, Taf. 142: 23). Similar appliqués are also known from the territories south of the middle Danube, including the Manđelos cemetery in Vojvodina (Bugarski 2015, 134, fig. 6).

Similar fittings occur relatively often in the Late Avar cemeteries in Slovakia. Attention should be paid primarily to the forms classified as types 245, 247, and 253 according to the classification of Jozef Zábojník. In the case of the latter type, an apparent similarity of the decorative pattern should be stressed. Presumably, the form of the damaged lower plate of the fitting from Janowiec was similar to the appliqués representing type 247. The aforementioned fittings types are included in the SSIII phase, dated to 750-780 AD (Zábojník 1991, 239, 248, fig. 40: 1-3, 9, 10; 41: 1).It is worth emphasizing that the finds of fittings representing types 245, 247, and 253 concentrate in cemeteries located in southwestern Slovakia, starting from the Bratislava-Čunovo cemetery (Zábojník 1991, fig. 40: 9), through three fittings from Nove Zamky (Zábojník 1991, fig. 40: 2, 3, 10) to the recently published appliqué from the cemetery in Obid (Zábojník 1991, fig. 40: 1; 2019, tab. 134). This list can be expanded to include the fitting from the Hungarian Szob, mentioned above, located less than 30 km east of Obid, and the bipartite application from the Austrian Edelstal, located only 15 km southwest Bratislava.

Strap fittings similar to the item discussed here also occur in the areas adjacent to the Kaganate. A series of finds from the 8th-9th century stronghold in Tismice, Kolin district deserves mentioning (Profantová *et al.* 2020, 217-219, obr. 22: 13-15, 17, 21). Thanks to systematic metal detector surveys, the stronghold provided an exceptionally rich collection of Late Avar style belt-set elements, already exceeding 100 items, along with finds indicating the local production of at least some of them (*cf.* Profantová 2020; Profantová *et al.* 2020, further literature there). Two fittings from the Croatian Biskupija are also noteworthy. These are loose finds, although undoubtedly deriving from the vast settlement complex associated with Knin – the seat of Croatian rulers in the 10th-11th centuries (Petrinec 2009, 36, fig. 90: 19, 20).

Bipartite strap fittings with the upper part in the form of an inverted shield only sporadically occur north of the Carpathians. An appliqué from Syrynia, Wodzisław district, can be regarded as the closest analogy from the Polish lands (Szymański 1962b, 307, fig. 17; see also Boroń and Foltyn 2011, 24, further literature there). Recently published strap fitting from the stronghold in Czermno, Tomaszów district should also be mentioned here. However, it differs from the find from Janowiec in the ornamentation details and proportions of the shield (Wołoszyn *et al.* 2016, 697-698, fig. 4).

Fitting No. 2 was placed at the end an additional strap attached to the main belt (*cf.* Szőke 2008). Similar, one-piece and hollow applications decorated with an openwork ornament are relatively rare, both in the Kaganate and neighboring territories. One related example is the fitting from Grave 133 in the Late Avar cemetery in Pilismarót-Basaharc, Esztergom county, which is the closest analogy, differing only in minor details (Fettich 1965, 47-48, fig. 81: 3). Similar, although more extended fittings also occurred in two cemeteries from Hungarian Transdanubia – Zalaegerszeg, Zala county (Szőke 2001, 103, fig. 2: 3) and Zamárdi, Somogy county (Bárdos and Garam 2014, 60-61, 124-125, fig. 196: 6, 235: 10-13). A strap end from the already-mentioned cemetery in Fészerlak-puszta also deserves attention (Szimonova 1972, 161-163. fig. 61). However, it should be borne in mind that the aforementioned applications differ from the find from Janowiec in the details of the decorative pattern.

In the assemblages from the Late Avar cemeteries in Slovakia and Lower Austria, similar fittings occur rarely. Strap ends representing type 107, and partly 99, according to J. Zábojník, can be regarded as close analogies in terms of form, although they differ in the openwork details. Both types can be referred to as phases SSIII and SSIV, dated to 750-800 AD (Zábojník 1991, 239-242, 248, fig. 23: 5; 24: 3-5).

Interestingly, a strap end almost identical to the find from Janowiec has been found outside the Kaganate, in the Czech Basin, in the vicinity of the stronghold Praha Dolní Liboc-Šárka, dated to 8th-10th centuries (Turek 1950, 62 fig. 2: 3; Profantová 1992, 664, tabl. 6: 4, 52: 2). Similar in form, though differently decorated, is a fitting from the stronghold in Tismice (Profantová *et al.* 2020, 217, fig. 22: 11). A strap end from the Avar warrior grave in the cemetery in Brateiu, Site 2, Sibiu district, Romania, is also worth recalling here (Zaharia 1977, 62, fig. 29: 2).

Fitting No. 3 was attached to the main belt (*cf.* Szőke 2008). Similar applications often appear in sets of several to a dozen items, both one-piece and bipartite. The belt set from Grave 3 in the Székkutas cemetery can serve as an example here. It includes 15 appliqués stylistically close to the find from Janowiec, among them only five one-piece fittings (Nagy 2003, 17, fig. 5: 1-15). Another cemetery located in the Great Plain, in Jánoshida, Jász-Nagykun, Szolnok county, provided 14 similar applications (Grave 30; Erdélyi 1958, 11, 12, fig. 13: 4, 5). An assemblage also containing 14 stylistically similar fittings (six one-piece items) was a part of the beltset from Grave 1866 in the cemetery in Zamárdi-Rétiföldek, Somogy county (Bárdos and Garam 2014, 60, 61, fig. 196: 8-21). A set of 13 appliqués (including two one-piece ones) occurred in Grave 142 in the Szebény I cemetery, Baranya county (Garam 1975, 82, fig. 11: 142:3-15; Pl. 14: 14). Seven partially damaged fittings, three of which were probably one-piece, from Grave 239 in the cemetery in Pilismarót-Basaharc also deserve mentioning (Fettich 1965, 80, 81, fig. 144: 3-9).

Similar fittings are not very abundant in the Late Avar cemeteries in Slovakia and Lower Austria. They were classified as type 234 according to J. Zábojník, characteristic of the SSIV phase, dated to the years 780-800 AD (Zábojník 1991, 241, 248, fig. 38: 20). They also can be found in the Czech lands – at least four fittings of that type are present in the collection from the stronghold in Tismice (Profantová 2020, 164, fig 4: 6, 7; Profantová *et al.* 2020, 217-220, fig. 23: 14-17). An analogous appliqué was found at the Kosoř /Praha-Radotín stronghold (Profantová 2015, 83, fig 5: 4). A stylistically similar strap fitting occurred in the aforementioned Avar warrior grave in Brateiu, Site 2 (Zaharia 1977, 62, fig. 29: 3), along with strap end analogous to the fitting No. 2 from Janowiec, discussed above.

Strap fittings No. 4 and 5 are characterized by identical form and decorative pattern; only the sizes differ. Fitting No. 4 is a metal reinforcement of the main belt holes while fitting No. 5 was probably attached to an additional strap (*cf.* Szőke 2008). Appliqués of a similar, highly standardized form can be found in the majority of the Late Avar cemeteries in today's Hungary. However, it should be emphasized that such a group is characterized by a vast array of ornamentation details. Therefore, it is difficult to indicate direct analogies to the finds from Janowiec. Undoubtedly, they have parallels among the strap fittings from the cemeteries mentioned above, including finds from Graves 3 (18 items) and 54 (28 items) in Székkutas (Nagy 2003, 17, 23, fig. 4: 8-17, 26: 4-7, 21-44), from Grave 1866 in Zamárdi (16 items; Bárdos and Garam 2014, 60, 61, fig. 196: 2-34), from Grave 30 in Jánoshida (12 items; Erdélyi 1958, 11, 12, fig. 13: 10-12), and from Grave 142 in Szebény I (26 items; Garam 1975, 82, fig. 11: 142:16-18, 21-35, Pl. 14: 10, 11). Similar appliqués occurred also in the cemetery Pilismarót-Basaharc (Fettich 1965, 13, 80, 81, fig. 6: 5, 7, 144: 11, 12). In the Late Avar cemeteries of Slovakia and Lower Austria, similar fittings are classified as type 172 according to J. Zábojník, they are characteristic for the SSIII and SSIV phases dated to 750-800 AD (Zábojník 1991, 239-242, 248, fig. 33: 20-24).

Fittings representing such a stylistic group are also present in the areas neighbouring the Kaganate, both from the south and the north. They occur relatively often in the Czech Basin and western Slovakia (see *e.g.*, Profantová *et al.* 2020, 217-219, fig. 23: 20, 25-29, 34-36, 41, 42). We also know a few finds from Polish lands, but it should be borne in mind that they do not constitute direct analogies to the fittings from Janowiec in terms of form and decoration. Nonetheless, appliqués from Biskupin, Żnin district, Naszacowice, Nowy Sącz district should be mentioned here, along with an unpublished set of four Late Avar fittings from Gródek upon the Bug River, Hrubieszów district, that also includes metal reinforcements of the main belt holes (Robak 2018, 94, 95, fig. 2: 1; 3: 8, 9, further literature there).

Summing up this necessarily brief typological and chronological analysis, it can be stated that the discussed metal strap fittings can be undoubtedly associated with the Late Avar period – given both the chronology and the stylistic features of the forms and ornamentation. Considering Gergely Szenthe's classification of changes in the decorative style of Late Avar strap applications, two groups can be distinguished in the Janowiec collection. The first one, representing the so-called Geometrical Circular Lobe Style, typical for the second half of the 8th century, includes fitting No. 1. Appliques No. 2-5 represent the declining horizon of the Avar decorative art, dated back to the last decades of the 8th and the beginning of the 9th centuries (Szenthe 2013, 314-316, fig. 3). It cannot be ruled out that the latter group of fittings from Janowiec had initially been part of the same belt set. Their location in a relatively small area, not exceeding 20 m^2, might support such a hypothesis (Fig. 5).

Finds Nos. 6 and 7 represent the type described as bracelets with trumpet-like endings. Although similar forms, made of copper or silver alloys, occur over vast areas of Europe from the Roman period to the early Middle Ages, bracelets with trumpet-like endings appear to be particularly characteristic for assemblages of early Slavic culture, particularly from the Middle Dnipro River basin, where they are dated relatively widely to the 6th-8th centuries. They occur in graves, strongholds, and open settlements, although primarily in hoards of the so-called Martynovka type (*cf. e.g.*: Košnar 1994, 76-90; Szymański 1995, 134, 135; Schuster 2016, 240-245; Rodinkova 2018, 671, 675; Hanoshchenko and Volodarec-Urbanovych 2019, 134-139; Gavritukhin 1996, 94, 95; 2005, 434, 435; further literature there).

Bracelets with trumpet-like endings can also be found in the Avar cemeteries dated to the 7th-8th centuries. Particularly characteristic of the Avar Kaganate material culture are hollow bracelets with enormously widened ends manufactured of silver sheet. They are described as the Szentendre-type and dated to the 7th century. These bracelets occur almost exclusively in the territory of the Kaganate; they are regarded as the products of artisans working for the needs of the Avar elites and continuing local Late Roman workshop traditions (Garam 2001, 67-74, 178-183, pl. 1; further literature there). Bracelets with trumpet-like endings manufactured of silver or bronze bars are much less common in Avar cemeteries (Garam 2001, 72-74, fig. 46-47). They are also rare in the northern borderlands of the Kaganate. Primarily, finds from Moravia should be listed here, among them six bracelets from the hoard from Poštorná (today part of Břeclav), dated to the first half of the 7th century (Košnar 1994, 70, 71, 97, fig. 1, 2) and a single find from Moravany (a suburb of Brno; Hájek *et al.* 2015, 250, fig. 3). A bracelet with trumpet-like endings was also found in the cremation grave in cemetery Bratislava-Dubravka, dated to the 6th-7th centuries (Hromada 1991, 282-283, obr. 3; Werner 1991).

There are a relatively significant number of bracelets with trumpet-like endings, predominantly manufactured of a bronze or silver bar, known from the Polish lands. The most numerous assemblage includes eight bracelet fragments (six bronze, two silver) from the excavated stronghold in Haćki, Bielsk district. They occurred in the stratigraphic context dated by the radiocarbon method to the 7th century (Kobyliński and Szymański 2015, 123-126, fig. 23, 24). Of particular importance is the hoard from Machnów Stary, Tomaszów district. It contained fragments of three bracelets with trumpet-like endings, a bronze trapeze-like pendant, and bronze bars – probably raw material. The deposit is dated to the 7th-8th centuries and interpreted as the property of a craftsman (Piotrowscy 2010, 76, 77, fig. 1). Preliminary publication of the hoard also contains information about the raw materials of bracelets: bronze, silver, and electrum (Piotrowscy 2010, 76, footnote 9). It is, however, difficult to comment on such statements before the laboratory analysis of chemical composition. Another bracelet was found in an early Slavic stronghold in Szeligi, Płock district, also in the context dated to the 7th century (Szymański 1962a, 358, 359, fig. 3). A fragment of a silver bracelet, analogous to bracelet No. 6 from Janowiec, was discovered in Kobylarnia, Międzychód district (sierakowhistorianieznana.pl/2020/06/27/miejsca/warta-zapomniany-szlak-handlowy/romanchalasz/?highlight=bransoleta). Regrettably, it is a loose find. Two silver bracelets with widened endings were also found in Lubiewice, Sulęcin district. According to Wojciech Szymański, their form and decoration refer directly to the stylistic features of Szentendre-type Avar bracelets (Szymański 1962b, 288, footnote 17; 1995, 135). Information about further finds from Polish lands made by metal detector users (at least three items) can be found on the Internet, unfortunately without even approximate place of discovery (cf. https://poszukiwanieskarbow.com/forum/). Finally, one should also mention a hollow bracelet made of bronze sheet, found in Biskupin and dated to the late 7th-8th centuries. W. Szymański recognizes it as a local, simplified replica of silver Szentendre-type bracelets (Szymański 1962b, 288-293; 1995, 134-135).

The relatively broad timeframe widespread of bracelets with trumpet-like endings hinders determining an unambiguous chronology and cultural attribution of the finds from Janowiec. Opportunely, stylistic analysis of decorative patterns provides specific hints.

Bracelets made of silver or bronze bar with ornament analogous to bracelet No. 6 can hardly be found in the relevant literature. It is worth emphasizing that similar decorations are absent in the collection of bracelets from the middle and upper Dnipro River basin. Patterns including lines and stamps in the form of the letter "S" can, however, be found on Avar bracelets of the Szentendre type (*cf.* Nagy 1998a, 381, 425, fig. 20; Garam 2001, 72-74, fig. 46-47; further literature there). One can indicate, among others, a pair of bracelets from Grave 1 in the Csepel-Háros Duna-gát cemetery in Budapest (Sós 1961, 32, fig. 3: 3-4; Nagy 1998b, 144, fig. 99: B: 2-3, 168: 9-12), as well as bracelets from Grave 123 in the cemetery in Gyenesdiás, Zala county (Garam 2001, 69, fig. 45: 6). Given the finds from the area outside the Kaganate, an analogous motif occurred only on the bracelet from Kobylarnia, and the find from an unknown place in Poland, published on the Internet mentioned above.

The decorative pattern of bracelet No. 7 – punctures imitating granulation – appears to be more widespread. Also, in this case, analogies are extremely rare in the Eastern Slavonic territories (*cf.* Hanoshchenko and Volodarec-Urbanovych 2019, 134, fig. 7, 9, 10), although similar motifs frequently occur in Central Europe. Ornament on the bracelet from the post-Roman cemetery at Keszthely-Fenékpuszta, Zala county, dated to the second half of the 5th century, can be regarded as one of the oldest examples (Straub 2011, 327-331, 337, fig. 2: 2, Pl. 1:7). It is notable that bands of stamps imitating granulation can also be found in the repertoire of decorative motifs applied on Szentendre-type silver bracelets (*cf.* Garam 2001, 67-74, fig. 42-45; further literature there). Two bracelets decorated with the use of such pattern were found in Grave 31 in the Avar cemetery in Üllő, Pest county (Sós 1955, 196, 208, fig. 59: 1, 2). Analogous stamped ornament also appears on the Moravian finds discussed above – silver bracelets from the Poštorná hoard (Košnar 1994, 70, 71, 97, fig. 1, 2), and a single find from Moravany (Hájek *et al.* 2015, 250, fig. 3). Presumably, such a pattern refers to the bracelets, described by Joachim Werner as the Verona type, decorated with the granulation technique. They are dated to the 7th century and occur primarily in northern Italy. J. Werner also included to the Verona type several finds from Central Europe, i.e., bracelets from Avar cemeteries in Keszthely (Hungary) and Želiezovce, Levice district (Slovakia), along with the aforementioned bracelet from Bratislava-Dubravka (Werner 1991, further literature there). In turn, analogies to the motif of stamped circles, closing the decorated zone of bracelet No. 7, can be found on the above-mentioned bracelets from Csepel-Háros Duna-gát, also decorated with granulation (Nagy 1998b, 144, Pl. 168: 9-12). Circles embossed with a stamp also decorate the endings of the bracelet from Biskupin, although in this case, they fill the zones delimited by engraved lines (Rajewski 1939, 343, Pl. 65: 1). According to W. Szymański: "the motif of round stamps is probably a vulgarization and a far-reaching simplification of the rhombus with a convex circular eminence in the centre, typical for Hungarian specimens" (Szymański 1962b, 292).

To sum up, silver or bronze bracelets with trumpet-like endings made of metal bars were widespread over vast areas of the territories of the Eastern Slavs between the 6th and 8th centuries. They also occur in the middle Danube basin, although it should be emphasized that hollow bracelets made of silver sheet predominate in the Avar environment. They appear relatively rarely in the areas neighbouring the Kaganate from the north, interestingly, mainly in Moravia. The recently growing number of bracelet finds from Poland, and their relatively wide territorial range is also noteworthy. However, one should agree with the opinion of Igor Gavritukhin (2005, 434) that the question of provenance, chronology, and stylistic changes of this group of jewellery is still only poorly understood. This hinders establishing the precise dating and cultural attribution of finds from Janowiec. As already mentioned, the results of the analysis of the decoration can be helpful in this case.

Imprints of a stamp in the form of the letter "S" appear almost exclusively in the Avar environment, on Szentendre-type bracelets. Items made of a metal bar decorated with analogous decoration are known, as yet, only from Polish lands; along with find from Janowiec, one should mention the bracelet from Kobylarnia and another one from an unknown place. It cannot be ruled out that the aforementioned finds document local appropriation of the form (significantly enlarged endings) and the stylistic features (stamps filling the space limited by horizontal lines) of Szentendre-type bracelets while maintaining the manufacturing technique traditional for the areas north of the Carpathians (fully cast). The inspiration for the decorative technique imitating granulation probably also derives from the middle Danube basin, where such decorative patterns are present from the Great Migration period until the end of the Avar period. What is more, we can find it both on cast bracelets and items made of sheet.

Both bracelets from Janowiec can be dated approximately to the 7th-8th centuries and regarded as items manufactured probably in the Slavic milieu but under the strong influence of Avar stylistic features and craftmanship. Regrettably, the typological and stylistic analyses do not provide an unambiguous answer to whether the bracelets arrived in Janowiec from the territories south of the Carpathian Mountains or were manufactured locally, although certain premises indicate the latter option.

4. METALLOGRAPHIC ANALYSIS

In order to identify the chemical composition of the alloys and manufacturing techniques of the objects, all discovered elements of the belt set and bracelets, along with two bars, remains of the pouring channel and lump of melted metal underwent laboratory analysis. The chemical composition of the samples was investigated with the help of X-ray fluorescence methods, using an ARTAX spectrometer (μXRF) and the Tescan scanning microscope with a PGT analyser (SEM-EDS). The experimental conditions for the Artax spectrometer were as follows: measurement time 100 seconds, voltage 50keV, ambient atmosphere, Rh lamp, 0.200 μm collimator. BCS standards and copper standards from the Institute of Non-Ferrous Metals in Gliwice were used to calibrate the results. On the SEM microscope, a 100-second measurement time was used in a vacuum at a voltage of 20kV. Each result is the average of several measurements.

Additionally, macroscopic observation and X-ray defectoscopy were also applied. In order to obtain better metal characteristisation, measurements were taken on both mechanically cleaned and intact surfaces. The phrase "intact surface" refers to a surface covered with corrosion products, patina, or any coating that has not been cleaned prior to the measurement. The results are summarized in Table 1, while Fig. 6 presents the spots where measurements were taken from. It should be stressed here that this presentation of metallographic analyses is of a preliminary character. The small number of items, their differentiation in terms of their raw materials (copper alloys, silver) and function (belt elements, ornaments, items related to metallurgy) limit both the scope of comparative analyses and detailed interpretations of the results.

The metallic material indicates the use of the casting method to manufacture all the analysed items. Fittings No. 1 and 2 are made of tin-lead bronze (range of determinations: Sn 12.41-26.82%; Pb 3.12-12.57%), appliques No 3-5, in turn, were cast of lead-tin material (range of determinations: Sn 5.40-9.35%; Pb 11.,49-18.35%). A small proportion of zinc, which does not exceed 1.75%, with average percentage of 0.87% is characteristic for all analysed strap fittings elements. Such content does not significantly affect metal properties and should probably be associated with the use of mixed copper ore (Niewęgłowski 1986, 313, 314). Rivets fixing the fittings are made of copper alloy with an average Cu content of 96.64% and a small number of contaminations from polymetallic copper ores. Adding lead and tin, slightly reducing the melting point, could intentionally compliment the alloy for some rivets. However, their measured contents, not exceeding 5% of the whole, do not noticeably change the physical properties of pure copper. In all probability, the manufacturer was not aware of the contaminations and wanted to use a different metal for fittings and rivets. He was concerned to obtain metal softer, easier to work with, and applicable at the rivet head. The bronze alloys utilized for casting the fittings are, in turn, appropriate for such castings. They are also characterized by high hardness after solidification and some anti-corrosion properties.

Given the research methods applied, the results of chemical analyses cannot indicate the origin of the raw materials (Pernicka 2014). However, ranges of the main alloy components with the lack of correlation between them, as well as the low levels of residuals from ore smelting indicate metallurgical production based on multiple remelted scraps rather than the use of pure metals. Neither does data on the chemical composition of the alloys provide premises for unambiguous identification of the origin of the analysed fittings. The above-indicated variable proportions of the main alloy components characterize many early medieval metal objects from Central Europe (see, *e.g.*, Doncheva *et al.* 2017, 82-84). It is worth emphasizing, however, that there are similarities between the objects discussed

Fig. 6. Selected places of metallographic analyses: CL20883 (a-d); CL20884 (f-i,k); CL20885 (e); CL20886 (j); CL20887 (l); CL20891 (m); CL20892 (n); CL20893 (o). Photo P. Gan

Table 1. Results of the chemical composition analyses of metal objects from Janowiec, Site 3. The results are percentages by weight (wt%), x – measurement below the detection threshold. Prepared by P. Gan

No. CL	Description	Cu	Sn	Zn	Pb	Ag	As	Sb	Au	Fe	Ni	Al	Si	P	S	Bi	Remarks
20883.01	Fitting	72.01	20.61	0.98	3.12	0.21	0.20	0.25	0.00	0.17	x	x	0.28	1.82	0.32	0.04	Cleaned
20883.02	Fitting	80.21	12.41	1.75	3.32	0.23	0.23	0.13	0.00	0.15	x	x	0.20	1.08	0.25	0.03	Cleaned
20883.03	Fitting	70.40	21.63	1.32	5.36	0.42	0.30	0.27	0.00	0.23	0.04					0.04	Uncleaned
20883.04	Rivet	97.58	1.17	0.55	0.28	0.04	0.06	0.07	0.00	x	x	x	x	x	x	0.01	
20883.05	Rivet	94.05	2.49	0.43	2.14	0.07	0.19	0.09	0.00	0.26	x	x	x	x	x	0.03	
20884.01	Fitting	70.99	16.86	0.34	9.53	0.16	0.30	0.32	0.00	0.11	0.11	x	0.36	x	0.81	0.13	Yellow coating
20884.02	Fitting	57.82	26.82	0.43	12.57	0.22	0.39	0.36	0.00	0.14	0.12	x	0.32	x	0.71	0.12	Grey coating
20884.03	Rivet	57.70	36.90	0.21	3.40	0.20	0.22	0.26	0	0.10	0.09	x	0.29	x	0.61	0.04	
20884.04	Fitting	47.55	22.69	0.40	25.61	0.23	0.91	0.67	0.00	0.19	0.12	x	0.19	x	1.32	0.20	uncleaned
20884.05	Fitting	68.73	17.48	0.20	12.85	0.16	0.42	0.02	0.00	0.10	0.05	x	x	x	x	0.00	uncleaned
20884.06	Fitting	63.90	13.78	0.57	20.65	0.22	0.03	0.49	0.01	0.26	0.03	x	x	x	x	0.07	uncleaned
20884.07	Fitting	67.91	21.32	0.66	9.07	0.17	0.25	0.27	0.00	0.22	0.06	x	x	x	x	0.07	Cleaned
20885	Bracelet	47.81	1.50	0.39	0.35	49.26	0.01	0.39	0.01	0.29	x	x	x	x	x	0.00	Cleaned
20886	Bracelet	55.94	0.82	0.66	0.35	41.44	0.01	0.57	0.01	0.20	x	x	x	x	x	0.00	Cleaned
20891.01	Fitting	74.07	5.24	0.42	18.85	0.13	0.11	0.10	0.00	0.11	x	x	x	x	0.75	0.05	Cleaned
20891.02	Rivet	96.28	0.36	0.00	1.76	0.09	0.27	0.12	0.00	0.50	x	0.20	0.21	x	0.00	0.06	
20892.01	Fitting	79.13	5.80	1.53	11.49	0.10	0.04	0.08	0.00	0.29	x	0.32	x	0.754	0.31	0.04	Cleaned
20892.02	Rivet	96.19	1.14	0.00	1.95	0.17	0.07	0.07	0.00	0.21	x	x	x	x	x	0.06	
20892.03	Fitting	83.37	9.35	1.25	5.20	0.10	0.12	0.19	0.01	0.31	x	x	x	x	x	0.02	Uncleaned
20893.01	Fitting	78.12	5.40	0.76	13.94	0.12	0.06	0.12	0.00	0.22	x	0.32	0.19	0.00	0.53	0.05	
20893.02	Rivet	97.74	0.33	0.00	0.14	0.09	0.10	0.09	0.00	0.27	x	x	0.26	0.83	x	0.04	
20887.01	Lump	74.88	17.52	1.01	5.55	0.20	0.06	0.23	0.00	0.14	0.11	x	0.08	x	0.21	0.02	
20887.02	Melted rivet	96.31	0.47	0.31	0.37	0.00	0.56	0.00	0.04	0.12	x	0.82	0.36	x	0.47	0	SEM-EDS Ti 0.36; Cr 0.09; Mn 0.06
20887.03	Melted rivet	98.31	0.53	0.00	0.65	0.00	0.00	0.08	0.00	0.14	x	1.67	4.34	x	0.20	0	SEM-EDS Ti 0.02
20922	Raw material bar	82.80	4.35	7.43	5.14	0.04	0.02	0.07	0.00	0.09	0.05	x	x	x	x	0.01	Cleaned
20923	Raw material ar	85.07	10.64	0.16	3.61	0.05	0.10	0.20	0.00	0.11	0.05	x	x	x	x	0.01	Cleaned
20924.01	Pouring channel	72.18	23.87	1.06	2.47	0.20	x	0.09	0.00	0.07	0.05	x	x	x	x	0.01	Cleaned
20924.02	Pouring channel	40.81	53.48	0.35	4.25	0.39	x	0.13	0.00	0.55	0.04	x	x	x	x	0.01	Uncleaned

here and other Late Avar belt elements. The vast majority of them were manufactured of tin or tin-lead bronzes. Such a composition of metal was established, among others, for 14 applications from the Czech Basin (tin – 3.73-21.80%, lead – up to 16.40%; Frána and Maštalka 1992, 782-789), as well as for five fittings from the stronghold in Tismice (tin – 9.42-45.37%, lead – 0.9-15.49%; Profantová 2020, 169). Among the finds from Slovakia, a series of 44 fittings from the cemetery in Obid should be mentioned (Tirpák and Tirpaková 2019, 333), along with ten appliques from the cemetery in Valaliky-Všechsvätých (tin – 4.10-20.55%, lead – 0.38-62.13%), and 34 fittings from the hoard discovered in Dolné Orešany (tin – 2.07-54.38%, lead – 6.49-24.20%; Pieta and Ruttkay 2017, 543-545). From among the Avar finds from Polish lands, only the belt fitting from Czermno has been subjected to laboratory analysis. It was cast from bronze, with the share of tin reaching 16% (Wołoszyn *et al.* 2016, 707).

Only a few analyses indicate brass as the raw material of fittings dated to the period in question. Primarily, this concerns the appliqué from Grębocice with a 10% zinc content, although the artefact does not have close analogies in Late Avar materials, and researchers associate it with Great Moravian influences (Jaworski *et al.* 2012, 34). However, the zinc level does not usually exceed 2% in the alloy; hence, it can be interpreted as contamination derived from ores or a component of repeatedly remelted scrap metal, the content of which was unknown to the caster.

On the other hand, levels of silver increased by about 1% among the majority of analysed objects, most probably evidence the use of inaccurately refined lead ores. This corresponds with the opinion of Falko Daim (1987, 168), according to which Avar artisans prepared small portions of the alloy, which explains the significant variation in the chemical composition. It can also be added that the alloy with a high proportion of low-melting metals (melting point for Sn is 232°C, for Pb 327.5°C) allowed the lowering of the melt temperature and, above all, improvement of the casting properties.

Specific difficulties related to the interpretation of relatively high Sn/Pb contents should be stressed here. In the opinion of many researchers, such high values indicate the existence of a tin coating, which of course, is possible. It should be emphasized, however, that mixtures of two or more structural components (*e.g.*, Cu/Sn/Pb) usually characterize themselves by a disturbed external appearance, different colours, and heterogeneous internal structure, which is related to the long-term temperature range of the alloy solidification and gradual separation of phases. In turn, tin properties favour the formation of patina layers enriched with it during naturally occurring corrosion processes. A similar saturated surface layer may also be formed under favourable conditions during the metallurgical process (Meeks 1986, 133). Undoubtedly, the surface analysis is not sufficient to confirm the existence of such a coating without visible external traces, and examination of cracks, and flaking fragments. For this purpose, cuts on sections appear to be necessary, although such a method physically interferes with the object's structure.

Such a question deserves mentioning since the differentiation in surface measurements was also registered in the case of the fittings from Janowiec. Areas covered with grey

Fig. 7. Bars of raw material cleaned of patina at the measurement points with visible colour differentiation: CL20922 – multi-component alloy CuZnSnPb (a), CL20923 – tin-lead bronze alloy (b). Photo P. Gan

bloom (approx. 26% Sn), as well as zones with a clear yellow colour (approx. 16% Sn), are visible on the surface of fitting No. 2 (CL20284), while measurements from the additionally cleaned measuring point revealed over 20% Sn. A simple explanation for such a differentiation is the phenomenon of tin segregation occurring in the cast and non-homogeneous alloys. It should be assumed that after obtaining the cast, further processing was limited to surface retouching and rivet forging. The working of tin high-tin alloys is in principle only possible with the use of a "hot" method. A noticeable difference in the Sn/Pb proportions (tin-lead bronze versus lead-tin bronze) have been registered for bigger and smaller fittings. Apparently, in the case of larger and more complex objects, the craftsman added a more significant portion of low-melting raw material to better fit the mould than in smaller applications. In the case of the latter ones, he could also replace the less-available tin with relatively cheap and readily available lead.

The analyses of two raw material bars also produced interesting results. One of them (No. 8) was made of a yellow-coloured multicomponent alloy (Cu-Zn-Sn-Pb), while the other one (No. 9) was identified as tin-lead bronze, similar to the analysed fittings. Bars could be a standard form of raw material contained in a crucible, and the colour differences facilitated obtaining a specific alloy recipe (Fig. 7). The chemical composition of the pouring channel of a mould (No. 10) can be determined as tin-lead bronze, corresponding to the analysed fittings. The chemical composition of the molten metal lump (No. 11) also correlates with other appliqués. Therefore, the lump in question can be considered a fragment of another fitting.

Two fragments of bracelets derive from products made of low-quality silver. Both alloys were contained over 40% copper, which undoubtedly influenced the weight and external appearance, with many surface pits. The significant addition of copper significantly reduced the gloss, increased the hardness of the silver that hindered striking decorative patterns, and made it difficult to melt. It remains unclear whether this was the result of the artisan's decision, or an effect of his inability, or desire, to spare the raw material. The possibilities of a comparative analysis of the chemical composition of bracelets from Janowiec and similar artefacts are limited. A series of laboratory tests performed for silver bracelets from the stronghold in Haćki should be mentioned here at first. It is noteworthy that they revealed a similar copper-silver chemical composition of raw material (*cf.* unpublished analyses from the archives of the Laboratory of Bio-and Archaeometry of the Institute of Archaeology and Ethnology Polish Academy of Sciences, order No. 568/89).

5. CONCLUSIONS

The results of typological analyses and laboratory tests allow for, at least preliminary, hypotheses on the origin of the finds, the circumstances, and the reasons for which they found themselves in the middle Vistula River basin. Metal elements of an Avar beltset form the most numerous group in the discussed collection of finds. They can be relatively reliably dated to between the mid-8th and early 9th century, and have numerous and well-documented analogies, both from the territories of the Kaganate and the lands under its political and cultural influence..

In the areas of today Poland, Late Avar belt fittings are still rare, although we should point to a gradual increase of such a group of finds. As a rule, we are dealing with single items; the exceptions include series of two (Pełczyska, Pińczów district and Swaryczów, Zamość district), three (Naszacowice) or four (Gródek upon the Bug River) items (*cf.* Poleski 2013a, 342-344; 2013b, 218 ff). Thus, Site 3 in Janowiec has produced the largest collection of metal elements of the Avar beltset from Polish lands. It is noteworthy that after submitting this text for publication, three more applications, similar to the fittings 4 and 5 discussed here, were discovered during the surveys at Site 3 in Janowiec in 2022.

Distribution analysis indicates three distinct clusters of such finds in Polish lands: in the upper Odra River at the mouth of the Moravian Gate, in western Lesser Poland (vicinity of Kraków), and the area between the upper Bug and middle Vistula (Fig. 8). Apparently, the finds from Janowiec appear to be related to the last two groups, and the element connecting them is the course of the Vistula River. Researchers discuss various interpretations of the influx of Late Avar finds to the area north of the Carpathians. Both direct military and commercial contacts with the Avars are taken into account, as well as the long-range exchange organized by the Slavic elites formed in the 8th-9th centuries in Moravia and the Czech Basin, intermediating in contacts with the Kaganate. It cannot be ruled out that the Late Avar bronzes appeared there as "spoils of war" gained by the Slavs after the fall of Avar rule – either as personal loot or as an object of trade (see *e.g.*, Poleski 2013a, 344, 345, further literature there). It is also difficult to assess the role played by the Late Avar belt fittings in the Slavic communities inhabiting the lands north of the Carpathians. Undoubtedly, their influx was associated with the formation of "tribal" elites. However, how they adapted the elements of the Avar costume is debatable.

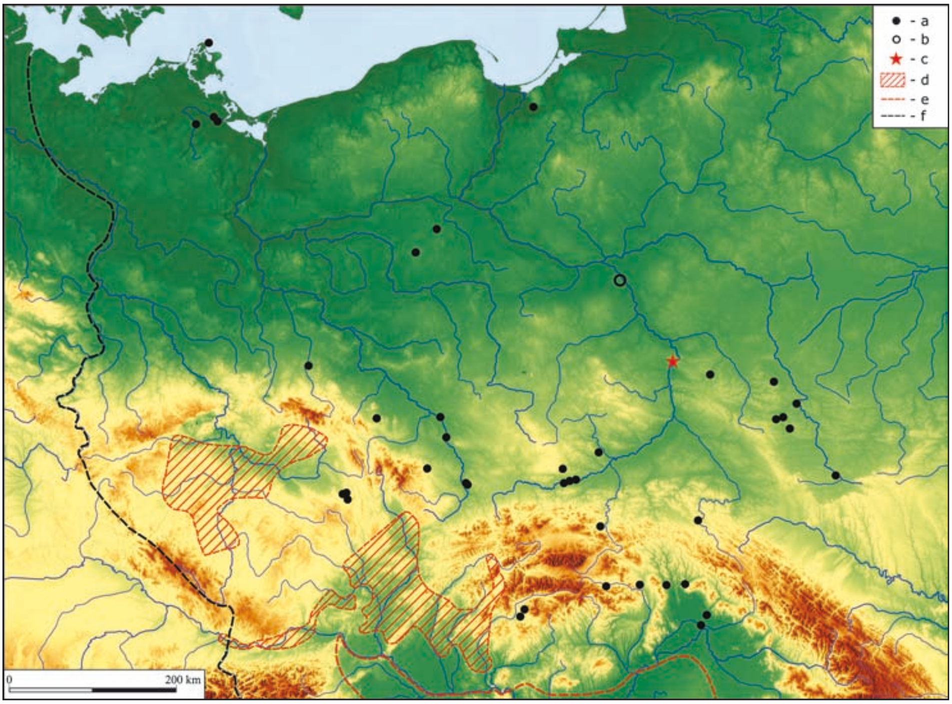

Fig. 8. Finds of artefacts linked with the culture of the Late Avar Khaganate in Western Slavic territories located to the north of the Khaganate. Legend: a – Late Avar finds; b – find with uncertain localization; c – Janowiec; d – areas of high concentration of the Late Avar metalwork outside the territory of the Khaganate; e – reach of the Late Avar bi-ritual burial grounds (territory of the Khaganate); f – eastern border of the Carolingian Empire administration *ca.* 803–828.
After: Poleski 2013a, Robak 2018; prepared by G. Kuś (base: https://maps-for-free.com/)

Given that the vast majority of finds comprise single items, it cannot be ruled out that single Avar fittings played the role of personal decorations, perhaps not necessarily placed on the belt. It cannot also be ruled out that they were primarily a source of raw material and were imported for this purpose (*cf.*, *e.g.*, Szymański 1962b, 309-311; Profantová 1992, 621 ff; Poleski 2003, 217 ff; Robak 2018, 56-63, further literature there). It should be thus highlighted that four fittings from Site 3 are in all likelihood elements of a single beltset. Furthermore, the relatively good condition of the rivets may indicate that not only the fittings were brought to Janowiec, but entire belts or their large fragments.

The chronology and provenance of the bracelets with trumpet-like endings are more challenging to establish. The stylistic and technological analyses indicate their relationship with Early Slavic material culture, although with the apparent influence of the Avar style. Following the current state of research, their chronology can be generally referred to as the 7th and 8th centuries. Finds from the upper Bug River basin, such as the hoard from

Machnów Stary or items from the stronghold in Zimnye, Volodymyr-Volynskyi district, suggest that bracelets discussed here can be considered as imports from this region. Bracelets from Moravia, including the hoard from Poštorna, may indicate an alternative direction. Eventually, it cannot be ruled out that the bracelets were manufactured in Polish lands for the needs of local elites. Given the current state of research, it can only be stated that their form and decoration are consistent with a broader stylistic trend, combining ancient, early Slavic, and nomadic traditions, covering a vast territory from Middle Dnipro through the Carpathian Basin and the lands on the central Danube, up to the Vistula and Oder basins.

The context of discovery hinders an unequivocal answer whether the finds discussed here can be regarded as an assemblage or represent different chronological horizons. It cannot be ruled out that the bracelets arrived in Janowiec earlier than the strap fittings, perhaps even in the 7th century, while the appliqués could not have been be brought there earlier than the last decades of the 8th century. Adopting a different time of influx of the discussed items, which – taking into account the local cultural context – can be considered as material indicators of the elites, would suggest a unique role of Site 3 in Janowiec in the social structures and settlement network of the central Vistula basin between the 7th and early 9th centuries. Regrettably, we lack other material traces that could support such a hypothesis. The vast majority of Early Medieval objects and finds from Site 3 represent a much later horizon, dating to the 11th-12th centuries. The excavations revealed only one feature containing a few fragments of hand-made pottery, which can be dated to the 7th-8th centuries according to a preliminary assessment. Another dozen or so potsherds dated generally to the older phases of the early Middle Ages, found in a secondary deposit, have been discovered during the excavations in the centre of Janowiec, about two km from Site 3 (Trzeciecki 2012). One might argue that such a humble picture is the result of the low level of investigation of the Early Medieval settlement in the area in question. It should be emphasized, however, that the entire territory on the left bank of the Vistula River, between Janowiec and Radom, has not provided finds documenting the existence of a settlement network older than the late 9th century (Cieślak-Kopyt *et al.* 1994; Auch *et al.* 2019, 104 ff). A totally different situation was recorded on the right bank of the Vistula in the immediate vicinity of Janowiec. The settlement in Puławy-Włostowice from the 7th-9th centuries, located only five km northeast of Janowiec, should be mentioned here (Lis 2018, 684-688). However, the settlement complex in the Chodelka River basin, the origins of which may even date back to the 6th century, deserves much more attention. The centre of this microregion was the stronghold in Chodlik, erected probably in the late 8th century, one of the oldest and most prominent sites of this type in Lesser Poland. Excavations, conducted for over half a century, have provided considerable material evidence of far-reaching contacts, although so far, no objects of Late Avar provenance have been found there (Hoczyk-Siwkowa 2004, 64-65; Miechowicz 2018, 27 ff, further literature there). We can thus assume that slight traces of settlement in Janowiec should be associated with the Chodlik settlement complex.

The hypothesis on the relationships between the finds and alleged potential "tribal" period elite seat in the Janowiec area appears, therefore, barely plausible. It is important to highlight that the present research stage hinders even initial interpretations of the circumstances in which the discussed artefacts found their way to Site 3 in Janowiec. Metallographic analyses also contribute little here. Noteworthy, the place of finding can, however, provide some indirect evidence. Site 3 is located near the crossing over the Vistula, opposite the mouth of the Chodelka River, the natural axis of the aforementioned Chodlik settlement complex. It thus appears probable that the items discussed here constitute a material trace of the flow of goods stimulated by the local "tribal" elites concentrated around the stronghold in Chodlik. The finds document intensification of supra-regional contacts, favoured by the collapse of the Kaganate and the overwhelming impact of Avar cultural patterns. Simultaneously, they indicate the importance of the upper and middle Vistula as a natural communication axis connecting the "tribal" centres of power in the Kraków land and the north-eastern Lesser Poland.

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Anna Tyniec[1]

THE EARLY MEDIEVAL POTTERY WITH ADMIXTURE OF CALCIUM CARBONATE IN THE CERAMIC FABRIC (SAMPLES FROM HILLFORTS IN THE NIDA BASIN)

ABSTRACT

Tyniec A. 2022. The early medieval pottery with admixture of calcium carbonate in the ceramic fabric (samples from hillforts in the Nida Basin). *Sprawozdania Archeologiczne* 74/2, 317-336.

Among vessels used in the Early Medieval Ages in the area of western Lesser Poland, special attention should be paid to specimens made of ceramic fabric with a tempering agent composed of minerals containing calcium carbonate. Such vessels are usually labelled as Kraków "white" pottery. The "white" pottery from the area of the Nida Basin may be characterized on the basis of vessels made of clay with calcium carbonate admixture discovered in archaeological features. The most numerous materials derive from hillforts in Stradów and Szczaworyż. This pottery could have been some kind of a tribal emblem. For more than 200 years it was dominating among vessels in western Lesser Poland. The group producing vessels made of calcium carbonate fabrics may be the Vistulans mentioned in written sources.

Keywords: Early Medieval Ages, Lesser Poland, pottery, ceramic fabric with calcium carbonate, Kraków "white" pottery, hillforts in the Nida Basin

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INTRODUCTION

Among vessels used in the Early Medieval Ages in the area of western Lesser Poland, special attention should be paid to specimens made of ceramic fabric with a tempering agent composed of minerals containing calcium carbonate. Such vessels are usually labelled by archaeologists as Kraków "white" pottery. This name, deriving from the territorial scope of the first discoveries, was adopted in the archaeological literature but in fact it does not reflect the essence and specific characteristics of these early Medieval pottery materials (made of ceramic fabric tempered with crushed stones containing calcium carbonate). Vessels made of such ceramic fabric rarely have surfaces and fractures of "white" colour (typical of pottery made of kaolinite clays, in the Kraków region occurring often in the Late Medieval Ages – see below). The term "white" suggests as well that it is identical with the early medieval pottery made of white clay known from the areas of Sandomierz or the Opatów region (*cf.* Buko 2005, *passim;* older literature there). The definition "white" in the case of this recipe requires writing it consistently in quotation marks. Also the second part of the name "Kraków" is not fully adequate because the usage of carbonate admixture to ceramic fabric is noticeable in vessels discovered also at sites situated about 150-200

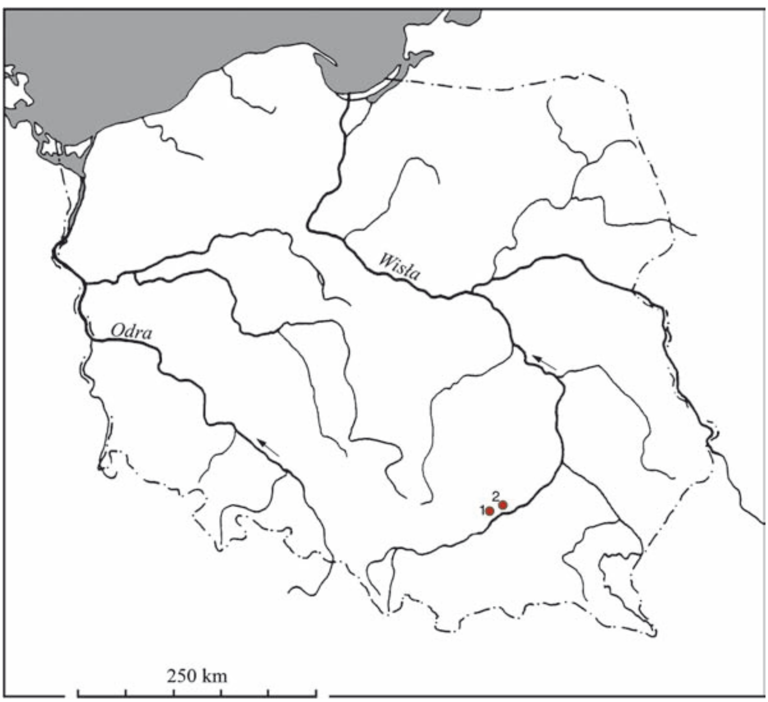

Fig. 1. Location of hillforts: 1 – Stradów, Kazimierza County, Świętokrzyskie Voivodeship, 2 – Szczaworyż, Busko County, Świętokrzyskie Voivodeship (drawing by B. S. Szmoniewski)

kilometres from Kraków (not only single potsherds – see below). The most completely analysed assemblages of vessels of this type of ceramics are materials registered in Kraków (Radwański 1968), Nowa Huta region of Kraków (Kubica-Kabacińska 2000; 2001) and in Mionów in Silesia (Parczewski 1977). Noteworthy are as well vessels made of this type of ceramic fabric deriving from the area of the Nida Basin – mainly from hillforts in Stradów and Szczaworyż (the author of this article obtained Professor Elżbieta Dąbrowska's written permission for use of unpublished materials from Szczaworyż) (Fig. 1).

OUTLINE OF THE STATE OF RESEARCH ON THE SO-CALLED "WHITE" POTTERY

The first complete definition of the "white" pottery was proposed by Elżbieta Dąbrowska (1963, 57, 58). The basic characteristics of these vessels as well as their dating frameworks defined by Dąbrowska have been so far only slightly modified. They were supplemented with physic-chemical data (Dereń *et al.* 1968; Radwański 1968, 14-16; Tyniec-Kępińska *et al.* 1996; Szmoniewski *et al.* 2006), chronological information (Radwański 1968, 24-31) and discussions on local concentrations of pottery registered beyond Lesser Poland (Parczewski 1977; Szuwarowski 1994), but in principle the definition has been so far positively verified. There is no doubt that the dissertation written by Kazimierz Radwański (1968) also remains the publication of fundamental significance for the majority of aspects of this pottery.

The "white" pottery was made of plastic, shale fabric (depending on its origin with various mineral admixtures), tempered with calcium carbonate or sometimes sand or mineral crushed stone. On the account of specific chemical processes occurring in this type of ceramic fabric under the influence of temperature, firing of vessels was taking place at a temperature below 900°C (at a higher temperature the carbonate compound is decomposed and the earthenware loses its functional qualities). The colour of the surfaces of vessels is diversified – from creamy, brown to grey – sometimes even at the surface of the same vessel – this may result from the course of post-depositional processes – mainly from the character of a deposit (Fig. 2).

The detailed studies on pottery have a great significance for issues connected with settlement – mainly for its dating. While it is true that the seminal publication of K. Radwański of early medieval Kraków pottery (1968) remains a fundamental basis for study of this material, the increase in number of materials and new methods used for research into pottery encourage taking up the matter again. Not surprisingly, this issue has been present among research postulates for many years (*e.g.*, Poleski 2004, 298) and it is the basis for interdisciplinary analyses, mainly in the field of "white" pottery (Dereń *et al.* 1968; Tyniec-Kępińska *et al.* 1996; Kubica-Kabacińska 2000; 2001; Pawlikowski 2000; 2001; Auch 2005; Szmoniewski *et al.* 2006). Alongside the such phenomena as the construction of

Fig. 2. Szczaworyż Busko County, Świętokrzyskie Voivodeship. The diversified colour of vessels surfaces (photo by B. Pilarski)

great strongholds of the tribal period or the practice of building huge barrow-graves, the specific recipe for this type of ceramic fabric for vessels, remains one of the distinguishing features of the material culture of early medieval western Lesser Poland (Radwański and Tyniec 2010). Use of clays with admixture of calcium carbonate resulted mainly from accessibility of raw material deposits. Despite the fact that this raw material caused numerous technological problems (for example this fabric required taking extra care during firing clay pots), such type of pottery in a short time became dominant (at sites in the area of contemporary Kraków) or constituted a very significant percentage share among pottery production of pre-craft character (for example in Kraków Nowa Huta-Mogiła, Kraków Kurdwanów or in hillforts in Stradów or Szczaworyż).

Did the idea of its production originate in this area or was it a result of some external impulse? Perhaps in the Early Medieval Ages, pottery production in the Kraków region was the inspiration to produce pottery including calcium carbonate for other areas? The answer for such question may contribute to our knowledge of the external contacts of early medieval Kraków. One of the possibilities is the assumption that it was the attempt to obtain ceramic fabric with parameters similar to products made of white kaolinite clays (*cf.* Buko 2005 or Hadamik 2005). In such a case, technological problems should stop fabric production of vessels with admixture of calcium carbonate as this had most probably happened in western Lesser Poland where traces of specific recipes for pottery were registered. In regions devoid of deposits of kaolinite clays or local outcrops of carbonate raw materials, different recipes are noticeable, possibly the effects of a search for a qualitatively similar ceramic fabric. There are vessels made of poorly noticeable temper, creamy in colour, fragile with soft surfaces – their fragments were discovered in features (nos 10, 23, 24, 33 and 57) of the early medieval settlement at Site 20 in Brzezie, Kłaj community on the right of the Vistula River (Tyniec 2013 – this pottery at first glance is similar to “white” Kraków pottery with admixture of dusty calcium carbonate in ceramic fabric). Fragments of such vessels were discovered as well on the eastern peripheries of neighboring Site no. 37 (Tyniec 2012b). It is possible that vessels with admixture of dusty sand in the ceramic fabric discovered at the stronghold in Zawada near Tarnów also represent an attempt to obtain visibly similar pottery.

At this point, we should mention E.N. Simonowa’s opinion on the issue of the early medieval white kaolinite pottery, *i.e.* technologically advanced, thick-walled vessels registered in the area of Poland, Moravia, Czech Republic, Slovakia, Hungary, northern Bulgaria, Romania and Crimea. The researcher links this pottery with Byzantine impulse reflected in ethnically different milieus. Simonowa considers the Kraków “white” pottery made of ceramic fabric with calcium carbonate as identical with pottery production made of kaolinite clays from areas mentioned above (Simonova 1996, 139; 2008, 39-45). The equality, however, should be made only as regards production of vessels in perfect white color.

Dobruja in Romania has a special place on the map of distribution of pottery generally known as white – this is the area where both types of vessels made of pottery fabric with calcium carbonate admixture and with kaolinite clays have been registered (Szmoniewski and Voinea 2021, 119; Szmoniewski and Voinea 2020; Cursaru-Herlea 2016, 75-76). A special category there is white pottery made of kaolinite clays with red and brown-painted surfaces (Diaconu 1973, 209, 21; Stănică 2015, 219-222; Cursaru-Herlea 2016, 143-145).

It is a question that may be asked of this material whether for the inhabitants of western Lesser Poland (Vistulans) and their neighbours deriving from other cultures, these sets of forms, ornamentation program or technology of pottery production were the evident distinguishing features of the group. Such a situation was registered in case of the Pannonian Avars inhabiting the Carpathian Basin and their yellow pottery (Vida 1999; 2015) dated to the 8th-10th century that is the indicator of Avar burials (Bognar 2016). These vessels are thought to have their prototypes in vessels from Bulgarian Pliska (Henning 2007, Taf. 4, 5) or polished Carolingian pottery (Bognar 2016, 27). There is no doubt that yellow pottery is connected with the Avars.

In this respect, the set of vessels, technology of production and ornamentation would constitute a peculiar medium of ideas/culture and constitute a tribal determinant. Did in case of Vistulans the pottery with calcium carbonate in ceramic fabric (or other experimental recipes mentioned above) play the role of the emblem? Vessel type ceramics on the account of their impermanence offer the opportunity for frequent changes. The attachment to a tradition of making of pots from material creating problems or requiring special attention at the stage of production (mainly firing) noticeable in western Lesser Poland, proves the creation and cultivating there of a specific style and a consciousness of its integrating meaning inside the group. Outside, it confirms membership to this group (*cf.*

Niewęgłowski 1992, 289, 292-294; earlier literature in the volume). In this case, the group making vessels with admixture of calcium carbonate may be the Vistulans mentioned in written sources.

The chronology of the Kraków "white" pottery was designated by E. Dąbrowska as the period from the 8th to 11thcentury with the possibility of its appearance in small quantities even up to 13th century (Dąbrowska 1963, 58). K. Radwański dated this type of pottery based on stratigraphy analyses and coexistence in assemblages (1968, 24-31). The source material deriving from the research from Kraków before and after its chartering ensured his publication a permanent place in discussion on the early medieval pottery production and its chronology. Radwański located the period of domination of the Kraków "white" pottery between the 8th and 12th centuries and its mass appearance in Kraków assemblages since the half of the 9th century. A similar situation is seen nearby in assemblages from Nowa Huta-Mogiła where the appearance of the "white" pottery is dated to the turn of the 7th and 8th century on the base of findings of hooked spurs with hooks bent inwards (Radwański 1968, juxtaposition at p.27, subsequent literature in the volume). Despite serious concerns over the correctness of dating of these artefacts (*cf.* Poleski 1992, 24 and footnote 7; 1993-1994, 238, 239; further literature in the volume), Radwański's findings are not contested. At the turn of the 10th and 11th centuries and at the beginning of the 11th century, a significant drop in quantity of the "white" pottery occurred in assemblages from Kraków region. Single fragments still appeared in materials from mixed and backfill layers up to the beginning of the 13th century (which could be the result of post-depositional processes). Kazimierz Radwański considered as well that introduction on a massive scale of the "white" ceramic fabric was connected with technological improvements (including: coil-building with clay strips [*technika ślizgowo-taśmowa*]) and changes in organization of pottery production (Radwański 1968, 30). This led to the increased frequency in the pottery assemblages in early medieval Kraków of, pottery vessels made of clay marls with admixture of calcium carbonate ($CaCO_3$) so-called white pottery and made of ferruginous clays with an admixture of alluvial sand (group VI). Generally speaking, without details concerning chronology, changes in technology and typology, it should be stated that white pottery prevails (up to 90% of all findings of pottery) in undisturbed or weakly disturbed structures constructed before the 11th century. Pottery from group VI constitutes sometimes even 100% of finds in later assemblages dated from the 11th to the middle of the 13th century (Radwański 1968). The research confirms that in areas where white pottery was discovered, traces of settlement dated before the 11th century are noticeable. Radiocarbon dating for part of the Wawel Castle fortifications confirm the correctness of this chronological position (Kukliński 1995, 247, 251; 2005 *passim*; 2017; Firlet 2003 *passim*). It should be taken that the period of actual use of the "white" pottery ends in the first decades of the 11th century and finds deriving from younger layers are the accidental components.

It seems that the centre of production of pottery with ceramic fabric with admixture of calcium carbonate was situated in Lesser Poland in the Kraków region (*cf*. Dąbrowska 1963, 58; Radwański 1968, 37). Its percentage share in early medieval material was low in areas located further from this region but also its local centres of production for local purposes are noticeable also there. A particular place in this group has pottery production in the Nida Basin in hillforts in Stradów (*cf*. Maj 1990, group I) and Szczaworyż (Dąbrowska 1965; 1973).

CARBONATE POTTERY FROM STRADÓW AND SZCZAWORYŻ

The "white" pottery from the area of the Nida Basin may be characterized on the basis of vessels made of clay with calcium carbonate admixture discovered in archaeological features. The most numerous materials derive from hillforts in Stradów and Szczaworyż (Fig. 1). Also at the settlement site in Szarbia, one such vessel was registered (*cf*. Baczyńska and Maj 1982, 175, fig. 8a). The remaining fragments of "white" pottery were registered in layers or as stray finds at archaeological sites. It should be mentioned that the "white" pottery find at the hillfort in Szczaworyż has provided only a limited set of data deriving from macroscopic observation. This is the result of the specific state of preservation of this material. The surfaces of vessels discovered there – made of clay with admixture of calcium carbonate – are worn or have distinct grooves (Fig. 3). These changes result from the character of soil in the Szczaworyż area (Szwarczewski 2006) – the high acidity causes damage to the surfaces of this kind of pottery.

Pottery with calcium carbonate admixture was discovered at the site in Stradów in 87 settlement features. Its percentage share in pottery materials was as follows (calculations based on Maj 1990, Tables):

– 0-25% in Features: 103 – 5%; 26 – 9%; 11 – 17%; 106 – 18%; 90 – 20%; 57 – 22%; 32/B – 23%; 7, 9/B – 24%; 10a, 3/M – 25%;

– 26-50% in Features: 49 – 29%; 20, 29, 46, 63, 65, 112, 6/B, 7/B, 33/B – 33%; 25 – 34%; 17, 44a, 56 – 36%; 45, 55, F/W – 38%; 61, 79 – 40%; 14/B, 4/M – 42%; 18, 5/B, 17/B – 43%; 1/B, 2/M – 44%; 111 – 45%; 1002/B – 46%; 21 – 47%; 33 – 48%; 3,4 – 49%; 16, 27, 50,78, 81, 93a, 98, 4/W , 4/B, 16/B, 30/B, 39/B, 1/M – 50%;

– 51-75% in Features: 52 – 52%; 41 – 53%; 73 – 56%; 62, 20/B- 60%; 88, 12/B, 38/B – 63%; 25/B – 64%; 44, 101, 11/B, 13/B – 67%; 14 – 69%; 8/B – 70%; 24 – 75%;

– more than 76% in Features: 2 – 78%; 77 – 86%; 20a, 35, 44c, 59, 63a, 66, 71a, 77a, 97, 129, 1b/W, 23/B, 35/B – 100%.

From a comparison of these data and the dating of the features in Stradów based on typological determinations for pottery materials and stratigraphic relations (Maj 1990, table II), we may conclude that pottery made of ceramic fabrics with carbonate admixture

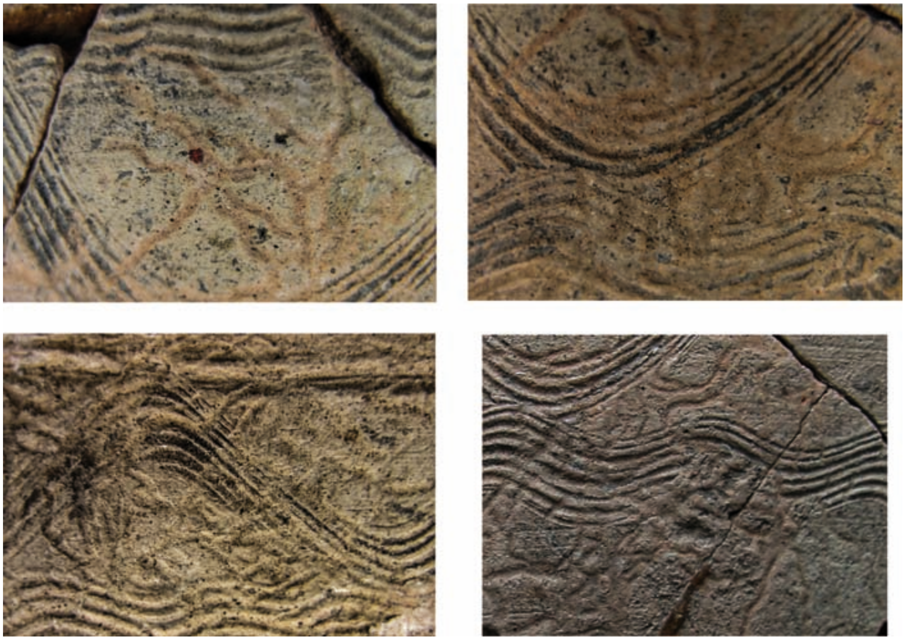

Fig. 3. Szczaworyż, Busko County, Świętokrzyskie Voivodeship. Damage to surfaces of pottery (photos by B. Pilarski)

is a constant component in the set of vessels in use at this site. Features comprising low (and high) percentage of pottery with calcium carbonate are dated to phase II and phase III of Stradów pottery. Phase II is dated from the second half of the 9th up to the middle of the 10th century (Szmoniewski and Tyniec 2010, 13), and Phase III – about the middle of the 10th up to the middle of the 11th century (Maj and Zoll-Adamikowa 1992; Tyniec-Kępińska 1996; 2007, 103-105).

In the set of pottery deriving from 12 features at the site in Szczaworyż the percentage of vessels made of ceramic fabric with calcium carbonate is lower than at Stradów. It may be presented as follows (calculations based on author's research):

– 0-25% in Features: 13 – 3%; 10 – 4%; 3 – 5%; 6, 22 – 6%; 9 – 7%; 1 – 9%; 20 – 11%; 15 – 12%; 5 – 14%; 16 – 22%;

– 26-50% in Features: 14 – 26%.

This lower rate of "white" pottery at the hillfort in Stradów does not result from its state of preservation because even among destroyed potsherds it is still possible to distinguish fragments made of this material (Fig. 3). It therefore does not seem that the relative paucity of this material at this site can be explained by environmental factors (acidity of soils). At the site in Szczaworyż, pottery of fabric with calcium carbonate did not play a major part in the assemblage of vessels in use at the site.

POTTERY WITH ADMIXTURE OF CRUSHED *INOCERAMUS* SHELLS

The specific variant of „white" pottery are vessels made of clay including admixture of crushed *Inoceramus* shells – the extinct genus of fossil marine pteriomorphian bivalves dated to the Jurassic and Cretaceous periods (Fig. 4). In Stradów pottery this admixture was identified by U. Maj (1990, 15). She described this type of ceramic fabric as her II variant. Distinction of vessels made of clay with admixture of crushed fragments of shells is no doubt reasonable.

It is still an open question whether the admixture of crushed *Inoceramus* shells is the potential source of calcium carbonate in "white" pottery as it was suggested in a footnote (*op. cit.*, footnote 12). The lack of published information on observations of such remains in assemblages of "white" pottery deriving from other regions and their presence in the ceramic fabric at two sites from the Nida Basin (Stradów and Szczaworyż) may testify the local character of this phenomenon. It turns out that crushed *Inoceramus* shells in ceramic fabric are also present in pottery from Kraków (for example inventory reports on

Fig. 4. Proszowice, Proszowice County, Lesser Poland Voivodeship. Pottery with admixture of crushed *Inoceramus* shells (photo by A. Tyniec)

Table 1. Szczaworyż. Fragments of pots with an admixture of Inoceramus shells in the ceramic fabric

<table>
<tr><th colspan="7">SZCZAWORYŻ</th></tr>
<tr><th>feature no.</th><th>Inv. No.</th><th>Edge</th><th>Ornament</th><th>Rolling area</th><th>Smudging</th><th>Percentage pots with carbonate admixture in the facility</th></tr>
<tr><td rowspan="5">9</td><td>200/63</td><td></td><td>e_5</td><td>2-4</td><td>-</td><td rowspan="5">7%</td></tr>
<tr><td>201 /63</td><td>J_1</td><td>f_3</td><td>2</td><td>-</td></tr>
<tr><td></td><td></td><td>a_2</td><td>?</td><td>?</td></tr>
<tr><td>203/63</td><td></td><td>B</td><td>-</td><td>+</td></tr>
<tr><td>211/63</td><td>H_1</td><td>-</td><td>2</td><td>-</td></tr>
<tr><td rowspan="2">13</td><td>9/65</td><td></td><td>b_3</td><td>-</td><td>+</td><td rowspan="2">3%</td></tr>
<tr><td>12/65
2 fragm.</td><td></td><td>?</td><td>?</td><td>?</td></tr>
<tr><td rowspan="2">20</td><td>41/66</td><td></td><td>-</td><td>-</td><td>+</td><td rowspan="2">11%</td></tr>
<tr><td>52/66
5 fragm.</td><td></td><td>-</td><td>4</td><td>-</td></tr>
</table>

materials deriving from trenches in the Dominican or Franciscan monasteries, gardens of the Archaeological Museum in Kraków or from Kraków-Kurdwanów) and for example in Zofipole or Proszowice. This admixture is rather the effect of its presence in deposit just like fragments of snail shells in vessels from Slovakia and northern Hungary (Fusek 1994, 16).

Tables 1 and 2 presented below contain basic information regarding known fragments of pottery with crushed *Inoceramus* shells in the ceramic fabric.

In Stradów, the rims of vessels with admixture of crushed *Inoceramus* shells in the ceramic fabric are qualified as of type D (according to the typology of U. Maj 1990, supplemented by the author of the article); the remaining rims are qualified as of types G, J, B and F. The majority of vessels was slipped in the upper parts of the belly and on the neck. The remaining rims were examples characterized by more elaborate working. The ornamentation of these vessels is the equivalent of a trend observed in the whole collection of the "white" pottery. It is noteworthy that all the vessels with admixture of crushed shells were discovered in features linked by U. Maj (1990, table II) to phase III of technological development of Stradów pottery (except for Feature 7 – phase II and Features 79 and 16/B – phase II or III).

The rarity of potsherds with admixture of crushed *Inoceramus* shells at the hillfort in Szczaworyż is indicative of the transfer of items rather than of some manufacturing idea. Regardless of both mentioned possibilities, this type of pottery proves the existence of some undetermined but direct contacts between the inhabitants of hillforts in Szczaworyż and Stradów.

Table 2. Stradów. Fragments of pots with an admixture of Inoceramus shells in the ceramic fabric

STRADÓW 1						
Feature no.	Pot no.	Edge	Ornament	Rolling area	Smudging	Percentage pots with carbonate admixture in the facility
2	11		g_{1-4}	3	-	45%
3	12		c_{3-6}	-	+	39%
4	13	D_2	e_6	4	-	49%
	18	D_2	E	3	-	
	23	G_4	-	2	-	
7	7	D_5	-	2	-	24%
14	15		$b_{3?}$	3	-	69%
17	6		i_6	4	-	36%
41	40		-	6	+	53%
44	19	D_6	-	3		67%
	39		-	?	?	
45	17	D_4	-	2	-	35%
61	2	F_2	e_5	3	-	40%
62	6	D_6	-	2	-	60%
	7	D_5	-	2	-	
	11		E	?	?	
73	3		c_3	3	+	56%
77	3	J_8	E	3	-	86%
	5		-	-	?	
	6		-	5	+	
	7		H	3	-	
79	4		E	5	+	40%
81	24		-	5	+	50%
88	8	G_1	e_6	3	-	63%
4/W	2		-	5	+	50%
9/B	8	B_2	E	2	-	24%
16/B	2		-	-	+	50%
25/B	5	D_3	-	2	-	55%
	8		-	5	-	
38/B	3	J_3	-	3	-	63%
	7	D_7	-	2	-	
	8	G_4	e_1	3	-	
	13		c_{3-4}	3	-	
1002/B	2	D_5	g_1	4	-	45%

CALCIUM CARBONATE INCLUSIONS IN POTTERY FROM STRADÓW AND SZCZAWORYŻ IN THE LIGHT OF SPECIALIST ANALYSIS

Pottery with calcium carbonate admixture in the ceramic fabric at sites in Stradów and Szczaworyż was distinguished on the basis of macroscopic observations proved with use of hydrochloric acid causing noticeable effervescence on the surfaces of potsherds). Physico-chemical research was also conducted in the case of a few potsherds (fragments made of clay with calcium carbonate admixture as defined by U. Maj, 1990).

Analyses of six fragments of vessels deriving from Feature 32/B (Barzyńskie settlement) in Stradów were performed at the Lviv Polytechnic and Lviv National Academy of Arts (Tyniec-Kępińska *et al.* 1996), including two macroscopic analyses confirming usage of calcium carbonate to "white" pottery production.

X-ray and structure research were conducted with the use of a DRON X-ray diffractometer. Their result is a conclusion that even samples where macroscopic observations do not indicate any presence of calcium compounds, there were trace amounts deriving from feldspars. The analysis of microstructures confirms that firing of vessels had taken place in relatively low temperatures (below 850-900°C).

Potsherds deriving from vessels made of ceramic fabric with admixture of calcium carbonate discovered at the site in Stradów were subjected to multilateral analyses in laboratories of the AGH University of Science and Technology in Kraków in the scope of the grant of the State Committee for Scientific Research nr 2H01H02623 (agreement no. 1056/H01/2002/23) under the title: *"The early medieval settlement complex in Stradów – specialist analyses of findings from the years 1956-1963"* (Szmoniewski *et al.* 2006).

The research at the AGH University of Science and Technology in Kraków was conducted in the scope of project "The characterisation of textures and structures of samples of ceramics from Stradów" implemented by a team under the supervision of Prof. A. Kielski and Dr K. Wodnicka (Szmoniewski *et al.* 2006).

Twelve samples of vessels were subjected to tests – samples were assigned by U. Maj (1990) to fabrics made of variations of carbonate admixtures: PR. 1 (Id), PR. 2, PR. 7 (Ia) (fragments of two different vessels), PR. 3 (If), PR. 4 (Ie), PR. 5 (Ib), PR. 6 (Ig), PR. 8 (Ic), PR. 9 (Il), PR. 10, PR. 11 (Ik), PR. 12 (Ih). The basic goal of these tests was to determine the technological characteristics of samples aimed at identifying methods of their production (*cf.* Szmoniewski *et al.* 2006). The results are as follows: all examined samples are distinguished by relatively high total porosity about 30%, characteristic for sherds. This porosity in conjunction with usually high values of specific surface area proves that the vessels were fired at relatively low temperatures. In some samples this conclusion is confirmed as well by presence of illite that would have been degraded in higher temperatures.

Vessels were made of marl clays, which is testified by their phase composition shown in X-ray research. In the majority of samples, calcite is present next to quartz as the main phase, in several samples (nos. 1, 5, 6, 12) it is the main phase. Only in the case of a few samples (nos. 2, 4, 7, 8, 9) X-ray research did not reveal any presence of calcite. Accompanying phases are: microcline, albite and in single cases diopside and gehlenite. Such phase composition is fairly typical for aluminosilicate ceramic materials produced by firing marl clays. It is characterized by a high variability affecting the textural properties of examined vessels. Also, the helium density of examined samples is typical of aluminosilicate ceramics materials – it ranges between 2.6-2.7 g/cm^3. Assuming the lack of closed porosity on account of the low temperature of firing, density should be considered as equivalent to density of solid particles (specific gravity). Against this background, sample no. 8 stands out due to its elevated density plausibly as a result of organic admixture. The apparent density of the samples is considerably lower in comparison to their density due to significant porosity. The porosity is also characterized by the total amount of pores expressed in cm^3/g of material. The specific surface area is characterized by fluctuating numerical values which results from the presence of very small pores in the form of micropores and mesopores. The high values of the specific surface area prove the relatively low temperatures of firing vessels because these small pores disappear in the course of firing. Changeable numerical values are a consequence of changeable phase composition and presumably changeable conditions of firing of the vessels. It is worth noting that particularly high values of the specific surface area are usually connected with presence of illite. These samples, as it results from their macroscopic description, are characterized by increased fragility. The presence of illite may result from the low temperature of firing or process of rehydroxylation facilitated by low temperatures of firing.

Furthermore, some of the samples (ten, with three potsherds from Kurdwanów and one from Szczaworyż) were subjected to tests in the laboratory of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in Warsaw (Auch 2005). This research was aimed at getting information on the composition of the fabric of carbonate pottery. Samples were tested on the account of their absorbability, density of fabrics, non-elastic tempering admixtures and chemical composition of fabrics (the analyses were conducted with use of scanning microscope VEGA TS5135MM manufactured by Tescan company and optical spectrometer of X-ray fluorescence EDAX PV 9800).

Tests proved that samples from the Stradów vessels are of sufficient absorbance to enable their usual kitchen usage – in contrast to the fragments of vessels from Kraków-Kurdwanów (CL13436-13438 – Auch 2005, 89) where their permeability renders them unsuitable for any kitchen or table usage.

Analyses of the non-elastic tempering admixtures have shown that their macroscopic assessment sometimes is deceptive because the part of the analysed fragments did not in fact consist of fabrics with carbonate admixture (samples: CL 13427 kaolinite clay, CL 13428 ferruginous clay with a high amount of quartz pelite – *cf*. Auch 2005, 90).

The characterisation of pottery with calcium carbonate should be initiated with determination of macroscopic composition of ceramic fabrics. Often, mainly in materials from

Szczaworyż, the only admixture to clay is dusty calcium carbonate (for example: material from Features no.1 and 3) sometimes with noticeable uncrushed lumps of limestone (for example in Feature no.9 in Szczaworyż). A specific type of aggregate are fragmented shells of *Inoceramus* bivalve (see below). Potsherds made of such raw material usually are characterized by fine, dusty surfaces (see above: Sites 20 and 37 in Brzezie, Kłaj commune, to the right of the Vistula River – Tyniec 2012a, 65, 66; Tyniec 2012b, and the hillfort in Zawada near Tarnów – Okoński 1989, 128). A part of pottery with admixture of calcium carbonate has ceramic fabric with different kinds of crushed minerals (grains with a diameter up to 0.2 cm). The fabric of the "white" pottery from Stradów (as well as the vessels from Szarbia) also contain grains of sand (diameter up to 0.1 cm). The physic-chemical research shows that some vessels with different fabric than in case of "white" pottery also reveal the presence of carbonates in their composition. This results from the fact that they were produced with the use of feldspars. Similar "reflexes" may also result from the use or accidental addition of organic matter to the ceramic fabric. This type of pottery does not have any connection with the pottery defined as "white" (*cf*. Tyniec-Kępińska *et al*. 1996). Vessels made of ceramic fabric with admixture of calcium carbonate are absorbent which had impact on their functionality. Fragments of vessels were subjected to a simple test – they were soaked in water for 72 hours. Samples were weighed before and after soaking and then their weights were compared (*cf*. Auch 206, 87-89). The same test for kaolinite artefacts proved their better parameters.

Among fragments of "white" pottery from Stradów (518 artefacts), 239 rims of vessels were registered (this description of pottery is based on typology of rims and ornaments by U. Maj 1990). The vast majority of them are straight rims: 24% of type D (1-12, 16), 21% of type G (1-9), 16% of type F (1-9, 11, 13), 13% are of type J (1-10), 9% of type B (1-4), 4% of type A (1-4), type C (1-2) and type E (2-6, 8). The least numerous rims are of type M (expanded rims: 2-4, 6, 8, 10, 13) and type AB (1, 3). The best represented are variants: F_4 (15 artefacts), J_1 (13 artefacts), G_4 (12 artefacts), D_6 (10 artefacts), D_5 (8 artefacts), B_2 (8 artefacts), B_3 (8 artefacts).

In features in the hillfort of Szczaworyż, 178 potsherds with admixture of calcium carbonate were discovered, including 10 fragments of rims: 2 specimens of variant $F_{7,}$ G_4 and single fragments of variants AB_7, D_{14}, H_1, H_2, J_1 (according to classification of pottery for site in Stradów, Maj 1990).

Bases of vessels made with clay with calcium carbonate admixture are: flat (Szczaworyż, Features nos 1 and 13), with circumferential rings (for example: Stradów- Feature 11, vessel 4; Feature 18, vessel 14; Feature 24, vessel 7; Feature 26, vessel 28 *etc*. – *cf*. Maj 1990) or with impression of the axle of a wheel (Stradów, Feature 88, vessel 52; Feature 129, vessel 1 – *cf*. Maj 1990). There were also discovered bases with traces of sand (Stradów Feature 44, vessel 33 – *cf*. Maj 1990, 89, fig. 32: 33). Some bases are characterized by noticeable two layers (for example: Stradów, Feature 45, vessel 34 – *cf*. Maj 1990, 93, fig. 26: 34). Also bottoms with potter's marks were registered (for example Stradów, Feature 18, vessel 13; Feature 41, vessel 24 and 25 – *cf*. Maj 1990, 86, fig. 29: 24, 25).

The grade of slipping of the surfaces of vessels made of ceramic fabric with admixture of calcium carbonate should be investigated on the basis of the assemblage from Stradów. As it has been already mentioned, potsherds of "white" vessels are characterized by the very poor state of preservation resulting from conditions of the soil from which they were recovered. Traces of slipping in this material may be observed only on the basis of structuring of grains of the ceramic admixture. In the case of "white" pottery, it is not always possible on the grounds of macroscopic analyses (particularly in the absence of other admixtures). Damage to the surfaces make impossible determination of traces of slipping in the case of 38% fragments; a further 17% did not bear such traces. A significant part of the slipping on potsherds (26%) is linked with zone 4. The fragmentation of 12% of potsherds makes impossible precise identification from which part of the belly they came from. Generally these potsherds derive from vessels slipped in zones 2-4. A minimum percentage of potsherds (in total 5%) derive from vessels slipped in zones 2, 3 and 5.

The collection of so-called "white" pottery from Stradów is easier to identify and describe. Of the sherds of pottery made of ceramic fabric with calcium carbonate, 8% of the assemblage have destroyed surface, 10% have no traces of slipping. Of the remaining fragments of vessels: 35% have traces of slipping in zone 3, 17% fragments in zone 2, 17% fragments in zone 4, 9% in zone 5 and 4% in zone 6.

The ornamentation of vessels made of clay with admixture of calcium carbonate is diversified. The use of decorative motifs may be analysed on the basis of the pottery from Stradów. Just as in the case of determination of zones of slipping, the material from Szczaworyż may not be fully presented due to significant damage to the surfaces. There is no doubt that deepened ornamentation had a greater chance to be preserved than delicate surface traces of slipping, this is why this collection is interpreted as a random collection. In Stradów (according to the typology by U. Maj 1990), vessels were more often decorated with ornamentation included in her group e (38%), group b (18%) and group c (14%). Decoration of group g (9%), f (7%) and group a (5%) are less frequent. Decorative motifs of group h were determined in the case of 3% of the vessels, groups: k (3%), m (2%), d and l – less than 1%. In case of Szczaworyż, the percentage share of individual decorative elements is slightly different. Group e decisively outweighs the others (49%), with a high rate of groups a (20%) and b (12%). Decoration of the remaining groups: c (5%), g (5%), f (3%), k (3%), h (2%) were present only in the case of few vessels. Differences in selection of decorative motifs on vessels made of pottery fabric with calcium carbonate admixture result from tendencies noticeable at the described sites. Just as in the case of vessels made of other ceramic fabrics they are related to chronological transformations of ornamentation of vessels. It cannot be excluded that ornamentation was not only used to meet aesthetic expectations but it was also an element of a system of signs and performed some magical functions.

As discussed above, the temperature of firing (below 900° C) for potsherds with calcium carbonate admixture was confirmed in a laboratory and this proves the high proficiency of the producers of this "white" pottery in selection of means of production. The chosen temperature of firing guaranteed obtaining durable vessels with high performance characteristics.

CONCLUSIONS

The appearance of well-dated pottery with calcium carbonate at sites in the Nida Basin is a very beneficial phenomenon for chronologic considerations regarding the development of pottery production in this region. In regards to the limited number of better dated examples (so-called "selected" artefacts), mainly these found in archaeological features, until we obtain new (non-archaeological) dates for some sites, this type of pottery remains an indicator of determined chronological period and the reference point for technological and stylistic transformations of the pottery.

The potsherds subjected to analyses have provided much information. Despite application of different methods of research and testing devices, it turns out that their results are convergent and comparable – at least at a general level. Analyses of the vessels proved also that their producers had working knowledge of secrets of pottery production resulting in vessels with the highest performance characteristics.

The research permits drawing several conclusions and suggestions. Parameters connected with absorbability substantiate the statement that whilst vessels made of carbonate ceramic fabrics at sites in Kraków, Nowa Huta and Stradów were typical utility (serving or cooking) vessels, at site in Kraków Kurdwanów they were numerous but of little use (*cf*. Auch 2005, 89). So the question is what motivated their producers and users? It seems that their absorbability made these vessels functioned as prestigious goods, or were related in some way with tradition (sort of an "ancestral porcelain"). It is similar to the situation in Szczaworyż where acidic soil and water damaged the vessels but despite this, they were still produced and carefully decorated. It is noteworthy that their ornamentation is similar to vessels deriving from the cemetery in Nitra Lupka.

Analyses on non-elastic tempers indicate that their macroscopic assessment can sometimes be deceptive and the part of fragments originally assigned to this fabric did not in fact come from vessels made with carbonate admixture (*cf*. Tyniec-Kępińska *et al*. 1996; Auch 2005, 90).

In the course of analyses into the chemical composition of fabrics, it turned out that samples deriving from two vessels form Stradów (*cf*. Auch 2005, 91: CL 13433 and CL13434: no. 6 from feature 45 and no. 11 from feature 88) are similar to vessels known from Bulgaria (including some from Pliska – Henning 2000; 2007). Significantly, it includes younger (*sic*!) carbonate pottery form Stradów dated to phase III with vessels strongly wheel-formed and slipped with low absorbability. It is possible that the direction of diffusion of ideas could have been opposite to that indicated by M. Auch (2005, 93). In the 8th and 9th century this type of pottery was developing in western Lesser Poland and in the 10th century, the period of its prosperity, it was an inspiration to potters to the south of the Carpathian Mountains who so far had been using kaolinite clays (producing white and red-painted vessels)?

Finally, there is the matter of whether pottery calcium carbonate temper could have been some kind of a tribal emblem. It seems that it could. For more than 200 years, this product so sensitive to changes (see above), impermanent and challenging was dominant among vessels in western Lesser Poland. The attachment to tradition of production of vessels from such a challenging material requiring attention at each stage of production (mainly firing) testifies to the creation and maintenance of a specific style and consciousness of its integrating meaning inside a group. From the outside it indicates affiliation with the group. The group producing vessels made of calcium carbonate fabrics may be the Vistulans mentioned in written sources.

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THE SECOND HOARD FROM STRZELCE KRAJEŃSKIE (2014) – PRELIMINARY STUDIES AND METAL ANALYSES OF SELECTED COINS

ABSTRACT

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The second hoard from Strzelce Krajeńskie was discovered in 2014. The assemblage consists of at least 1948 coins. The article presents the interdisciplinary study of 109 of these coins. Apart from all Prague groschen, wittens, hellers and Jagiellonian pennies also 10 Brandenburg and 70 West Pomeranian pennies were loaned for this project by the museum where the assemblage is housed. Care was taken to select the most statistically representative sample possible. Twenty *Vinkenaugen* from the Szczecin mint were selected – as well as ten pennies minted in Gryfino, Koszalin, Słupsk, Stargard and Kołobrzeg. Additionally, 48 coins were subjected to a metallographic analysis – 18 Prague groschen of Wenceslas IV, two pennies of Vladislaus III, two Mecklenburg and three West Pomeranian wittens, four coins identified as Silesian hellers and 19 West Pomeranian pennies.

The results we obtained demonstrate the benefits of collaboration between numismatics and natural sciences. Interdisciplinary research conducted on part of the second hoard from Strzelce Krajeńskie reveals its research potential and value as an archaeological source for the study of monetary history.

Keywords: Strzelce Krajeńskie, hoard, Prague groschen, *Vinkenaugen*, metallographic analyses
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INTRODUCTION

In the history of Polish numismatics there have already been cases of two hoards discovered in the same location, a phenomenon which provokes questions of whether they may be parts of one hoard or two separate finds. Each time, this issue requires careful examination, as there are known cases of pairs of hoards with the same chronology and very similar composition, which are nevertheless clearly separate assemblages. The best-known case from Poland are the hoards from Środa Śląska (Środa Śląska District, Lower Silesia Province). Both hoards are very rich – each comprises over 3,500 coins and the second one also contains a royal crown, brooches and other jewellery. The two hoards have a similar chronology, the *terminus post quem* for the first one has been set at 1340 and for the second one at after 1350. Unfortunately, in spite of more than three decades from their discovery, they have not received a complete monographic publication, but only a large number of shorter or longer, widely scattered, references and a few book entries, which, however, cannot be considered critical source monographs and certainly do not exhaust the subject. The first hoard from Środa Śląska discovered in 1985, consisting solely of 3773 items, mainly Prague groschen of John the Blind (1310-1346) and six Meissen groschen of Frederick II (1323-1349). It has been mentioned in print at least several times, with its description also included in the inventory of medieval finds from the territory of Poland, but has never been properly analysed (Piniński 1990a, 63-65; Idem 1990b, 194-200; Kubiak 1998, 255, no. 760/I). The second Środa Śląska hoard was discovered in 1988. Apart from 3,963 coins (mainly the Prague groschen of John of Luxembourg, amounting to 3,824 specimens and 39 gold coins, among which Hungarian florins predominate) this assemblage also consists of opulent jewellery and a monarch's jewels. The second hoard from Środa Śląska aroused much greater interest among researchers and has been the subject of considerable literature (Kubiak 1998, 255-256, no. 760/(II); Pieńkowski 2002; Żerelik ed. 2006; Borowski and Błażejewski eds 2011; Witecki 2018).

The second similar case are the hoards from Mstów (Częstochowa District, Silesian Province), discovered in September 1961 and May 1963. While there was no supposition that the finds could be two parts of a single hoard, it should be noted that they were discovered relatively close to each other. Both hoards differ in the number of coins, composition and chronology. The first assemblage, discovered in 1961, consisted of more than 650 coins, mainly Jagiellonian pennies and half-groschen and quite a number of Prague groschen of Charles IV and Wenceslas IV. It had been deposited after 1434, and its *terminus post quem* is determined by the crown pennies of Vladislaus III (1434-1444). The second hoard, found in 1963, is a homogeneous find of 109 Prague groschen of John the Blind (1310-1346) and Charles IV. It was buried after 1370 and the youngest coin is a Prague groschen of the Charles VI type Pinta V.b, minted between 1370 and 1375 (Kazanowicz-Milejska and Milejski 2021, 142, 143). Both hoards have been described in detail in the inventory of medieval finds (Kubiak 1998, 190, no. 532/I; Kubiak 1998, 190, no. 532/II),

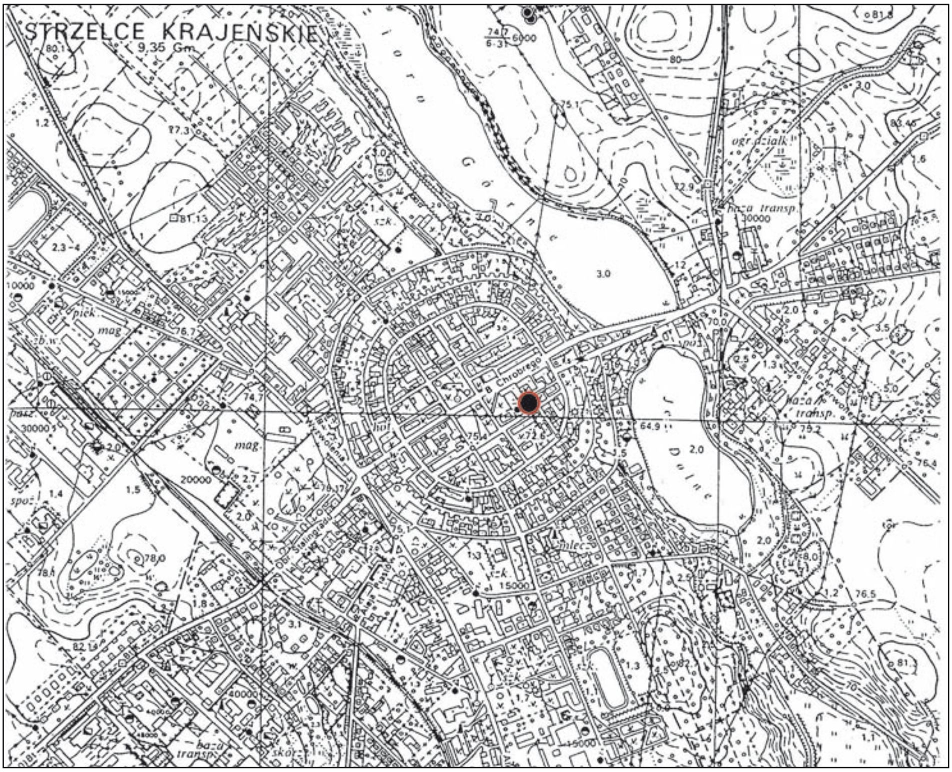

Fig. 1. A map of Strzelce Krajeńskie, the black dot with a red border marks the location of the 2014 hoard discovery (after Kaźmierczak 2016, 119, fig. 1)

and a detailed study of the homogeneous find of the Prague groschen has recently been printed (Kazanowicz-Milejska and Milejski 2021).

The last example of this phenomenon worth mentioning and which will be the main subject of this article, are the hoards from Strzelce Krajeńskie (district of Strzelce-Drezdenko, Lubusz Province).

The first hoard from Strzelce Krajeńskie was discovered in June 1977, within the town walls, in today's Katedralna Street (then Franciszka Jóźwiaka Street). It consisted of 2,783 coins, mainly small Pomeranian pennies (*Vinkenaugen*), two Jagiellonian pennies and eight Prague groschen of Wenceslas IV (Szczurek 2017, 51-94, 100, table 1). Polish numismatics had to wait almost 40 years for a complete study of this find, but the painstaking work of T. Szczurek, whose studies on the first Strzelce Krajeńskie hoard are a valuable basis for further research, should be fully appreciated. The second hoard from Strzelce Krajeńskie was discovered during archaeological research in Ludowa Street, conducted in 2014-2015 (see Fig. 1). The archaeological supervision was carried out by Paweł Kaźmierczak from the Jan Dekert Lubusz Museum in Gorzów Wielkopolski and the most valuable

Fig. 2. Coins from the Strzelce Krajeńskie hoard before conservation, photo by P. Kaźmierczak

outcome of the research was a hoard of late medieval coins (Kaźmierczak 2016, 119-124). With the use of a metal detector and the help of volunteers, it was possible to find 1948 coins in the excavation and on the heaps, which probably make up the main part of the hoard. The exact number of coins that made up the deposit is not known, because not all the coins have been accurately counted and documented. The number of coins discovered there is quoted after Kaźmierczak 2016, 125. All the discovered coins were heavily corroded and patinated, which is reflected in their state of preservation. Many of the coins were stuck together, forming clusters of five to eight, and while separated, part of the surface of one specimen remained stuck to another. This affected the completeness of the preserved coins and their measured weight is often much too low (Fig. 2).

The hoard from Strzelce Krajeńskie discovered in 2014 is far less numerous than the first assemblage discovered in this locality. It should be noted, however, that its composition, although strongly similar, is definitely more interesting and more varied than the 1977 hoard. The core of the find is composed mostly of West Pomeranian pennies, the so-called *Vinkenaugen*, of which about 1880 occurred in the recovered material from this hoard. Among numerous municipal and episcopal issues, *Vinkenaugen* minted in Szczecin and Stargard prevailed. Apart from these two centres, municipal coins from Trzebiatów, Goleniów, Gardziec, Uznam, Koszalin, Kołobrzeg and Słupsk were also recorded. The second most numerous group of coins are Brandenburg pennies, very similar to West Pomeranian pennies, minted in Prenzlau in Uckermark, during the reign of Frederick I (1415-1440). About 40 such specimens were discovered. There is also a noticeable group of Prague groschen, which are at the same time the largest denomination recorded in the studied find. There were 18 Bohemian groschen, all with the titles of Wenceslas IV (1378-1419). Apart from the Bohemian coins, the larger denominations were represented by five Hanseatic wittens. A most interesting feature is a small number of imitations of Silesian hellers, which have tentatively been identified as Silesian coins from an official mint. The smallest part of the hoard consists of two Jagiellonian pennies, undoubtedly dating from the times of Vladislaus III (1434-1444). No ceramic vessel in which the coins may have been hidden was found in the immediate vicinity of the discovery site. There were only fragments of fabric, which in several places were covered with patina identical with that found on the coins. We can therefore conclude that the hoard was wrapped in fabric and only then placed in a container. Perhaps it is possible that the hoard from Strzelce Krajeńskie could have been held in a protective container made of organic materials – for example, a wooden box, like the hoard of Prague groschen from Oleśnica (Milejski 2015, 17-18)- which would explain the lack of any remnants of such protection. It is also possible that was a ceramic vessel or a clay pot that was lined with fabric and filled with coins. We suppose that a find of this size could have been hidden in one large or in two medium-sized ceramic vessels, as in the case of the hoard of 1385 Prague groschen from Boguszów-Gorce (Rodak 2020, 127-133; Miazga and Miazga 2020, 155-166).

MATERIALS AND METHODS

For the time being, the size of the assemblage makes a full study of the second hoard from Strzelce Krajeńskie impossible. Ideally, we would conduct a research project focused on this find alone, which could finance the necessary analyses, photographic documentation of all the coins and physical and chemical studies that would enrich the monographs of the hoard. Taking advantage of favourable circumstances, namely two simultaneous grant projects carried out at the Institute of Archaeology of the University of Wrocław and devoted to similar issues, we were able to select 109 numismatic items from all the coins comprising the second Strzelce Krajeńskie hoard, which were described in detail and photographed, with 48 specimens subjected to metallographic tests. The main aim of the research was to study the structure of the hoard from Strzelce Krajeńskie, and in particular to analyse and describe the mint alloy of the Prague groschen found there. The imitations of Silesian hellers, very uncommon in finds, were also selected for analyses, as their rarity made us particularly interested in their chemical composition. An additional aim was to examine all the smaller components of the hoard – the Mecklenburg and West Pomeranian wittens and the Jagiellonian pennies. It was also important to analyse the core of the entire find, which consisted of West Pomeranian pennies, in order to determine the cities of issue and the quality of the coins, which so far have not been thoroughly studied by Polish researchers.

Unfortunately, only about 1/20th (5%) of the total find has been studied. Among the 109 coins borrowed for this study from the museum housing this material, there were all the Prague groschen, wittens, hellers and Jagiellonian pennies from the Strzelce Krajeńskie hoard. Additionally, 10 Brandenburg and 70 West Pomeranian pennies were studied. Care was taken to select the most statistically representative sample. Twenty *Vinkenaugen* from the Szczecin mint were selected – ten of each of two different types (DbgP 253 and DbgP 353d) – as well as ten specimens minted respectively in Gryfino, Koszalin, Słupsk, Stargard and Kołobrzeg – the mints of the Kamień Bishopric.

All the coins that constituted smaller groups within the described hoard were selected for metallographic analyses, including: 18 Prague groschen of Wenceslas IV (cat. nos 11-28), two Jagiellonian pennies of Vladislaus III (cat. nos 35-36), two Mecklenburg and three West Pomeranian wittens (cat. nos 29-30; 37-39) and four specimens tentatively identified as Silesian hellers (cat. nos 31-34). The remaining 19 specimens, whose mint alloy was checked, were West Pomeranian pennies – six from the Bishopric of Kamień (cat. nos 42-46, 48), five from Gryfino (cat. nos 52, 56-59) and eight from Szczecin, four of each variety (DbgP 353d, cat. nos 91, 92, 94, 95; DbgP 253, cat. nos 100, 103, 104, 109). Specialised analyses were carried out primarily by energy dispersive X-ray fluorescence spectrometry (ED-XRF), which was used to examine all the selected coins. Analytical studies were performed with Spectro Midex spectrometers, featuring an X-ray tube with a molybdenum anode, which gave an excitation energy from 44 to 50kV and a current of 0.3-0.4mA. The spectrometers had SDD detectors cooled with the Peltier effect. Additional equipment included a 20x magnification CCD camera that allows a precise selection of the examined area. Owing to their variable collimators, XRF spectrometers guarantee spot analysis for micro-areas with a diameter of 0.2-1.0 mm. The instruments were calibrated using certified reference materials and the analytical results were averaged and normalised to determine the content of the main components of the mint alloy.

Some of the coins were additionally examined using a scanning electron microscope coupled with an EDS spectrometer. SEM-EDS analyses were performed with a Hitachi Tabletop TM4000 benchtop scanning microscope with an Oxford Instruments spectrometer (AZtecOne software). Microscopic measurements were performed at the excitation energy of 15kV and in a low vacuum mode with the use of a BSE detector. This examination was designed to verify the previous XRF measurements and determine the amount of surface silver enrichment. The coins were prepared for metallographic examination by grinding and polishing the edge with abrasives containing corundum.

RESULTS AND DISCUSSION

West Pomeranian *Vinkenaugen*

The second hoard from Strzelce Krajeńskie is dominated by small West Pomeranian coins, the so-called *Vinkenaugen*, which were minted in various municipal and episcopal centres from around the mid-14th century. In the analysed hoard, municipal pennies of many West Pomeranian towns were recorded, but only some of them were present in the

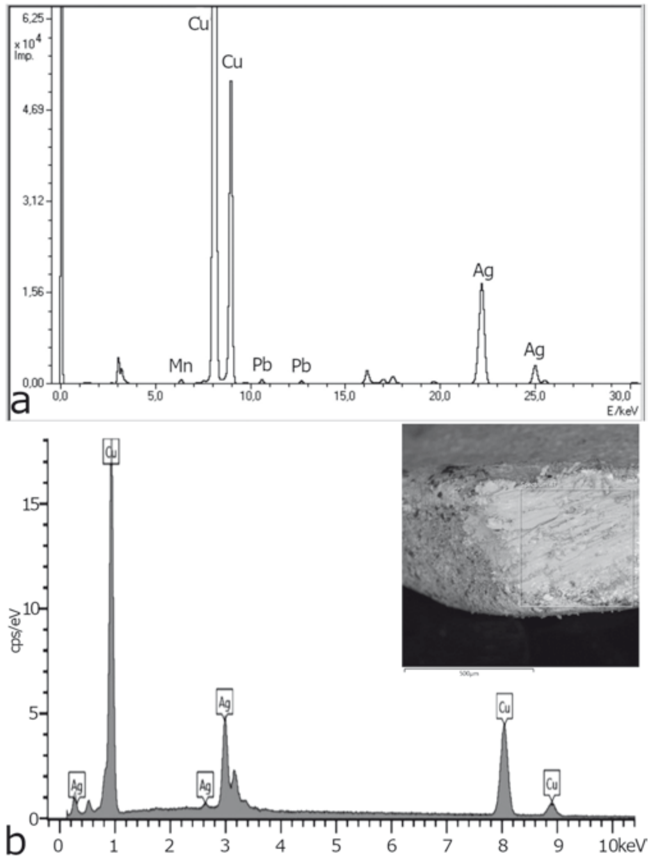

Fig. 3. XRF (a) and EDS (b) energy spectra of a selected Szczecin *Vinkenaugen* (cat. no. 93)

sample examined. A total of 70 West Pomeranian pennies were submitted for examination. These were ten specimens from Gryfino, Koszalin, Słupsk, Stargard and the Bishopric of Kamień and 20 from Szczecin (ten specimens of two separate types). Additionally, 19 of the coins in the sample were metallographically examined.

The main body of the hoard is made up of Szczecin pennies of two basic types – the first, with a majuscule letter C and a five-pointed star in the centre (DbgP 353d) and the second with a griffin's head looking to right (DbgP 253). The dating of both varieties of the Szczecin pennies is rather problematic, as we are not able to determine their specific chronology and can only propose approximate chronological limits. Both varieties are clearly 15th century ones, as was already pointed out by Hermann Dannenberg (Dannenberg 1893, 100, 127-131). We are able to more precisely determine the beginning of the issue of type DbgP 253, which most probably started after 1408, when the Szczecin mint introduced

Table 1. The content of selected metals in West Pomeranian pennies minted in Szczecin, DbgP 353d determined by XRF testing (%/weight)

Cat. No.	Place of research	Fe	Ni	Cu	Zn	As	Ag	Sb	Au	Pb	Sum
101	core	0.0	0.2	84.6	<LOD	<LOD	14.7	<LOD	<LOD	0.2	100.0
102	core	0.1	0.1	86.2	<LOD	<LOD	13.0	<LOD	<LOD	0.5	100.0
104	core	0.0	0.1	83.7	<LOD	<LOD	15.8	0.1	<LOD	0.2	100.0
105	core	0.1	0.2	84.8	<LOD	<LOD	14.1	0.1	<LOD	0.6	100.0

<LOD (below Limit Of Detection)

Table 2. The content of selected metals in West Pomeranian pennies minted in Szczecin, DbgP 253, determined by XRF testing

Element/Cat. No.	90	93	94	99
Fe	<0.1	<0.1	0.6	0.1
Ni	0.1	0.1	0.5	0.1
Cu	82.3	70.9	86.3	63.5
Zn	<0.01	<0.01	<0.01	<0.1
Ag	16.7	28.2	11.8	35.6
Au	<0.02	<0.02	<0.02	<0.02
Pb	0.8	0.8	0.8	0.7

four-penny coins (firchen, in Low German firken) with representations analogous to those on the pennies (Paszkiewicz 2011, 289, 292; Piniński 1976, 19). On the other hand, we can only date the DbgP 353d variant broadly to around the middle of the 15^{th} century. The dominance of the Szczecin coinage in collective finds composed of *Vinkenaugen* is quite a common pheno-menon and so noticeable that, irrespective of the minting location, an alternative name was formed for the West Pomeranian pennies, which became referred to as Szczecin pennies (Kiersnowski 1962, 12). Eight Szczecin *Vinkenaugen*- four of each variety – were examined metallographically. Pennies of type DgbP 353d are characterised by a strongly similar elemental composition of the mint alloy. The most dominant component is copper, constituting 83.7-86.2% of the alloy, with a small but significant (13.0-15.8%) admixture of silver. Also noticeable is the presence of lead, determined at 0.2-0.6% (Figure 3). As can be seen, Szczecin pennies from the fourth-fifth decade were minted from 130-158/1000 silver, which translates into 2-3 lots (purity of silver was determined in lots (in Polish łuty), 1 lot means 6.25% of pure silver, 16 lots gives 100% pure silver). We expected such a result, as it is commonly believed that West Pomeranian pennies were minted from low quality mint alloy with a predominance of copper. The expected limit for the base silver used for minting these coins should not exceed 3 lots.

We can compare the results obtained from the examination of *Vinkenaugen* DbgP 353d with the analysis of the Szczecin pennies DbgP 253 (see Tables 1 and 2). In the case of the older of the Szczecin pennies, we can see a greater variation in the quality of the mint alloy in individual specimens. Copper continues to dominate at 63.5-86.3%, with silver ranging between 11.8-35.6%. The coins with cat. nos 90 and 94 represent the poor standard of pennies with the letter C on the obverse. However, the analyses of the pennies with cat. nos 93 and 99 let us assume that the quality of the silver used to mint Szczecin pennies in the early 15th century was better. The sample of the examined coins is relatively small and does not allow for the definite conclusion on the improvement of the minting standard in Szczecin at the beginning of the new century.

The next significant group of coins in the second hoard from Strzelce Krajeńskie are issues of the Kamień Bishopric, which minted its coins in Kołobrzeg. The sample of coins studied here contained two variations of the basic type DbgP 186, with two crossed croziers on both sides of the coin. The first variety, DbgP 186b has pellets around the croziers while on the second variety, DbgP 186c, there is a St. Lazarus cross below the croziers. The right of minting of the Bishopric of Kamień, together with the mints that produced the bishop's pennies, were studied by Ryszard Kiersnowski, who nearly 60 years ago revised the views on the subject (Kiersnowski 1962). Based on his studies, until recently the *Vinkenaugen* of type DbgP 186 were considered municipal coins of Kołobrzeg, issued after the bishop's authority over the Kołobrzeg mint had ceased (Kiersnowski 1962, 21-23). However, a new and more acceptable hypothesis has recently been proposed regarding the attribution and chronology of these coins. Borys Paszkiewicz, while examining an interesting hoard found on the Brandenburg-Pomeranian borderland, in the area of Barlinek and Choszczno, *i.e.* an area very close to Strzelce Krajeńskie, suggested that the coins should be attributed to the Bishopric of Kamień. He made an interesting observation that can influence their chronology. The fact that the coins are absent from the hoards discovered in Cieszyno (Koszalin district, West Pomeranian Province) and Kłodzino (Pyrzyce district, West Pomeranian Province) and appear for the first time only in the hoard from Pyrzyce (district city, West Pomeranian Province), where they very smoothly replace the DbgP 185 pennies, which immediately preceded the analysed pennies with croziers on both sides, makes it possible to date the coins to the first decade of the 15th century (Paszkiewicz 2011, 290, 291).

Six bishopric pennies were submitted for a metallographic examination – three variants of DbgP 186b (cat. nos 42-44) and three DbgP 186c varieties (cat. nos 46-48), whose detailed data is presented Table 3. It may be noted that, irrespective of the variant, the bishopric pennies are characterised by copper concentrations of 72.3-85.8%, with a predominance of coins with 72-79% of the metal. The silver content in these pennies ranges between 19-26%, which means that the coins were minted from 3-4-lot silver (190-260/1000). Studies of the mint alloy of 15 bishopric pennies of the DbgP 186a variety and its variants may serve as comparative material. These coins come from a hoard consisting of 453 *Vinkenaugen* of the bishops of Kamień, discovered in August 1989 in the historical centre of Kołobrzeg (Kubiak 1998, 145, no. 413/I). The pennies from the Kołobrzeg hoard

Table 3. The content of selected metals in West Pomeranian pennies, Bishopric of Kamień, DbgP 186, struck in Kołobrzeg, determined by XRF testing (%/weight)

Cat. No.	Place of research	Fe	Ni	Cu	Zn	As	Ag	Sb	Au	Pb	Sum
42	core	0.0	0.1	73.5	<LOD	<LOD	24.9	0.2	<LOD	1.1	100.0
43	core	0.6	0.1	72.3	0.0	<LOD	25.7	0.1	<LOD	1.1	100.0
44	core	<LOD	0.1	85.8	<LOD	<LOD	12.9	0.1	<LOD	0.8	99.9
45	core	0.1	0.1	74.0	<LOD	<LOD	26.1	0.1	<LOD	1.1	99.7
46	core	0.5	0.1	79.2	<LOD	<LOD	19.1	0.1	<LOD	0.9	100.0
48	core	0.2	0.1	77.7	<LOD	<LOD	20.5	0.1	<LOD	1.1	99.8

Table 4. The content of selected metals in West Pomeranian pennies minted in Gryfino, DbgP 339a determined by XRF testing (%/weight)

Cat. No.	Place of research	Fe	Ni	Cu	Zn	As	Ag	Sb	Au	Pb	Sum
52	core	0.2	0.1	78.6	<LOD	<LOD	20.0	0.1	<LOD	0.9	100.0
56	core	0.2	0.1	79.6	0.0	<LOD	22.6	0.1	<LOD	0.6	100.0
57	core	0.0	0.2	78.7	<LOD	<LOD	19.4	0.8	<LOD	0.6	100.0
58	core	0.1	0.1	79.9	<LOD	<LOD	19.0	0.2	<LOD	0.5	100.0
59	core	0.3	0.1	77.2	<LOD	<LOD	21.4	<LOD	<LOD	0.6	100.0

<LOD (below Limit Of Detection)

have a mint alloy similar to that of the examined coins from the Strzelce find. It should be noted, however, that the coins found in Kołobrzeg show an even higher level of copper, which only in two cases drops below 75%, and in the majority of the specimens ranges between 75-86%. At the same time, we can see a decrease in the silver content, which varies between 12.6% and 22.4%.

Another town whose pennies were included in the studied part of the hoard is Gryfino. On the obverse of the coins there is an isosceles cross with flared ends, with a large ring and a pellet inside placed in the centre of the cross. The reverse has an image typical of West Pomeranian *Vinkenaugen*, *i.e.* a griffin walking to the left. The type was already known to Dannenberg – DbgP 339 and 339a – who, however, attributed them to bishopric issues (Dannenberg 1893, 118). This view was revised by Ryszard Kiersnowski, who attributed the coins to an unspecified duke or town in Pomerania (Kiersnowski 1962, 9). However, this act of depriving the bishops of Kamień of these coins and attributing them to an unspecified city, did not solve the problem of determining the attribution of the pennies with a cross and a ring inside it. The Gryfino *Vinkenaugen* must have existed and functioned on the monetary market at least in the first third of the 15th century, because after the purchase of the New March, the Teutonic Order decreed to withdraw West Pomeranian pennies from circulation. In 1439, the *vogt* Hans von Stocheim ordered that local coins should be minted in Arnswalde (Choszczno) and Schivelbein (Świdwin), ordering at the same time the withdrawal of Szczecin, Pyrzyce, Gardziec and Stargard coins. On the other hand, we know about a decree of a new *vogt*, Walter von Kirskorff, issued the following year, which prohibited the acceptance of Pomeranian coins, including also coins from Gryfino and Goleniów (Paszkiewicz 2011, 18). While analysing the occurrence of this type of coins in hoards and single finds from Pomerania and together with the dies used for minting the DbgP 339a pennies, Borys Paszkiewicz proposed a hypothesis, generally accepted, of attributing these coins to Gryfino (Paszkiewicz 2011, 17; Szczurek 2012, 101; Szczurek 2017, 109). We believe that their issue could have started in the last years of the 14th century or in the first years of the 15th century, since the Teutonic Order, included, among others, the Gryfino *Vinkenaugen* in the list of West Pomeranian coins intended to be purged from the New March market.

Five of the ten Gryfino pennies included in this study were subjected to metallographic examination (cat. nos 52 and 56-59). Specimens of this type of coin had never been subjected to specialist analysis before, which is the reason why the results of our examination were so important. The results presented in Table 4 show that the Gryfino *Vinkenaugen* were struck from a mint alloy very similar to that of other West Pomeranian pennies. It is practically two-component in nature – characterised by a high copper content of 77-79.9% and an approximately 20% admixture of silver. Also noticeable is the content of lead, which in some coins reaches around 1%. Other elements are present rather in trace amounts and often do not exceed 0.2%.

Another group of West Pomeranian pennies identified in the Strzelce hoard was struck in Słupsk (DbgP 258, cat. nos 70-79). The Słupsk *Vinkenaugen* are distinguished by three wavy lines on the obverse, which symbolise the Słupia River, while the reverse features a griffin walking to the left. Unfortunately, we have not been able to perform metallographic analysis on this group of pennies, but we know from the literature an individual analysis of their quality, which showed a silver content of 52.9%, a value significantly higher than the results we obtained in the earlier analysed groups of West Pomeranian coins. It should be noted, however, that the examination was carried out on the surface, probably enriched in silver after conservation procedures, or perhaps also after flan blanching, as was indicated by the authors of the research themselves (Miazga and Paszkiewicz 2018, 152, 153, 162). Słupsk coins dating to the first half of the 15th century should have been struck from a 234/1000 alloy and weighed 0.255 g, as announced in the mint agreement of Greifswald, Stralsund, Anklam and Demmin in 1428 (Miazga and Paszkiewicz 2018, 152). The *Vinkenaugen* from Słupsk found in the second Strzelce Krajeńskie hoard are heavier than stipulated in the agreement of the Wendish cities. The heaviest specimen weighs 0.354 g (cat. no. 75), and the weight of the next two is equal to or exceeds 0.300 g. The mean weight of all the Słupsk pennies from the analysed group is 0.269 g, which is significantly higher than the value agreed on in 1428. However, we must remember that our data come from a selected group of only ten specimens, hence the relationship we observed may not be the rule.

The next town whose pennies were identified in the discussed hoard is Koszalin (DbgP 187, cat. nos 60-69). The obverse of the coins features the head of St. John facing, long haired and bearded, which differs slightly in its form on each specimen. On the reverse there is a majuscule letter Z, with a pellet on each side (this is a town sign of Koszalin, interpreted as a double hook). Hermann Dannenberg, in his work on Pomeranian coinage in the Middle Ages, distinguishes yet other varieties of this type, which differ primarily in the marks placed next to the letter Z on the reverse. Apart from the pellets we recorded, there might have also been annulets, saltires or stars. We also know other variants, featuring an inverted Z with additional symbols placed next to it (Dannenberg 1893, 83). However, only the basic variant of this DbgP 187 coin occurred in the sample of a portion of the hoard studied here. The chronology of these coins is not well determined, we date them to the first quarter of the 15th century (Dannenberg 1893, 82; Kiersnowski 1962, 15, 22-23). Among the analysed part of the Koszalin pennies we have not noticed a newly distinguished variety of these coins, characterised by a differently shaped image of St. John. The Saint's beard is much longer and clearly divided into six strands, the outermost of which are hair extensions. The reverse of the new variety is analogous to those previously recorded (Miłosz 2015, 206-209). It is possible that the analysis of the entire find and a thorough study of the Koszalin part of the Strzelce hoard will bring coins of this variety or specimens of new, so far unrecorded variants.

The last group of West Pomeranian *Vinkenaugen* in the studied portion of the second hoard from Strzelce Krajeńskie was struck in the Stargard mint (DbgP 243b, cat. nos 80-89). The obverse of the Stargard pennies has a broad six-pointed star with pellets between each ray and a centrally placed ring with a pellet inside it. On the reverse, there is the typical griffin walking to the left. We do not know the exact date when the town of Stargard acquired the mint, but on the basis of the existing numismatic material we can assume that it must have been in the 14th century (Paszkiewicz 2011, 285). There is a type of Stargard coins, with great iconographic similarity to the pennies described in this article, which Borys Paszkiewicz dates to the third quarter of the 14th century (Paszkiewicz 2011, 288, 291). This is type DbgP 236, with representations on both sides analogous to type DbgP 243b. The obverse lacks only the ring in the centre of a six-pointed star. We can suppose that the type with the ring, DbgP 243b, may have directly followed type DbgP 236. Therefore, we can propose the dating of the DbgP 243b Stargard pennies to the late 14th and early 15th centuries. This assumption may be supported by the composition of the Barlinek-Choszczno hoard, which contained pennies DgbP 236a, b and c without the DbgP 236 variant (Paszkiewicz 2011, 288). The absence of these coins from the aforementioned hoard suggests that the assemblage might be later, which supports our hypothesis that the chronologies of DbgP236 and DbgP 243b are similar.

Brandenburg pennies of Frederick I (1415-1440)

The largest addition to the West Pomeranian *Vinkenaugen* are Brandenburg pennies minted during the reign of Frederick I, Prince Elector of Brandenburg (1415-1440). Approximately 40 such specimens were recorded in the entire hoard (Kaźmierczak 2016, 125), and the sample studied here included ten of these coins for our analyses (cat. nos 1-10). The pennies are the only local coin found in the second hoard from Strzelce Krajeńskie. The coin was minted in Prenzlau, in the territory of the Uckermark (Paszkiewicz 2013, 17). The obverse of the coins shows an eagle facing to left. On the reverse there is an image of a tournament helmet, the so-called frog-mouth helm, facing to left. It is the representation on the reverse of the Brandenburg pennies that can help us with the dating of this type of coin. The tournament helmet was introduced into the coat of arms of Prenzlau in 1426, so we believe the pennies with this representation must have started to be struck that year at the earliest. In addition, we know the rent settlements from 1430 and 1436 of the mint operating at that time in Prenzlau (Paszkiewicz 2013, 20), which may confirm that coins with an eagle on one side and a tournament helmet on the other were struck from about 1426 to the end of the reign of Frederick I, namely till 1440. Brandenburg pennies are similar in shape and quality to West Pomeranian pennies. Unfortunately, no Brandenburg penny has been examined in terms of its mint alloy. The metrology of the Brandenburg *Vinkenaugen* parallels that of their West Pomeranian counterparts. The weight of the pennies with a tournament helmet on the reverse ranges from 0.160 to 0.312 g. One of the reasons for this relatively large span may be the coins' very poor state of preservation, as they had lost up to 30% of their weight during conservation procedures. The coins were struck from base silver, and we may assume that they were of a quality similar to that of the Pomeranian *Vinkenaugen*, struck from 2-3-lot (120-180/1000) silver. The flans of the Brandenburg pennies are of a rather irregular shape, and their diameters range between 10.1-11.1 mm.

Prague groschen of Wenceslas IV (1378-1419)

The largest coin discovered in the second hoard from Strzelce Krajeńskie are Prague groschen. A total of 18 specimens of these Bohemian coins were discovered, all struck during the reign of Wenceslas IV. Despite the poor state of preservation, we managed to classify all of them according to their latest typology by J. Hána (Hána 2003). We identified one coin from the 1384-1395 issue, Hána type V. It is the oldest example of Prague groschen in the entire find. Then, there are two coins attributed to Hána type VII, dated to 1395-1400. By far the largest group are 15th century issues, which can be divided into two main groups. The first consists of Hána types VIII, IX and XI, minted between 1400 and 1405. The second contains exclusively type XIV, which is the most abundantly represented in the entire hoard. Eight such coins were identified, the dating of which has recently been

Table 5. Mint alloy of Wenceslas IV's Prague groschen from the second hoard of Strzelce Krajeńskie

Cat. No.	Typ according to Hána	XRF		SEM-EDS		
		%Ag	%Cu	%Ag	%Cu	surface enrichment with Ag (%)
11	V.h/1	70.0	30.0	72.5	27.5	11.4
12	VII.a/1 or VII.d/2	76.0	24.0	66.1	33.9	25.0
13	VII.d/1, 3–4	88.0	12.0	90.9	9.1	10.1
14	VIII.a/3	75.0	25.0	71.7	28.3	24.2
15	VIII.a/3	59.0	41.0	61.1	38.9	32.2
16	VIII.a–e	62.0	38.0	64.4	35.6	35.0
17	VIII.e/1, 3–5	65.5	34.5	68.0	32.0	23.5
18	IX.e/1	68.1	32.9	65.5	35.5	23.5
19	XI.a/1	61.5	38.5	61.1	38.9	24.6
20	XIV.a/1 (variety)	59.0	41.0	60.7	39.3	26.9
21	XIV.b/2	68.9	31.1	58.0	42.0	42.0
22	XIV.h/1	58.7	41.3	62.9	37.1	27.0
23	XIV.h/1 or XIV.i/1	58.6	41.4	55.0	45.0	42.0
24	XIV.i/1	65.0	35.0	66.5	33.5	30.2
25	XIV.i/1–2	76.4	23.6	60.9	39.1	31.1
26	XIV.i/2	63.4	36.6	61.6	38.8	35.3
27	XIV.i/10	56.0	46.0	57.5	42.5	27.6
28	XIV.i/10	34.8	65.2	33.0	67.0	29.9

debated. Until now the chronology of Hána type XIV was determined as the years 1407-1415 (Hána 2003, 111), however Borys Paszkiewicz in his conclusions concerning the study of a large find of Prague groschen from Boguszów-Gorce proposed to modify the dating of the last regular types of groschen distinguished by J. Hána. Having analysed the distribution and composition of Polish, Bohemian, Lithuanian and Ukrainian finds, which included types XIV, XV and Wenceslas IV's groschen minted posthumously, Paszkiewicz suggests classifying type XV to the group of coins minted after Wenceslas IV's death in 1419 (Paszkiewicz 2020, 179-181). Then the dating of Hána type XV would shift from 1415-1419 to 1420 onwards. At the same time, we should assume that type XIV was minted from 1407 to 1419. This hypothesis is quite plausible, but in our opinion it requires additional research and more analyses, especially of the late regular types distinguished by Hána and, above all more posthumous groschen of Wenceslas IV.

All the Bohemian coins from the analysed find were examined metallographically, with both methods used during our study, namely the XRF and SEM-EDS. The detailed results are presented in Table 5, where the last column provides additional information on the surface silver enrichment in all the coins. We can see that those values vary from 11.4% to as much as 42%, which clearly shows that the examination limited only to the surface of coins can very often yield quite distorted and uncertain data. More reliable results come from the examination of the core, as that method limits the impact of conservation procedures and surface treatment on the obtained results.

When analysing the table presenting the mint alloy composition of Wenceslas IV's groschen, we can notice significant differences between individual coins. The best mint alloy was recorded in the Prague groschen of Hána type VII.d (cat. no. 13), which contains 88% of silver with an admixture of copper of just 12%, which translates into 14 lots (880/1000). During interpreting the silver content results of the groschen, the current state of preservation of the coins and previous conservation work, resulting in the removal of a significant amount of copper from the coin (*i.e.* its enrichment in silver) should be taken into account. This fact made it much more difficult to determine the original composition of the mint alloy. Without the permission to interfere more significantly with the edge of the groschen, the results of most of the coins indicate much overrated silver content. Such groschen are certainly specimens nos 13, 25 and 27. The figures obtained should therefore be approached with caution.

The next four coins are characterised by a silver content of 70-76%. This group consists of groschen of different types – Hána V, VII, VIII and XIV – whose chronological span is quite wide and reaches 20 years. The most similar results were obtained from coins of Hána type XIV. For these groschen, the silver content ranges between 56-68.9%, with two notable exceptions. The first irregularity is a groschencat. no. 25, where the content of silver exceeds 70%, reaching 76.4% of Ag. In the second coin, cat. no. 28, an extremely low silver content of 34.8% was recorded, with a 65.2% copper admixture. It is worth noting that a comparison of groschen cat. nos 27 and 28 – both assigned to the type Hána XIV. i/10- reveals quite significant differences between both coins. The latter is a groschen with the lowest silver content of all the examined groschen, while in the coin no. 27 the silver content was measured at 56%, with a 46% admixture of copper. We suppose that such a large discrepancy may be a result of the coins' very poor state of preservation just after their discovery and the rather aggressive conservation method used. Reportedly, the conservation procedure was carried out with the use of ammonium and sodium tartrate, and corrosion accounted for as much as 30% of the coins' weight, which was determined by comparing the weight of the object before and after conservation (this is verbal message from Dr Grzegorz Bejcar, who was engaged in conservation of coins from the second Strzelce Krajeńskie hoard).

Fortunately, we have a substantial quantity of comparative material for Wenceslas IV's Prague groschen from two Silesian hoards, where 10% of each was subjected to similar mint alloy testing. We are referring to the hoards from Oleśnica (Milejski 2015; Miazga 2015) and Boguszów-Gorce (Miazga 2020, 115-126; Milejski 2020, 81-90). Particularly valuable are the analysis results of Wenceslas IV's Prague groschen from the Boguszów hoard, where more than a hundred coins were selected for mint alloy examination. The results of the metallographic tests conducted on Prague groschen of Hána type V for all the deposits compared range between 61.2% and 76.9%. Only three coins – all from the Boguszów hoard – showed more than 70% (Miazga 2020, 116). The hoard from Oleśnica produced one examined coin of this type, in which the silver content was measured at 66.99% (Miazga 2015, 212). The data confirm that silver content in type V pennies usually ranges between 62-70%, with a few exceptions where the value exceeds 70%. On the one hand, the Prague groschen of Hána type VII from all three hoards analysed are characterised by a rather stable silver content, ranging between 60.0-65.9% (Milejski 2020, 85), but on the other hand, in each hoard there is at least one coin of this type in which the silver content is surprisingly high and exceeds 80%. The Oleśnica hoard contains one coin with a silver content of 81.6% (Milejski 2015, 54), the Boguszów hoard also contains one coin with 84.4% of silver (Milejski 2020, 85). The analysed find from the second Strzelce Krajeńskie hoard also included one type VII coin with a silver content of as much as 88%. The subsequent types of Prague groschen, Hána type VIII and IX, are characterised by a similar content of silver, determined at 61-70%. In the hoard from Boguszów only one coin of type VIII (cat. no. 959) has a silver content of over 70%, *i.e.* 72.1% (Miazga 2020, 120, 121), whereas in the hoard from Oleśnica no type VIII or IX groschen exceeds this value. Similar results were obtained from Wenceslas's groschen from the Strzelce Krajeńskie hoard; no coin assigned to these two types was struck from a mint alloy in which silver would exceed 70%. More noticeable are the deviations in the opposite direction, with several coins showing a silver content dropping below 60%. The most extreme example from the Boguszów find is a specimen in which the silver content falls to 51.4% (cat. no. 1135). Generally, however, even in the groschen with a reduced content of silver, the metal still reaches between 57.3-59%. The last metallographically examined coins were classified as Hána type XIV. This type of Wenceslas IV's Prague groschen did not appear in the hoard from Oleśnica (*tpq* 1405). However, they are present in large numbers in the hoard from Boguszów-Gorce (*tpq* 1420), where as many as 53 type XIV coins were identified, 12 of which were subjected to metallurgical analysis. The groschen from the Silesian hoard maintain an even silver content that ranges from 54.0% to 62.8%, so with a spread of less than 8% (Miazga 2020, 122, 123). However, in the hoard from Strzelce Krajeńskie these differences are significant, which was probably influenced by the method of conservation. We can see that in most cases the groschen are characterised by a silver content of 56.0-68.9%, with the two exceptions mentioned above.

We can see that the Prague groschen of Hána type V, VII, VIII and IX are of better fineness, with about 65-75% of silver (of course with noticeable deviations both ways). However, we note a steady deterioration of the minting alloy from which the coins were struck in the Kutná Hora mint. Particularly important for us is the mint act of 1407, which stipulated that large coins should be produced from 610/1000 silver and small coins from 400/1000 silver (Castelin 1953, 142-143; Hána 2003, 24, 25; Milejski 2020, 46). The principles must have been applied to Hána type XIV groschen, which – as we have demonstrated above – were struck from an alloy that complied with the requirements of Wenceslas IV's act, which indicates that the minting law in the Crown of Bohemia at the end of the 14th and the beginning of the 15th century was actually observed and, despite the regular debasement of the Bohemian coin, the groschen were minted in accordance with the acts in force.

Mecklenburg and West Pomeranian Wittens

The second largest denomination identified in the hoard from Strzelce Krajeńskie are Pomeranian and Mecklenburg wittens. These coins were introduced in 1365 in Lübeck (Berghaus 1973, 89). Their nominal value was set at four pfennigs, but in the Sound currency zone their value was equivalent to six pfennigs. Some Pomeranian towns, *e.g.* Stralsund, joined the Wendish Monetary Union only in 1381, and the decision resulted in these centres issuing a large silver coin – the witten (Stefke 1982, 60, 61).

In the hoard from Strzelce Krajeńskie we have relatively early Mecklenburg wittens, minted after 1387 in Friedland (cat. nos 29, 30). We cannot determine a more precise dating of the Mecklenburg wittens, all we know is that the first large coins in this area were struck in Rostock in 1371 (Oertzen 1904, 51). On the obverse there is a griffin facing left, while the reverse features a Greek cross with a quadrilobe with a pellet in the middle. There are also two pellets in the fourth quarter of the cross. The margin legend on both sides of the coin is the same – MOŊЄTA∵VRЄDЄL (Friedland = Vredeland). Mecklenburg's Wittens are rarely found in Poland, so it was highly desirable to metallographically examine the coins from the Strzelce hoard. An analysis of Table 6 reveals that Mecklenburg's wittens were minted from 356-378/1000 silver, which corresponds to 6 lots. The predominant component of these coins' mint alloy is copper – 60.1-62.8%. There is also a clear presence of lead, constituting about 1.0% of the alloy in both coins.

Table 6. The content of selected metals in Mecklenburg and West Pomeranian pennies determined with XRF testing (%/weight)

Cat. No.	Place of research	Fe	Ni	Cu	Zn	Ag	Sb	Au	Pb	Sum
Mecklemburgia										
29	core	0.1	0.1	62.8	0.0	35.6	0.1	<LOD	1.0	100.0
30	core	0.2	0.1	60.1	0.0	37.8	0.3	<LOD	1.1	100.0
West Pomerania										
37	core	0.0	0.1	71.2	0.1	27.4	0.1	0.1	0.8	100.0
38	core	0.0	0.1	61.5	0.1	36.7	0.3	<LOD	0.9	100.0
39	core	0.1	0.1	55.6	0.1	42.5	0.1	<LOD	1.1	100.0

<LOD (below Limit Of Detection)

In the hoard there were also three West Pomeranian wittens, all minted in the Wolgast duchy – two in the mint in Barth (cat. nos 37, 38) and one in Wolgast (cat. no. 39). The representations on each of the three coins are practically identical – a griffin to the left on the obverse and a Greek cross with a quadrilobe in the centre on the reverse. The chronology of these coins is also very similar – the Barth wittens were minted after 1415 (Danenberg 1893, 132-134) and taking into account the metrological data of the coin from the mint in Wolgast, we would date it to around 1420-1430 (Leukhardt 2013, 12, 18). Wittens minted in Barth are characterised by an additional symbol placed in the first or second quarter of the cross -a griffin's paw. The coins also underwent specialised physico-chemical analyses (Table 6). We can see that the slightly younger Wolgast coin was struck from a better quality mint alloy. The silver content in this witten is 42.5%, with 55.6% of copper, which means that the coin was struck from 7-lot silver. Older wittens, from the mint in Barth, were struck from a worse mint alloy containing 27.4-36.7% of silver, with over 61-71% of copper. We can therefore see that, despite the small time difference, the quality of the Barth and Wolgast wittens differs quite considerably. It is worth noting that two mints located in the same duchy used minting alloy of unequal quality to mint the same denomination. The mint in Wolgast produced wittens from 450/1000 silver, while the standard of the Barth wittens was only 274-367/1000.

New March or Pomeranian imitations of Silesian hellers

Among the mass of small West Pomeranian pennies, four coins were also distinguished, which were tentatively identified as Silesian hellers, most probably from the Głogów mint (Kaźmierczak 2016, 126; three Silesian hellers are mentioned there, however during a museum search conducted by Paweł Milejski in the Lubusz Museum, it turned out that there were four coins imitating Silesian hellers). After a thorough identification of these coins, it turned out that all of them belong to the so-called northern group of hybrid forgeries of Silesian hellers (this name was first proposed by Borys Paszkiewicz, see Paszkiewicz 2021, 65). There were two main types of the coins – with a bearded head and an eagle and with the letter G and an eagle. These hellers are definitely the most interesting coins in the analysed hoard.

In the second hoard from Strzelce Krajeńskie, three specimens of hellers with a bearded head and an eagle were distinguished, which differ from each other by small details. On the obverse of two coins (cat. nos 32, 33) there is only a bearded head, without any additional symbols (BRP SM 16.15a; FbgCDS 555), and on the obverse of the last coin of the type (cat. no. 34) there are also two slanted, crossing lines, forming a symbol interpreted as St. Andrew's cross (BRP SM 16.15b; FbgCDS 555a). There was no variation with a rim legend in the analysed hoard (BRP SM 16.15c; FbgCDS 555b), which is reconstructed as W C N (Paszkiewicz 2021, 66). Coins of this type are basically a combination of two Silesian hellers – the obverse refers directly to the depiction from Wrocław Rempel's hellers, with

Table 7. The content of selected metals in hellers determined by XRF testing (%/weight)

Cat. No.	Place of research	Fe	Ni	Cu	Zn	As	Ag	Sn	Sb	Au	Hg	Pb	Sum
31	core	0.1	0.1	91.2	1.6	0.2	2.4	1.0	0.2	<LOD	2.8	0.2	100.0
32	core	0.2	0.1	93.0	5.3	0.2	0.3	0.2	0.5	<LOD	0.1	0.0	100.0
33	core	0.3	0.1	80.7	4.3	0.4	5.2	1.8	0.2	<LOD	6.7	0.2	100.0
34	core	0.2	0.1	85.7	12.9	0.2	0.3	<LOD	0.2	<LOD	<LOD	0.2	100.0

a bearded head of St. John (FbgCDS 554), the reverse shows a Silesian eagle with a concave band across its wings and breast, which indirectly refers to the reverse of Legnica hellers (FbgCDS 588-589) (Miazga and Milejski 2019b, 137). This type of coin is very rarely recorded and, despite the fact that they refer to the Silesian hellers, only one specimen is known from Silesia so far, which was discovered at the Romsberg Castle on Gromnik Mountain (Miazga and Milejski 2019a, 344, 345; 2019b). Other finds are recorded primarily in hoards from Nosibądy (Dannenberg 1890, 301-306; Kubiak 1998, 195, no. 546) and Cecenowo (Dannenberg 1885, 398-401; Kubiak 1998, 92, no. 237) and the New March and Pomerania – Choszczno I and II (Dannenberg 1878, 73-91; Kubiak 1998, 180-183, no. 253/I; Kubiak 1998, 97, 98, no. 253/II; Menadier 1887, 194-197). The last recorded find of a heller with the head of St. Andrew comes from Tomice near Stęszew in Greater Poland (Bartkowiak 2017, 26, no. 6, 28). Unfortunately, the attribution and dating of this type of coin is highly uncertain and causes many problems. Ferdinand Friedensburg attributed these coins to Krosno Odrzańskie, where, according to this German numismatist, St Andrew the Apostle was the patron saint of the parish. The heller issue would then be dated to 1422-1430 (Friedensburg 1904, 34). However, as Borys Paszkiewicz has rightly pointed out, such an attribution is inaccurate, since there was no parish of St. Andrew in Krosno, and, more importantly, the eagle on the hellers in question does not feature a cross over the band, which was used by the dukes of the Głogów line (Paszkiewicz 2021, 66). The scholar has also considered several other hypotheses on the possible attribution of the coins with the head of St. Andrew – as possibly originating in Środa Śląska, Legnica, Ujazd in Upper Silesia or interpreting the image in question as St. Blaise's head and attributing the coin to Oława (Paszkiewicz 2021, 66, 67) – although none of the hypotheses is sufficiently supported by the sources to be considered plausible.

The specimen from the Romsberg Castle on Mount Gromnik and three hellers from the hoard found in Strzelce Krajeńskie were examined metallographically (see Table 7) and the results are very interesting. All the analysed coins have a similar elemental composition with the predomination of copper, which in the coin from Gromnik (Miazga and Milejski 2019a, 345) and in one specimen from Strzelce Krajeńskie (cat. no. 32) was determined as 91% and in the two remaining coins ranges between 80.7-85.7%. All the coins are also characterised by a significant admixture of mercury, which reaches 2.8-6.7% as well as a 1.6-12.9% presence

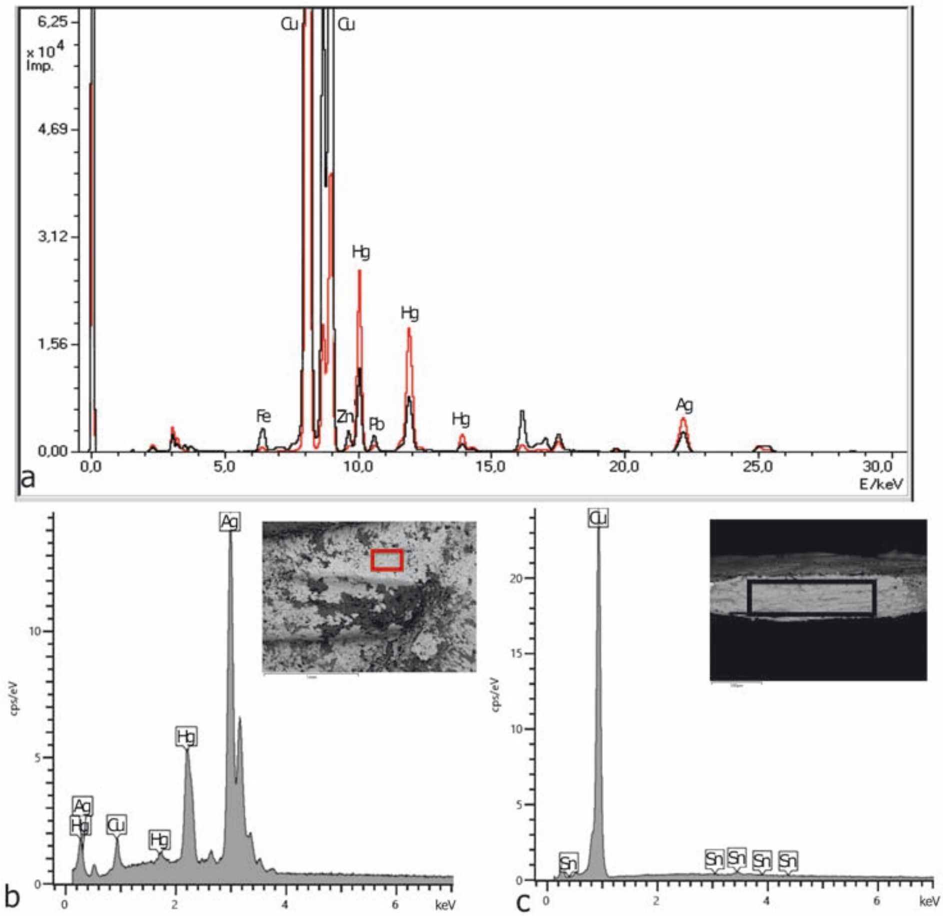

Fig. 4. XRF (a) and EDS (b, c) energy spectra of the heller cat. no. 33, which are indicative of the amalgam technique of coin silvering. The red line shows the surface results, the black line the core of the coin

of zinc. It is worth noting that only in the case of the coin cat. no. 33 the silver content exceeds 1% and reaches 5.2%. Such a composition of the mint alloy of these coins, similar to the coin from Gromnik and the second hoard from Strzelce Krajeńskie, clearly indicates forgery.

In the production of the forged hellers, imitating the issues of the Wrocław mint, the amalgam technique was used, which relies mostly on mercury (Miazga and Milejski 2019b, 139-142). Fig. 4 shows the results of the XRF spot analysis and SEM-EDS micro-area studies, indicating the presence of a significant amount of mercury on the surface of the coin in relation to its concentration inside the specimen. A similar forgery technique was used for coins minted by the lords of Diepholz, which were supposed to imitate Bohemian unilateral coins with the lion of Vladislaus II (1471-1516). As many as seven specimens out of 11 examined coins of Rudolf VIII (1480-1510) and Conrad XII (1510-1514) were blanched with the use of the amalgam technique (Cihlář *et al.* 2016, 122-129). While analysing the locations of the hellers with the head of St. Andrew and comparing them with the results of specialist research we may assume that the coins were struck in a forgery workshop located most probably in the New March or in (Western) Pomerania. Their chronology is also unclear, but the *tpqs* of their hoards allows us to date the specimens to the 1430s. Borys Paszkiewicz suggests that the area with particularly favourable circumstances for forgery activities in 1433-1435 was the New March (Paszkiewicz 2021, 67). The iconographic references on both sides of the analysed coins, clearly referring to Silesian hellers, allow us to assume that such small coins of the Silesian heller type, three specimens of which were discovered in the second Strzelce Krajeńskie hoard, were produced in the New March or in Pomerania in order to be put into circulation in Silesia. The forgeries would have been difficult to identify in the monetary mass circulating in Silesia in the first and second third of the 15th century. What is puzzling, however, is the fact that – despite their intended purpose – the only place in Silesia the coins have so far been recorded is the Romsberg Castle, which may indicate that the issue of coins with St. Andrew could have been ephemeral. It is also possible that the goal of the issuer of theforgeries may not have been reached, hence such a small overall number of finds (Paszkiewicz 2021, 67).

The last imitation of a Silesian heller recorded in the second hoard from Strzelce Krajeńskie is a coin with a majuscule, Gothic letter G, with a small serif and a decorative trefoil on the obverse and a representation of an eagle without a band on the reverse (cat. no. 31). Similar specimens were recorded in the Choszczno I and II hoards, dated to the 1430s. Coins of this type were quite often identified with very similar coins with analogous representations of BRP SM 4C.1 type, which are known from Silesian hoards dated to the beginning of the 16th century. The discovery of a heller of this type in the hoard from Strzelce Krajeńskie has made it possible to distinguish between the two coins, which was facilitated also by the observation that on the older coins the eagle is depicted without the feet (Paszkiewicz 2021, 67). The specimen is an imitation of Silesian hellers, its obverse clearly corresponds to the Głogów hellers, while the representation on the reverse generally refers to Silesian coins of the second half of the 14th and first half of the 15th century.

The imitation of the Głogów heller was also examined metallographically, and the results of the analyses are consistent with the results of the examination of the alloy used to struck the hellers with the head of St. Andrew. The elemental composition of the heller with the decorative gothic letter G is dominated by copper – 91.2%, with only a 2.4% admixture of silver. Worth noting is the pronounced presence of zinc, at 1.6%, and mercury, measured at 2.8%. These results also point to a forgery produced with the amalgam method, where mercury with a small admixture of silver forms a silvery coat on the coin surface that imitates genuine silver. There is also a high probability that this heller was minted in the same forgery mint as the three hellers with the head of St. Andrew described above. The conclusion is evidenced by study of the mint alloy and the fabric of the coins.

Jagiellonian pennies of Vladislaus III (1434-1444)

The smallest part in the discussed hoard constitutes of two Polish pennies of Vladislaus III. These small coins, minted at the royal mint in Cracow in 1434-1444, have a crown on the obverse, while the reverse features an eagle with outstretched wings, facing to right. Both pennies belong to the same type, Kubiak II: 4, which, according to this researcher, is characterised by joined upper and lower fleurons. In addition, in the lower parts of the crown there are ^ symbols, which divide the lower fields in half (Kubiak 1970, 101, 102).

Vladislaus III's pennies are a very common find, particularly in the territory of the Polish Crown, where they occur in large numbers, but they are also very often recorded outside its borders. They were, however, reluctantly accepted, as the forging of these coins in Silesia, Bohemia and Moravia grew to an unimaginable scale (Paszkiewicz 2008, 150-151), and also because even the original coins were made from only 2-3 lot silver (125-187.5/1000). It is highly probable that one of the forgery mints operated at the Romsberg Castle on Gromnik Mountain, where archaeological excavations have revealed a large number of forged Jagiellonian pennies of Vladislaus III as well as coin blanks, which could have been a semi-finished products used to mint these coins (Miazga and Milejski 2019a, 346-350; Miazga 2008, 156-159; Paszkiewicz 2008, 150-152). The most famous hoard of probably over 100,000 forged Jagiellonian pennies, which, apart from the coins of Vladislaus III, included also pennies of Vladislaus II (1386-1434) and Casimir IV (1447-1492), comes from Kazimierza Wielkiego Street in Wrocław (Butent-Stefaniak and Baran 2003, 217-218). Coins from an official issue should have been struck from 2-3 lot silver (125-187.5/1000) (Kubiak 1970, 103-104), but we sometimes record original coins with a much lower silver content. Taking into account that products of the Cracow mint should contain at least 1-2% of silver, the pennies in which the silver content is lower are considered forgeries.

Both Jagiellonian pennies from the Strzelce hoard were XRF tested and the detailed results of the analyses are given in Table 8. The elemental composition of both coins is very similar – the penny cat. no. 35 has a silver content of 14.2%, with 85.1% copper, while the penny with a cat. no. 36 was struck from an alloy of 14.3% of silver and 84.8% of copper. In comparison, the penny of Vladislaus III discovered in Wrocław, on the site of the Ołbin Abbey, had only 2.6% of silver. The results of metallographic research, together with the correctness of the images on both sides of the coin, allow for the classification of the penny as a product of an official mint (Milejski and Miazga 2016, 249, 250, 257).

Table 8. The content of selected metals in Jagiellonian pennies determined by XRF testing (%/weight)

Cat. No.	Fe	Ni	Cu	Zn	Ag	Au	Pb
35	0.06	0.2	85.1	<0.01	14.2	<0.02	0.4
36	0.1	0.1	84.8	0.1	14.3	<0.02	0.6

CONCLUSIONS

Discovered in late 2014, the second hoard from Strzelce Krajeńskie is one of the more interesting late medieval hoards recently discovered in Poland. The core of the hoard is formed by West Pomeranian pennies that have so far been poorly identified. From around the mid-14th century, such coins were minted in a number of Pomeranian mints, most of which were purchased or leased by municipal authorities. It is necessary to examine the entire hoard, as the sample studied here, consisting of 109 coins, certainly does not allow us to exhaust the subject. The find certainly deserves the attention of historians and numismatists and the formation of a research team to conduct interdisciplinary studies. Owing to external financing, it was possible to analyse 109 coins and examine the mint alloy of almost half of them.

In the process of determining the *terminus post quem* of the discussed hoard, on the basis of our current knowledge and the analysed part of the hoard, we would have to accept several possibilities. The decisive role in the dating of the Strzelce find will rather be played by small Polish, Brandenburg and Silesian coins. The hoard from Strzelce Krajeńskie does not include Prague groschen struck with immobilised dies of Wenceslas IV between 1420 and 1423, hence the Bohemian coin does not close the hoard. Also the West Pomeranian wittens, coined after 1415, do not mark the end date of the hoard. The broad dating of the group of northern imitations of Silesian hellers to the first half of the 15th century also does not allow us to establish the date of the hiding. The Brandenburg pennies of Frederick II were minted between 1426 and 1440, while the Cracow issue of the Jagiellonian pennies of Vladislaus III took place between 1434 and 1444. Without being able to narrow down the chronology, we must assume that it is the Polish small coin of Vladislaus III that determines the hoard's *tpq* as 1434. This date is not insignificant in the history of Strzelce Krajeńskie, as the years 1433-1435 were the period of the Polish-Teutonic war, which did not spare Strzelce Krajeńskie (Rymar 2016, 67-73). The town was in the possession of Brandenburg margraves from about the middle of the 13th century, after the northern part of Lubusz Land was subordinated by Brandenburg in the years 1250-1253 and the German name of Strzelce Krajeńskie – Fredeberg appears as early as in 1286 (Gierke 2016, 56-58). The situation in the New March changed dramatically when it came under the rule of the Teutonic Order (1402-1454). The lack of trust of the local population and the constant conflict with the Kingdom of Poland led to a new war, waged also in the New March between 1433 and 1435. Strzelce Krajeńskie was captured by Polish-Bohemian forces on 5th June 1433, and despite the fact that the enemy troops left the area already on 15 June 1433, foreign knights continued to prowl in the vicinity of the town (Rymar 2016, 71-73). The peace treaty between the Teutonic Knights and the Polish-Bohemian side was concluded only on 31 December 1435. However, the presence of Polish forces in the area of Choszczno and Strzelce is still recorded in 1437. The effects of warfare in Strzelce Krajeńskie must have been quite substantial and harmful, since on 20 April 1437 the Grand Master of the

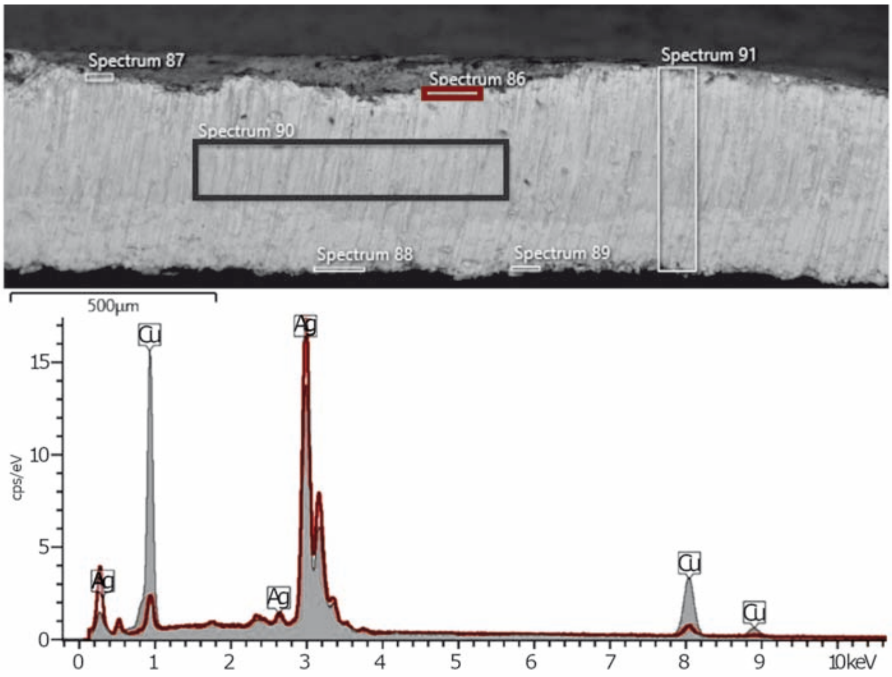

Fig. 5. Energy spectra of the groschen core (grey line) and surface (red line) for the groschen with a cat. no. 21

Teutonic Order Paul von Rusdorf (1422-1441) allowed the town to collect money all around the country to restore the church and its bells. Even as late as in 1450, Strzelce was granted the reduction of half of the real property tax as the place had still not returned to its state from before the Polish-Teutonic conflict (Rymar 2016, 75, 76). We can assume that the owner of the hoard may have hidden it in a safe place during the hostilities or immediately after the conclusion of the peace treaty. Faced with the conflict, or the possibility of the confiscation of his property for the purpose of the reconstruction of the city, the owner decided that it would be better to bury his goods and recover them when the situation improved. The hoard may have also belonged to a trader who had travelled from Western Pomerania southward along one of the trade routes. This would explain the dominance of West Pomeranian coins and the presence of the large Bohemian coin in the discussed find. Perhaps only by studying the find as a whole will it be possible to draw more definite conclusions about the hoard's origin.

Let us consider the relationship of the two hoards discovered in Strzelce Krajeńskie – the first from 1977 and that from 2014, analysed here. The composition of both finds is very similar -they are dominated by small Pomeranian coins accompanied by Prague groschen and Jagiellonian pennies. Having analysed only the contents of the two hoards, we might get the impression that they are two parts of the same assemblage. However, the fact that they were discovered on plots quite distant from each other clearly indicates that they must be two separate hoards – another example of the so-called "twin hoards" known to Polish numismatics, as we have indicated at the beginning of this text.

The analysed portion of the hoard from Strzelce Krajeńskie has once again confirmed the importance of cooperation between numismatics and science. Interdisciplinary research, enriched by mint alloy analysis, greatly enhances our knowledge. This approach is particularly appropriate when it comes to coins that have not been metallographically examined so far or whose comparative material is very small. This mainly concerns West Pomeranian *Vinkenaugen*, which have not evoked much interest from Polish researchers. The study confirmed the earlier assumptions that West Pomeranian pennies were produced from base silver whose fineness did not exceed 300/1000. The level of silver in the Jagiellonian pennies is clearly lower, but their appearance and physical characteristics enabled these coins to penetrate the monetary mass and circulate unnoticed in the territory of the New March and Western Pomerania. The same is likely to have been true of the circulation of counterfeit hellers, which imitated hellers from Wrocław and Legnica.

Thanks to the microscopic-analytical study, it was also possible to observe the numerical difference in the composition of the mint alloy, analysed on the surface and on a prepared edge, the latter location allowing for reaching the original mint alloy (Figure 5). The analysis of the figures for all the coins examined this way showed significant differences between the silver and copper contents in both batches of coins. The concentration of silver determined during the examination of the surface is much higher than inside the coins. This difference reaches even 40 units for the designated semi-quantitative concentration, a phenomenon known also from studies of other coins (Linke and Schreiner 2000; Beck *et al.* 2004; Beck *et al.* 2008; Borges e*t al.* 2017). Apart from the cooperation between a numismatist and an analyst, it is crucial to stress the importance of proper conservation of coins, especially those from archaeological excavations. The removal of soil contamination and corrosion layers with chemical methods can significantly affect the mint alloy by contributing to a distortion of the measurement of silver and copper concentrations in relation to the original mint alloy. Conservation practice suggests that the best results are obtained by various mechanical cleaning methods or with the use of disodium edetate (Miazga 2020).

The second hoard from Strzelce Krajeńskie relatively quickly entered the academic literature. The contents have been fairly thoroughly identified, at least in terms of its main body and the individual denominations. We cannot, however, exclude the possibility that in the remaining part, consisting of more than 1800 coins, we will find further imitations of Silesian hellers or other very interesting, so far unrecorded numismatic items, which will shed new light on the monetary circulation in the New March and the economic relations in the late Middle Ages in this area. Also desirable would be an accurate comparison of the composition and chronology of the two finds from Strzelce Krajeńskie, but this will not be possible without the full identification of the hoard discovered in winter 2014. The find from Strzelce Krajeńskie offers many research perspectives and constitutes an invaluable numismatic source for the study of economic relations in the New March in the first and second decade of the 15th century.

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CHRONICLE

Wojciech Filipowiak[1], Karolina Kokora[2]

REPORT ON THE JUBILEE INTERNATIONAL CONFERENCE "TOWNS THAT CREATED EUROPE. 70 YEARS OF POLISH ARCHAEOLOGICAL RESEARCH IN WOLIN", WOLIN, 26-28.08.2022

On 26-28.08.2022, the jubilee conference „Towns that created Europe. 70 years of Polish archaeological research in Wolin" took place in Wolin. The event was organised as part of the 6th Wolin Medieval Meetings by the Institute of Archaeology and Ethnology of the Polish Academy of Sciences, the Andrzej Kaube Regional Museum in Wolin, the National Museum in Szczecin and the Wolin Municipality. It is a biennial conference, starting in 2010 and organised for the first time on the initiative of prof. dr hab. Marian Rębkowski. The Wolin Medieval Meetings are a place for discussion and exchange of views between Polish and foreign medievalists, representing various scientific disciplines, including archaeology, history, art history and literary studies.

Each of the meetings held so far has been devoted to a specific topic. Until now, as part of the Wolin Medieval Meetings, the following conferences have taken place: „Exclusive Life – Dignified Burial. In the circle of elite culture of the Middle Ages" in 2010, „Economies, monetisation and society in the west Slavic lands 800-1200 AD" in 2012, „Churches in the era of Christianisation" in 2014, „Bishop Otto of Bamberg and his world" in 2016 and „Borderlands" in 2018. In 2020, the conference was postponed due to the outbreak of the COVID-19 pandemic.

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In 2022, the organisers decided to make the Wolin Medieval Meetings an anniversary event due to the 70th anniversary of the start of Polish archaeological research in Wolin, which falls in 2022. The research has been conducted since 1952, and since 1953 it was supervised by the Institute of the History of Material Culture of the Polish Academy of Sciences (now the Institute of Archaeology and Ethnology PAS). At the same time, the conference initiated the celebrations of the 70th anniversary of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences, which falls in 2023.

In the course of the 70 years of Polish archaeological research in Wolin, a huge number of data and artefacts were acquired, constituting first-rate sources for research on European history. This material has been presented in numerous exhibitions both at home and abroad. Three generations of Polish scientists have published hundreds of works in the course of interdisciplinary research, permanently inscribing the history of the town on the pages of history textbooks. The jubilee conference aimed to summarise this period rich in discoveries and to emphasise the role that early medieval Wolin played in the history of northern Europe.

At the same time, in line with the tradition of Wolin Medieval Meetings of placing the history of Wolin in the broader context of medieval research, the issue of early medieval urbanisation and its role in shaping the face of Europe at the time was proposed.

The conference was held at the Centre for International Cooperation, located in a 19th century manor house formerly owned by the Pomeranian von Below family (Fig. 1).

The event was held under the honorary patronage of the Deputy Prime Minister, Minister of Culture and National Heritage, prof. dr hab. Piotr Gliński, Minister of Foreign Affairs, prof. dr. hab. Zbigniew Rau, Minister of Education and Science, dr. Przemysław Czarnek, Deputy Minister of Infrastructure Marek Gróbarczyk, West Pomeranian Voivode Zbigniew Bogucki, and the Polish National Committee of the International Council for Monuments Protection ICOMOS POLAND. The conference was attended by nearly 70 participants (including 19 speakers) from Poland, Denmark, Sweden, Germany, Spain, Estonia, Ukraine and England.

The conference was opened by Ewa Grzybowska, Mayor of Wolin, together with the Deputy Minister of Education and Science, prof. dr hab. Włodzimierz Bernacki, and the Director of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences, prof. dr hab. Marian Rębkowski. The first paper was given by dr hab. prof. IAE PAS Mateusz Bogucki, who presented an introduction to early medieval urbanisation. Dr Wojciech Filipowiak from IAE PAS presented 70 years of archaeological research in Wolin, its course and results. He also presented the latest research results, as well as a new concept for the location of the legendary Jómsborg. Marek Konopka, from ICOMOS Poland, gave a presentation on the role of Wolin's history in European and world heritage. Professor Felix Biermann from the University of Szczecin presented Wolin in the context of the early medieval craft and trade centres on the Polabian coast, while prof. dr hab. Marian Rębkowski from the IAE PAS pointed out the relationship of Wolin in relation to the emerging early

Fig. 1. Joint photo of conference participants against the background of the Centre for International Cooperation building

Fig. 2. Signing of a letter of intent to include Wolin's heritage on the UNESCO World Heritage List and to build a new museum building. From left: Director of the Andrzej Kaube Regional Museum in Wolin dr Karolina Kokora, Deputy Minister of Education and Science prof. dr hab. Włodzimierz Bernacki, Mayor of Wolin Ewa Grzybowska, West Pomeranian Voivode Zbigniew Bogucki, Director of the Institute of Archaeology and Ethnology PAS prof. dr hab. Marian Rębkowski

Fig. 3. Sessions in the cellars of the former castle of the Dukes of Pomerania. The photo shows Dr Volker Hilberg presenting his paper

Fig. 4. The debate "The future of Wolin's past. How to protect, how to research, how to make it accessible, how to link it to the development of the modern city". From left: Marek Konopka, dr Sunhild Kleingärtner, prof. Søren M. Sindbæk, Mayor of Wolin Ewa Grzybowska, prof. dr hab. Marian Rębkowski and moderator prof. dr hab. Andrzej Buko

states of Poland and Pomerania. The final paper of day one was a presentation by the director of the Deutsche Bergbau Museum Bochum from Germany, dr Sunhild Kleingärtner, on the cultural potential of Wolin's early medieval history and its role in urban planning.

On the same day, a signing of a letter of intent to include Wolin on the UNESCO World Heritage List and to build a new building for the Wolin Museum took place. The document was signed by, among others, the Deputy Minister of Education and Science, prof. dr hab. Włodzimierz Bernacki, the West Pomeranian Voivode Zbigniew Bogucki, the Mayor of Wolin Ewa Grzybowska, the Director of the Institute of Archaeology and Ethnology PAS prof. dr hab. Marian Rębkowski and the Director of the Andrzej Kaube Regional Museum in Wolin, dr Karolina Kokora.

The event is linked to the efforts of the Wolin Municipality, the Institute of Archaeology and PAS and the Andrzej Kaube Regional Museum in Wolin to have the town of Wolin and its preserved early-medieval remains, both those located underground and those with their own field form, inscribed on the national list of Monuments of History, and then on the UNESCO World Heritage List. A joint photo of the conference participants was followed in the evening by a festive banquet at the Slavic and Viking Centre Wolin-Jómsborg-Wineta.

The second day of the conference began with papers also on Wolin. Dr hab. prof. UŚ Jakub Morawiec, presented the significance of the legend of the Viking fortress Jómsborg for the history of Wolin. In turn, prof. dr hab. Leszek Słupecki, representing the University of Rzeszów, presented a second legend related to Wolin - that of the sunken city of Vineta.

Further papers dealt with other European centres and regions. Natalia Khamaiko representing the Institute of Archaeology of the National Academy of Science of Ukraine presented Viking Age urbanisation in the core of Kyivan Rus. Dr Irene Baug from the University of Bergen in Norway considered the impact of long distance trade on Viking Age urbanisation with a particular focus on trade in stone objects – whetstones, querns and vessels. Dr Volker Hilberg from Schleswig-Holstein State Museums Foundation Castle Gottorf, Schleswig, Germany presented the latest research results on the development of craft production and trade networks in the Viking Age port of Hedeby, while dr Sven Kalmring from the Centre for Baltic and Scandinavian Archaeology, Schleswig, Germany presented the last 20 years of research on the Viking Age town of Birka in Sweden.

The second day of the conference also featured a two-hour debate entitled: "The future of Wolin's past. How to protect, how to research, how to make it accessible, how to link it to the development of the modern city", moderated by prof. dr hab. Andrzej Buko. The main participants in the debate were Marek Konopka, dr Sunhild Kleingärtner, prof. Søren M. Sindbæk, prof. dr hab. Marian Rębkowski and the Mayor of Wolin, Ewa Grzybowska.

The third day of the conference opened with a paper by prof. dr hab. Stanisław Rosik from the University of Wrocław on the formation of sacral centres of the tribal ecumenes in the towns of the Pomeranian-Slavs. Professor Søren M. Sindbæk from Aarhus University, Aarhus, Denmark spoke about the Danish craft and trade centre Ribe and its networks, presenting the results of recent research as well as the latest developments in archaeological research methodology. Dr Marika Mägi from Tallinn University, Tallinn, Estonia talked about recent research on the island of Saarema near the eastern coast of the Baltic Sea, while prof. Gitte Hansen from the University of Bergen, Bergen, Norway presented methods for analysing the urban community in 11^{th}-12^{th} century Bergen. Dr Marek Jagodziński, representing the Historical and Archaeological Museum in Elbląg, talked about the latest research results on Truso, while prof. Axel Christophersen from the Norwegian University of Science and Technology, Trondheim, Norway showed the transformation of Trondheim from a transshipment port to an urban centre *ca.* AD 900-1050. The conference was concluded with a paper by dr Karolina Kokora, director of the Andrzej Kaube Regional Museum in Wolin, who presented the history of the museum, its extraordinary, rich collection, and plans for the future. The proceedings were followed by a boat trip on the Dziwna strait.

The conference 'Towns that made Europe. 70 years of Polish archaeological research in Wolin" was organised in a special way. The proceedings were translated simultaneously from Polish and English. As the size of the meeting room and the constant threat of COVID-19 disease did not allow the conference to be open to all those wishing to attend, a professional audio-video recording of all speeches was also provided, which will be made available on the internet. The organisers also decided to use a method of recording the speeches that has never been used before at archaeological-historical conferences and to communicate them in a short and attractive form. This is graphic-recording, which is a kind of graphic summary of the speeches. It results in a graphic record of each speech, which will be made available on the internet and will also be included in the post-conference publication. The conference took place in a pleasant and friendly atmosphere, and its smooth and professional course was guaranteed thanks to the dedicated work of the staff of the Wolin City Hall, the Institute of Archaeology and Ethnology PAS, and above all the Andrzej Kaube Regional Museum in Wolin. The orga-nisers would like to express their heartfelt thanks to everyone at this point. They would also like to express their gratitude to the organising committee, which took care of the high scientific level of the meeting. The conference was financed by funds from the Town and Municipality of Wolin, the Andrzej Kaube Regional Museum in Wolin, the Institute of Archaeology and Ethnology PAS, as well as a grant from the Ministry of Education and Science (Excellent Science program, contract no. DNK/SP/567155/2022) and a private sponsor – the Mamre company. The materials from the conference will be published in print, with publication planned for 2023, and the next conference, the VII^{th} Wolin Medieval Meetings, will take place in 2024.

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REVIEWS AND SHORT REVIEW NOTES

Anna Rauba-Bukowska[1]

(Review) Aldona Kurzawska and Iwona Sobkowiak-Tabaka (eds), *Mikroprzeszłość. Badania specjalistyczne w archeologii*. Poznań 2021: Wydział Archeologii, Uniwersytet im. Adama Mickiewicza w Poznaniu.

In recent years, one of the most exciting applications of methods of other disciplines to the studies of archaeological material has been the analysis of ancient DNA (aDNA). The Nobel Assembly at the Karolinska Institutet has recognised this and awarded the 2022 Nobel Prize in Physiology or Medicine to Svante Pääbo for his discoveries concerning the genomes of extinct hominins and human evolution.

In the daily activities of an archaeologist, we do not deal with such spectacular discoveries, but scientific, technological, and IT progress has enabled the construction of sensitive and accurate machines. They make it possible to analyse very small samples and substances from thousands of years ago preserved in trace amounts - *e.g.*, in the walls of ceramic vessels. Thanks to this scientific progress, we can obtain more and more information not only from newly discovered artefacts, but also from those that have been in museums for a long time.

The book "Mikroprzeszłość" (eng. Micropast) is a very interesting work for anyone who professionally deals with archaeology, but also for lovers and enthusiasts of this field of science. In twenty-one chapters, it introduces us to the most important scientific specialities used to analyse historical material. The book's editors, Aldona Kurzawska and Iwona Sobkowiak-Tabaka, inform the readers in the introduction that the book emphasises research performed using various types of microscopes, microanalysers and, in general, on analyses at high magnifications. Each chapter includes the scientific basis of a given speciality, research methodology, the advantages and limitations of the methods, and examples of their use in archaeology. At the end of each chapter, there is rich literature.

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Most of the specialisations mentioned in the book are sciences that have developed through their close relationship with the study of historical material. These are the sciences used as standards in research on 1) the reconstruction of the ancient environment, 2) human activity in prehistory, and 3) the interrelationships of prehistoric populations.

The book can be divided into two parts. The first 11 chapters are devoted to the analysis of the remains of animate nature. The book's second part deals with the scientific disciplines dealing with inanimate nature.

The first chapter on "Palynology" by Piotr Kołaczek, Monika Karpińska-Kołaczek, Sambor Czerwiński, Katarzyna Marcisz and Mariusz Lamentowicz presents the basics of science dealing with the identification and analysis of plant pollen. These analyses make it possible to precisely reconstruct the vegetation of forests and open areas in the vicinity of archaeological sites at the time of use of the site by humans. It is also possible to make indirect conclusions about the climatic and hydrological conditions. At the same time, the authors pay attention to the issue of correct sampling methods so that the analysis gives the best results.

The chapter by Magdalena Moskal del-Hoyo presents the basics of "Archaeobotany". It is a science created at the junction of two fields: archaeology and botany. It allows us to learn the history of the use of vegetation in each area. Scientists identify plant remains obtained from archaeological sites. This research enables us to learn about flora associated with functioning a given type of site, for example, a permanent settlement camp and a cemetery, and to recognise human-plant-environment interactions. The author of the chapter devoted more attention to anthracological materials due to her speciality. She also drew attention to the importance of taxonomic identification of charcoal fragments before submitting them for ^{14}C dating.

The next chapter, entitled "Dendroarchaeology", was devoted primarily to dendrochronology, and Henryk Dąbrowski presents the details of this issue. The methodology of this field of science is explained in detail. Dendrochronology has permanently entered the scope of specialist analyses in archaeology and allows the dating of artefacts made of wood with accuracy to the year. The principle of this analysis is based on the observation and measurement of annual growth rings of trees. It is also used to calibrate radiocarbon dating results. At the end of the chapter, the author presented the most important possibilities and limitations of this research method.

The author of the next chapter is Monika Chodkiewicz, and it deals with diatom microfossils. Diatoms are single-celled plants that belong to the most common groups of algae, the occurrence of which is associated with the presence of water. Diatoms provide information about the conditions of existing water reservoirs today and in the past. Diatoms respond to changes in oxygen, PH and organic matter in the water. For this reason, they are used as bioindicators, and changes in the species composition of the diatom flora are often used as the basis for reconstructing changes in environmental conditions that occurred in the Holocene after the ice sheet retreated. Diatoms provide information about the geographic environment of past societies and facilitate the interpretation of complex relationships between culture and environment. Diatom analysis can also be used to determine the origin of archaeological artefacts (*e.g.*, ceramics) or to understand the different functions of some archaeological structures, for example, wells. The author points out that this type of research is rarely used in archaeological studies despite the significant research potential.

Izabela Zawiska presented the issue of the analysis of subfossil Diplostraca ('water fleas'). Diplostracans are freshwater planktonic crustaceans. These animals are one of the main components of freshwater plankton. About 600 species have been recognised and they live on almost all continents. Individual species differ in structure, but all are covered with a chitinous shell. The remains of diplostracans are preserved in lacustrine sediments and can be identified to the species level. Diplostracans are very sensitive to changes in the environment. The analysis of the species composition of diplostracans from the sediments makes it possible to assess changes in water fertility and, combined with the results of the palynological analysis, allows us to conclude whether these changes were the result of human activity. As a result, the study of diplostracans remains is a good tool for reconstructing environmental changes, particularly the impact of human activity on the environment.

Marcin Kadej, Szymon Konwerski and Agata Hałuszko are the authors of the chapter entitled "Archaeoentomology". This specialisation is on the borderline of archaeology and entomology. The authors introduced the reader to the information potential of this type of research. This speciality is not yet very common during standard archaeological research. However, the authors emphasise that it is becoming increasingly popular, and many communications and papers appear at international scientific conferences. The methodological basis is mainly based on entomology. In addition, they pointed out that microscopic techniques are the essential work tool of entomologists and archaeoentomologists. They allow for the identification of materials and their assignment to individual taxonomic units. Precise determination of insect species and knowledge of their ecological preferences makes it possible to learn about ancient communities' living conditions and diets.

A chapter prepared by Aldona Kurzawska presents archaeomalacology to the reader. This speciality, in turn, is a combination of archaeology and malacology, the branch of science dealing with molluscs. Archaeomalacology studies mollusc shells from archaeological sites. Shells or their fragments at archaeological sites can occur in different contexts, *e.g.* shells brought to the site by man and used as a raw material for the production of ornaments; shells as a source of calcium carbonate; shells dumped after eating, *e.g.* oysters; natural accumulation of shells. Various types of microscopes are used to study shell remains. They allow for the identification of all micro-traces created from the moment of obtaining the object by man through modification, use and deposit. Archaeomalacological analyses support archaeologists through detailed specialist analyses of artefacts made of shells.

The malacological analysis in archaeological research is supplemented by isotopic analysis of carbonate shells of freshwater molluscs. This issue was presented in the chapter entitled "Stable isotopes of carbon (đ13) and oxygen (đ18) in archaeomalacology" by Karina Apolinarska. The use of isotopic analysis of shells of freshwater molluscs is multifaceted. It allows us, for example, to determine environmental conditions and their variability over time, which is the environmental background for studying the living conditions of ancient people. The values of carbon and oxygen isotopes recorded in successive increments of the shell provide information about the seasonal variability of environmental conditions. The information recorded in fossil shells is a source of information about both long-term climate changes and seasonal variability of weather conditions. The author draws attention to the potential of isotopic studies of freshwater mollusc shells, which are less used than the study of marine mollusc shells.

Archaeozoology deals with accurately describing the animal remains found in archaeological sites. Jarosław Wilczyński presents this scientific discipline. This field's main task is identifying bone remains and explaining the formation of specific traces observed on the osteological material. The result of the analysis is the acquisition of information that is the basis for reconstructing the behaviour of ancient human communities, allowing us to know and understand their social organisation, economy, diet or religion. In addition to an interesting presentation of the standard methodology of archaeozoological research, the author introduced the issue of fossil DNA research, isotopic research of animal bones and the possibility of examining the age and season of death of the animal. In summary, attention was drawn to how much important information is provided by the analysis of animal bone material - for example, regarding hunting strategies used in the past, methods of managing livestock herds or functions and spatial organisation of the examined sites.

Physical anthropology has been for a long time collaborated with archaeology. The authors Dorota Florkiewicz-Muszyńska, Julia Sobol, Wojciech Kociemba, Anna Hyrchała and Mariusz Glapiński presented the fundamental issues concerning this field of science and its cooperation with archaeology. They explain the possibilities of modern methods of bone material research, including computer tomography, cone-beam tomography, digital radiography and microscopic techniques, for example, optical, stereoscopic, electron microscopy, and scanning microscopy. They note that bone material research could also be carried out at the molecular level – for example, DNA research. Some of these methods are still underestimated or rarely used, for example, microscopic analysis of thin sections of bone elements. An interesting subchapter is the presentation of medical imaging methods in anthropology. The result of such imaging is a reconstruction of the facial appearance based on the skull.

The introduction of this review mentions genetic research of human bones, and the chapter by Maciej Chyliński brings the reader closer to this issue. Archaeogenetics deals with the genetic analysis of prehistoric bones, *i.e.* the so-called fossil DNA (ancient DNA). Research on aDNA requires appropriate equipment, knowledge, reference databases and adherence to restrictive laboratory standards. The tests are carried out in so-called clean laboratories, separate from the laboratories dedicated to researching modern DNA. Thanks to such research, it is possible to obtain precious information, for example, about former populations or the social structure in individual cemeteries. The author also draws attention to many problems with interpreting the obtained results. At the same time, he points out that this field is developing extremely dynamically; the database is growing exponentially, the costs of DNA sequencing are decreasing, and the resolution of these data is increasing. This allows the verification of various research hypotheses, but there is a need to adapt the formulated questions to the availability of research material. I find this chapter to be the most useful. It allows people who do not have a physical education to get acquainted with the subject, making it possible to understand published research results.

From this point in the book, the chapters on the disciplines related to the Earth Sciences begin.

The first in this series is the chapter on Micromorphology written by Karolina Leszczyńska and Michał Jankowiak. Micromorphological methods analyse a broad spectrum of soils and unconsolidated sediments. Both natural and anthropogenic processes are studied and described. Undisturbed samples in the form of monoliths or thin sections are analysed. This method is used to study, for example, the genesis and evolution of soils, climate change or chronology. The authors present the methods of sample preparation, testing, and the presentation of the results. A proposal for how to describe thin sections has been submitted to help organise and compare them. Analyses of this type should be supplemented with additional tests, for example, fluorescence analysis, reflected light analysis, X-ray fluorescence spectroscopy (XRF), X-ray micro-computed tomography scanning, micro-CT scanning, gas-chromatography (isotope ratio) mass spectrometry (GC-(IR)MS).

Piotr Gunia and Ewa Lisowska presented a chapter entitled "Petroarchaeology". It deals with the research of rock and mineral resources. The purpose of the petrographic analysis of artefacts is primarily to determine the material the analysed object was made of. Then, attempts are made to determine where the rock was extracted. The primary tool of the petrographer in identifying rocks is an optical microscope under which a thin section made of stone is examined. Other analytical methods also are beneficial, for example, XRD, DTA, SEM and methods for analysing the chemical composition such as XRF, INAA and LA-ICP-MS.

One of the essential stone raw materials in prehistory is the subject of a chapter entitled "Silica raw materials – research opportunities" by Iwona Sobkowiak-Tabaka. The author discusses the most critical issues related to the absolute dating of artefacts and identifying places where flint raw material was obtained. Methods of geochemical and palynological research and organic remains preserved on flint artefacts were also presented.

The author of the next chapter entitled "Traseology" is Katarzyna Pyżewicz. During traseological research, macro and microscopic observations of flint and bone artefacts are carried out. They make it possible to determine, among other things: what techniques were used in the shaping of tools, what function a given artefact performed, what physical actions were taken with the use of tools, and what kind of raw materials were processed with given specimens. This is now a method widely used as a standard in the study of lithic artefacts.

The next chapter presents methods of testing ceramics. The chapter by Piotr Gunia, Marta Krueger and Ewa Lisowska is entitled "Ceramics – petroarchaeological research". The authors comprehensively present the methodology of research on ceramics on a microscopic scale. The essential methods of instrumental research are presented. They also give examples of the most important applications of this research and analysis during work on historical material.

The chapter entitled "Ceramics – research on organic deposits inside vessels" presents the scientific basis and methodology of research on organic residues in ceramic vessels. Marta Krueger points out that modern laboratories offer a huge cognitive range. There is also a large variety of substances that can be recognised. Therefore, already at the stage of constructing scientific projects, it is worth specifying research questions to select the best analytical methods. Analyses can be broadly divided into microscopic and molecular. It is possible to detect burnt plant remains stuck to the surface of ceramics, but also substances that have been preserved in trace amounts in the vessel walls, *e.g.* proteins, carbohydrates, alkaloids, alcohols, tar, and lipids.

In the chapter entitled "Textiles", Maria Cybulska and Anna Drążkowska presented the issue of studies and research on materials made with textile techniques. Fabrics, carpets, and other materials, *e.g.* strings, ropes, laces and knitted fabrics, are tested. Microscopic observations make it possible to identify and determine the numerical characteristics of each type of textile. They also allow the estimation of the degree of damage and the intensity of their contamination. Optical microscopes, scanning microscopes with an EDS attachment, and X-ray microtomography (micro-CT) are standard.

"Archaeometallurgy" by Marcin Biborski and Mateusz Biborski presents methods of researching metal artefacts. They can be generally divided into two directions: the archaeometallurgy of iron and archaeometallurgy of non-ferrous metals. Research issues are primarily an attempt to recreate the technology of making metal objects and identify the centres of production of these objects. The authors presented the most exciting research results, including recent research on 'Szczerbiec', the coronation sword of the Polish Kings and the famous Zygmunt Bell in the Wawel Cathedral.

The last two chapters present the use of microscopes in archaeology by Piotr Gunia, Ewa Lisowska and Aldona Kurzawska, and the use of a hand-held X-ray fluorescence (XRF) spectrometer by Michał Krueger.

In summary, the book "Mikroprzeszłość" is a much-needed work that allows the reader to become acquainted with the basics of the sciences cooperating with archaeology.

Information for Contributors

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