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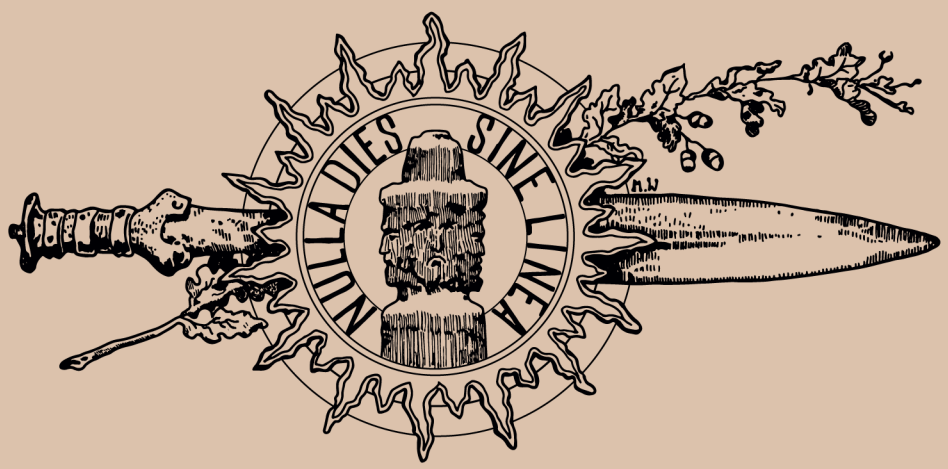

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TRADYCJE I INNOWACJE W TECHNOLOGII WŁÓKIENNICZEJ W EPOCE BRĄZU W EUROPIE I BASENIE MORZA ŚRÓDZIEMNEGO

REDAKCJA NAUKOWA

Agata Ulanowska
Małgorzata Siennicka

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TRADITION AND INNOVATION IN TEXTILE TECHNOLOGY IN BRONZE AGE EUROPE AND THE MEDITERRANEAN

EDITED BY

Agata Ulanowska
Małgorzata Siennicka

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Introduction to the Volume LVI of the 'Światowit' Journal

Dear Readers,

In the incoming year 2019 we are going to celebrate the centenary of the opening and foundation of the Institute of Archaeology at the University of Warsaw. This occasion makes all of us in the academic community very proud, since it was when the Institute became one of the most important and dynamically-developing institutions, where many generations of students could find an intellectual quiet harbour, hone their knowledge, and indulge in their fascination about the past and past cultures. One of the emblematic symbols strongly associated with this intellectual atmosphere has ever since been, and I hope it shall remain so, 'Światowit'. This archaeological journal has been considered the most important platform for presentation of research results and exchange of ideas with other scholars. If we take a careful look at the first volumes of 'Światowit', edited by one of the most prominent scholars in the history of Polish archaeology, Erazm Majewski, it will be clear that since the establishment of the journal it has been an academic and scholarly medium focusing not only on the local Polish archaeological research, but has included also contributions analysing findings, artefacts, and social and cultural processes from a much broader perspective. In this context, it is worth mentioning, especially for those Readers who have so far had little interest in the history of archaeology in Poland and the dynamics of development of this scholarly discipline, that the first volume of 'Światowit' was published as early as 1899. It makes the journal predate the history of archaeology in the Institute itself.

If we had another close look into the past, the process of the development of the journal can be clearly observed with its many editorial changes, which reflect a natural scientific, scholarly, and technological progress. It means that the 'Światowit' journal has never been a conservative medium and has instead ever been open to new ideas and research perspectives, even if sometimes they promoted controversial results or, much more often, heralded breakthroughs in our understanding of the past and past cultures with the dynamical processes of their expansion, decline, and transformation.

The technological aspects of the editorial process also required some adjustments over the years. The main goal of every change in the layout, reviewing process, or other such features was undertaken so as to help 'Światowit' become and remain a top-tier and valued archaeological periodical with readership in Poland and beyond.

This very intention was behind one of the most important recent decisions – to change the language of the journal and focus our attention on publishing articles in foreign languages, especially in English. This choice determined a thorough shift in the editorial approach and involved the latest modification of the layout of the periodical. The person who should be credited with reviving and pushing the idea of 'Światowit' forward was the late Tomasz Mikocki. He was a very dynamic personality and openly shared his ideas with other scholars and colleagues employed in the Institute of Archaeology at the University of Warsaw. As Chief Editor of the journal, he was in a position to rewrite, redefine, and renew its mission statement. One of his decisions was to split the two main channels of archaeological research and publish two volumes a year. One was dedicated to the prehistoric research and some aspect of archaeology of Poland. The other, in turn, focused on the so-called Mediterranean or non-European archaeological studies. Such state of matters continued for a relatively long time. The next two Chief Editors were simultaneously Directors of the Institute. It needs to be admitted that since Tomasz Mikocki reformed and renewed 'Światowit', it became a rule that the director of the Institute was automatically elected as Chief Editor of the journal. In consequence, with the personal involvement of Kazimierz Lewartowski and Wojciech Nowakowski, and their verve for the editorial work, it was possible to maintain the high scientific quality of 'Światowit'. The current situation, especially the internationalisation of the archaeological research, prompted another change in the editorial concept of the journal. Nowadays, the artificial border between the so-called Mediterranean research and pre- or protohistorical as well as medieval archaeology seems to be absolutely pointless. Even more so if one considers the diverse and interdisciplinary scholarly pursuits of the academic staff of the Institute of Archaeology at the University of Warsaw. Moreover, a very dynamic and active new generation of archaeologists took over as editors of the journal, which testifies that the legacy of the past generations and numerous scholars who

regularly published their contributions in 'Światowit' is still vivid among younger researchers, and thus makes keeping 'Światowit' up and running a worthwhile effort.

In parallel to the changes in the editorial team, as well as the recent activity of the journal's scientific board, the general concept of the periodical was also updated during meetings of the steering committee.

As a fruit of the said labour and choices, we are delighted to present the latest volume of 'Światowit'. It can be noticed on the first glance that in comparison to the previous editions this publication looks slightly different. The decision concerning the graphic layout of the journal, and a more open policy regarding the possible publications of the texts sent by authors not employed in our Institute, was broadly discussed, as already mentioned above. Right now, the final effect of these editorial works is becoming more visible. The whole editorial team and I personally believe that the new layout will be well-received and the scope of the problems and research published in contributions submitted to this volume, and those which shall be published in the future, will be welcomed warmly by the community of scholars and researchers.

This volume embodies the new way of thinking about our journal. The current issue contains numerous articles focused mainly on research on the ancient textile industry, fabric manufacturing, and weaving. These studies show almost the whole spectrum of this scholarly discipline and simultaneously put our new idea and concept of 'Światowit' to practice. Here, the Readers will find multi-faceted studies dealing with problems concerning textile production in the prehistory and protohistory of Northern Europe as well as the Mediterranean, Greece, Middle East, and other regions outside Europe. All of these eleven contributions were originally presented as lectures during the session '*Tradition and Innovation in Textile Technology in Bronze Age Europe and the Mediterranean*' organised by Agata Ulanowska and Małgorzata Siennicka during the 22nd Annual Meeting of the European Association of Archaeologists in Vilnius. It bears emphasising that the contributions presented in the current volume are not only of a high scholarly level, but also witness emergence of a small yet dynamic team of researchers from our Institute who are following the latest international studies on textiles and fabric manufacturing industries. Such activities represent new perspectives in archaeological research and as attempts at reconstruction of culturally- and socially-patterned behaviour in past societies will always be warmly welcomed and supported by the Institute. I hope deeply that this publication is opening a new chapter in the history of the 'Światowit' journal, which will confirm its position as one of the most important archaeological periodicals in Poland providing information on the latest state-of-the-art research endeavours. On behalf of the editors and my humble self, I can confidently say that we are ready to work hard to keep the journal on a good level and ensure its recognition among other archaeological periodicals published in the European Union.

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Tradition and Innovation in Textile Technology in Bronze Age Europe and the Mediterranean

Abstract

The papers collected in the present volume of the 'Światowit' journal examine developments in textile production in Bronze and Iron Age Europe and the Mediterranean by tracing both traditional and innovative elements in textile technology. The issue comprises 11 original contributions that resulted from the session '*Tradition and Innovation in Textile Technology in Bronze Age Europe and the Mediterranean*' organised in 2016 by Agata Ulanowska and Małgorzata Siennicka during the 22nd Annual Meeting of the European Association of Archaeologists in Vilnius. The papers discuss available archaeological evidence of textiles, textile imprints, textile tools and textile iconography, as well as botanical and faunal remains related to textile manufacture and dyeing. The papers examine the types of social relations and cultural and economic processes which may have enhanced developments in textile technology and impacted on cross-cultural transmission of textile knowledge and skills in the Bronze and Iron Ages.

Streszczenie

Tradycje i innowacje w technologii włókienniczej w epoce brązu w Europie i basenie Morza Śródziemnego

Artykuły zebrane w tym tomie „Światowita" traktują o zmianach w produkcji włókienniczej w Europie i w basenie Morza Śródziemnego w epoce brązu i żelaza. W skład tomu wchodzi 11 oryginalnych tekstów, będących rezultatem sesji pt. „*Tradition and Innovation in Textile Technology in Bronze Age Europe and the Mediterranean*" zorganizowanej przez Agatę Ulanowską i Małgorzatę Siennicką podczas 22-go *Annual Meeting of the European Association of Archaeologists* w Wilnie. Przedmiotem rozważań są tekstylia archeologiczne i ich odciski, narzędzia włókiennicze, ikonografia tekstyliów oraz inne pozostałości odnoszące się do wyrobu tekstyliów i ich barwienia. Analizowane są także relacje społeczne oraz procesy ekonomiczne, które sprzyjać mogły rozwojowi technologii włókiennictwa i wpływały na międzykulturowy przepływ wiedzy technicznej i umiejętności rzemieślniczych oraz dystrybucję wyrobów.

Keywords: textile technology, innovation, tradition, Bronze Age, Iron Age, Europe, Mediterranean

Textile archaeology has developed significantly in recent years, prompting growing academic interest in archaeological textiles, textile technology, and textile production. These developments have arisen from multi- and interdisciplinary approaches to studies of prehistoric textiles that comprise all the available evidence and comparative data, such as material-contextual, iconographic, and textual sources, as well as experimental archaeology and scientific analyses (*cf.* Rahmstorf 2015; Siennicka *et al.* 2018). As a result, textile production, with its complex technology and high socio-cultural significance, has been acknowledged as a key craft in the economies of Bronze Age Europe and the Mediterranean. In addition to this, the great diversity and complexity of knowledge and skills, as well as the large workloads required by textile-making, have been properly recognised as economically and socially important (*cf.* Andersson Strand, Nosch 2015).

Despite its complexity and importance, textile technology has often been considered rather traditional and unchanging throughout the centuries of the Bronze Age (for a discussion on traditional and innovative elements in textile production, *cf.* Nosch 2015). It is only in the last few years that innovations in textile technology, such as a spread of woolly sheep and the growing significance of 'wool economy' (*cf.* Breniquet Michel 2014; Nosch 2015; Becker *et al*. 2016; Bender Jørgensen, Rast-Eicher 2016; Sabatini in this volume), various methods of procurement of fibres and yarns (*cf.* Rast Eicher 2005; Grömer *et al.* 2013; Bender Jørgensen, Rast-Eicher 2016; Ruiz de Haro in this volume), various weaving and decoration techniques such as twill weaves, tapestry, embroidery (*cf.* Grömer *et al.* 2013; Nosch 2015; Bender Jørgensen, Rast-Eicher 2016; Banck-Burgess in this volume), as well as invention of advanced dyeing techniques such as purple dyeing (*cf.* Burke 2010; Nosch 2015; Hofmann-de Keijzer 2016; Landenius Enegren, Meo 2017) have been recognised as major developments in the Bronze Age.

In order to examine in more detail the processes that may have influenced innovations in textile technology, as well as possible factors which may have prevented textile techniques from changing through time, Agata Ulanowska and Małgorzata Siennicka organised a session *'Tradition and Innovation in Textile Technology in Bronze Age Europe and the Mediterranean'* during the 22nd Annual Meeting of the European Association of Archaeologists in Vilnius, in 2016. The session was intended to explore the ways in which traditional and innovative elements in textile technology may be traced and defined in the *longue durée* of the Bronze Age. To this end, the archaeological evidence for textiles, textile imprints, textile tools and textile iconography, as well as evidence for the botanical and faunal environment of Bronze and Iron Age Europe and the Mediterranean were analysed (see various contributions in this volume). It was also an objective of the conference to scrutinise what kinds of social relations, as well as cultural and economic processes, might have stood behind the developments in textile technology, and what their impact might have been on the transmission of textile knowledge and skills (*cf.* Ulanowska, Siennicka 2017a; 2017b).

The peer-reviewed contributions collected in the present volume of the 'Światowit' journal are the outcomes of the abovementioned EAA session in Vilnius.[1] The contributions are arranged geo-chronologically, starting with the discussion on the oldest traditions and innovations in textile-making in Europe.

In her paper "'*Nothing Like Textiles*": *Manufacturing Traditions in Textile Archaeology*', **Johanna Banck-Burgess** examines prehistoric techniques for making patterned textiles. She discusses several combinations of weaving and wrapping techniques observed in archaeological textiles from Europe dated to between the Neolithic and the Early Iron Age, and argues that manufacturing traditions were of significant importance for the value and visual appearance of prehistoric fabrics.

A study of 'textile ceramics' – impressions of textiles on Early Bronze Age ceramic vessels from Bruszczewo in Poland – is presented in the paper *'„Textilkeramik": Textileindrücke auf bronzezeitlicher Keramik vom Fundplatz Bruszczewo'* by **Stefanie Schaefer-Di Maida**. On the basis of silicone impressions taken from the original imprints on clay, she analyses technical features of the impressed textiles and suggests that second-hand textiles were used in production of pottery, as well as proposes possible aesthetic and symbolic meanings of the fabrics impressed on clay.

Serena Sabatini, in the paper '*Wool Economy During the European Bronze Age*', examines whether the conceptual frame of 'wool economy', which has been successfully applied to studies of textile production in the Near East and the Aegean Bronze Age, may also be applicable to the evidence from Bronze Age Europe. This contribution also considers the complex socio-economical mechanisms that must have stood behind the production and trade of wool in prehistory.

In the paper *'Innovative or Traditional: Diachronic Approach to Weaving Technology in Bronze Age Greece'*, **Agata Ulanowska** identifies potential innovations in weaving technology in Bronze Age Greece, as well as

[1] Unfortunately, not all of the originally presented papers could be published in this volume. For the complete list of the participants of the EAA session in Vilnius and short summaries of their presentations, *cf.* Ulanowska, Siennicka 2017a; 2017b.

discusses whether these innovations can be examined diachronically and in the context of specific socio-cultural relations. As potential innovations she suggests improvements in the construction of the warp-weighted loom, possible use of other types of big looms, and the introduction of new forms of loom weights.

Various uses of fibre-spun products, *e.g.* strings and ropes, as well the research potential of imprints of threads on clay and plaster, are studied in the contribution '*Beyond Textiles: Alternative Uses of Twisted Fibres. Evidence from Akrotiri, Thera*' by **Sophia Vakirtzi**, **Fragoula Georma**, and **Artemis Karnava**. Technical parameters of thread and string impressions from Late Bronze Age Akrotiri on Thera are also examined in relation to finds of actual strings and ropes from Akrotiri, as well as the functional parameters of textile tools discovered at the site, in order to recognise whether locally and non-locally produced threads may be distinguished.

Dominika Kofel discusses textile production and dyeing at Late Bronze Age Hala Sultan Tekke in the paper '*To Dye or Not to Dye: Bioarchaeological Studies of Hala Sultan Tekke Site, Cyprus*'. With the intention to scrutinise what kind of raw materials were used and what textile activities could have been undertaken at Dromolaxia Vizatzia, she analyses the compound evidence of bioarchaeological remains (plant macrofossils and molluscs) together with textile tools and built-in installations from the site.

The use of a spinning bowl and production of linen yarns in the Castreña culture of the Late Bronze and Iron Age are discussed by **María Irene Ruiz de Haro** in her paper '*Technical Innovation in Processing of Flax Yarn Production in the Northwest of the Iberian Peninsula: The Spinning Bowl*'. She analyses the limited and late distribution of the so-called 'spinning bowls' in relation to flax, a fibre that was presumably processed with these tools, contextualised by the raw materials and spinning techniques that were traditionally used in this region and time-period.

In the paper '*Textile-impressed Pottery Revisited: Its Usefulness for Studying Bronze Age Textile Craft in Estonia*', **Riina Rammo** examines and systematises textile impressions on pottery as indirect evidence of textile manufacturing in the Estonian Bronze Age. While discussing the limitations of the data that can be gained from the imprints, as well as the application of other items that may have been impressed on clay, she suggests that textiles were primarily impressed on clay for functional reasons, without excluding potential symbolic meanings of this practise.

Magdalena Przymorska-Sztuczka, in the paper '*A Comb or a Loom? An Attempt at Interpretation of the Szemud Urn Image*', discusses an engraving on a face-urn from the Late Bronze or Early Iron Age Szemud in Poland as a possible representation of a vertical warp-weighted loom. By presenting a comparative analysis of the Iron Age iconography of the warp-weighted loom, she suggests a new interpretation for a motif that is traditionally recognised as a depiction of a comb.

In the paper '*The Hallstatt Textiles from the Bi-ritual Cemetery in Świbie*', **Joanna Słomska** and **Łukasz Antosik** present the largest collection of archaeological textiles from the Hallstatt period in Poland. After discussing technical parameters of fabrics, braids, and threads, they argue that, unlike the other finds of archaeological textiles from the Hallstatt period in Poland, the textiles from Świbie represent several features that associate them with textile production of the Lusatian culture.

In the contribution '*Wool Textiles from the Roman Period at the Site of Grudna, Poland*', **Małgorzata Grupa** introduces unique remains of wool textiles, made using the sprang technique, that were discovered in a kurgan dated to the Roman period. She discusses the status of the person buried in the kurgan and the possible provenance, *e.g.* local or non-local, of the grave goods, including the textiles.

The editors of the present 'Światowit' volume wish to express their special thanks to Marie-Louise Nosch (Centre for Textile Research, Copenhagen) whose excellent paper '*The Wool Age: Traditions and Innovations in Textile Production, Consumption and Administration in the Late Bronze Age Aegean*' (2015) inspired them to choose tradition and innovation as the main framework for investigating developments in textile technology during the EAA session in Vilnius. We would also like to thank the colleagues from the EAA and the University of Vilnius for all the received support and help in organising the session. However, the organisation of the session would not be possible without the funding received by Agata Ulanowska from the National Science Centre in Poland for her research project 'Textile production in Bronze Age Greece – comparative studies of the Aegean weaving techniques' (FUGA post-doctoral internship at the Centre for Research on Ancient Technologies, Polish Academy of Sciences, awarded by the National Science Centre in Poland, DEC-2015/16/S/HS3/00085) and the funding received by Małgorzata Siennicka from the Research Executive Agency of the European Commission and the Marie Skłodowska-Curie Actions for her research on textile tools from Early Bronze Age Greece carried out at the University of Copenhagen (PIEF-GA-2012-329910).

The editors wish to express their gratitude to the director of the Institute of Archaeology at the University of Warsaw, Krzysztof Jakubiak, who kindly agreed to publish the proceedings of the Vilnius session in this issue of the 'Światowit' journal, as well as provided all the necessary funding for this publication. For the language proof

of the submitted contributions we are grateful to Maciej Talaga (English) and Martin Lemke (German).

Finally, the editors wish to sincerely and warmly thank all the peer-reviewers and experts who kindly advised on the submitted papers contributing their time and knowledge to improve the entire publication. These are, in alphabetical order: **Carmen Alfaro Giner** (University of Valencia, Spain), **Eva Andersson Strand** (Centre for Textile Research, Copenhagen, Denmark), **Marta Bazzanella** (Museo degli Usi e Costumi della Gente Trentina, Trento, Italy), **Lise Bender Jørgensen** (Norwegian University of Science and Technology, Trondheim, Norway), **Karina Grömer** (Natural History Museum in Vienna, Austria), **Anna Grossman** (Archaeological Museum in Biskupin, Poland), **Susan Möller-Wiering** (Archäologie und Textil, Germany), **Elena Soriga** ("L'Orientale" University of Naples, Italy), **Stella Spantidaki** (ARTEX Hellenic Centre for Research and Conservation of Archaeological Textiles, Athens, Greece), and **John Peter Wild** (University of Manchester, England).

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'Nothing like Textiles': Manufacturing Traditions in Textile Archaeology

Abstract

Textiles are evaluated mainly in regard to their visual appearance and technical features of textile production. From a modern point of view, it is their optical perception that is most often displayed in reconstructions. This, however, can rarely be achieved due to the poor and fragmentary preservation of archaeological textiles, which hinders gathering basic information about details of the production technique. Sources illustrating garments or putative textile patterns are often additionally consulted to achieve a better understanding of the textiles. Over the past two decades, the author has made an effort to present a different approach to textile archaeology, that is to demonstrate that the significance of textiles was predominantly governed by culture-specific production techniques whose differences were optical – *i.e.* at the first glance imperceptible even for experts. Textile patterns were predominantly applied during production. There was little subsequent embellishment where textiles acted as a carrier of the decoration. This means that patterns were rarely additionally integrated after the basic weave was complete, for instance as in the case of embroidery. In consequence, archaeological textiles assume a different cultural and historical significance than previously thought. They are not merely objects whose surfaces served as carriers for culture-specific patterns. In this context, embroidery is of particular significance, as it is a procedure for subsequent decoration of fabrics. In this article, the author presents prehistoric, including the Bronze and Iron Ages, textile finds that have been described as embroidery but are actually a combination of weaving and wrapping weaving techniques.

Streszczenie

„Nie ma jak tkaniny". Tradycje wytwórcze w archeologii tekstylnej

Celem artykułu jest przedstawienie tezy, konsekwentnie wysuwanej przez autorkę w ciągu ostatniego dwudziestolecia, zgodnie z którą o znaczeniu tekstyliów decydują kulturowo warunkowane techniki ich produkcji. Techniki te mogą być jednak często nierozpoznawalne na pierwszy rzut oka nawet przez specjalistów. Wzory wbudowywane były w tkaniny w czasie ich wytwarzania, a dodatkowa, uzupełniająca dekoracja, jak np. haft, stosowana była wyjątkowo i jej znaczenie było szczególne. W artykule omawiane są przykłady wzorzystych tekstyliów z epoki brązu i żelaza, które opisywane były jako tkaniny haftowane. Zdaniem autorki, wzory tych tkanin powstały jednak w efekcie kombinacji techniki tkackiej i techniki okręcania nitek wokół osnowy.

Keywords: prehistoric textile traditions, combination of weaving and wrapping weaving techniques, flying threads, embroidery

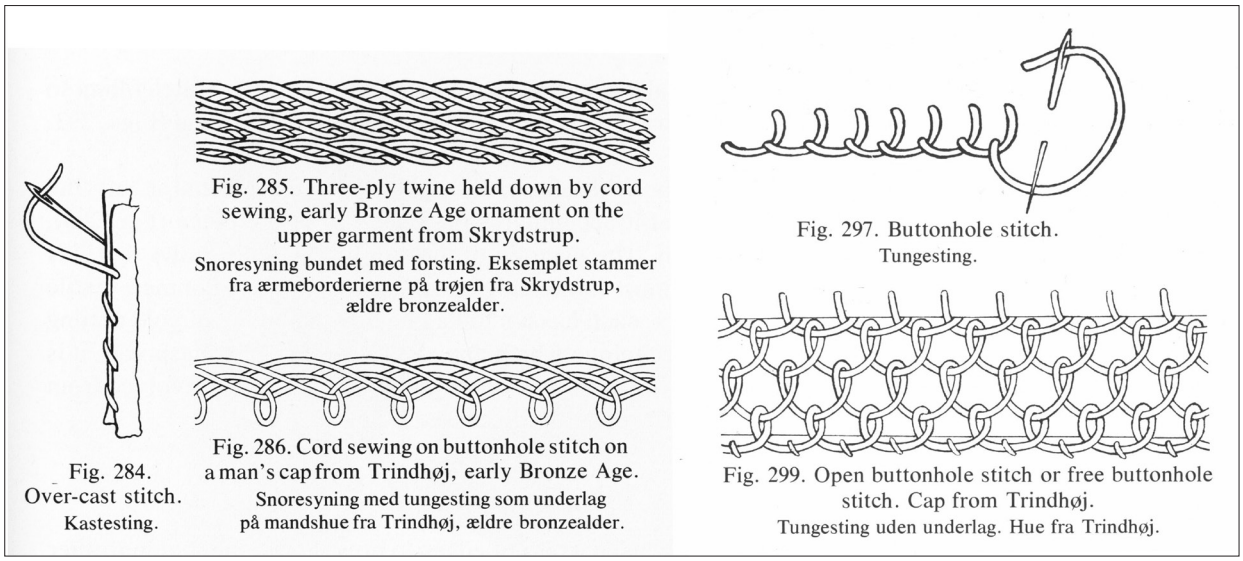

Fig. 1. After Margarete Hald who highlighted the need to distinguish between ornamental embroidery, used purely as decoration, and ornamental seams, such as "overcast stitch, buttonhole stitch (both free and as filling), pile sewing and cord sewing" (Hald 1980: 279, 281, 284, Figs 284–297, 299).

The measure of all things: textiles from Neolithic wetland settlements

The textiles from prehistoric pile-dwellings highlight how irreplaceable the use of textiles was in the everyday aspect of life at the time. The high level of knowledge and sophistication, which became very apparent by the Early Neolithic period, leaves little doubt that the method of production and materials at this level of sophistication were based on experiences stretching far back to the hunter-gatherer cultures of the Mesolithic period. With regard to textile manufacture, the beginning of weaving and use of fibre flax are frequently emphasised as significant within the context of the Neolithic Revolution. At this stage of human history, however, textiles manufactured of wood bast and vessels of tree bark made a major contribution, enabling the introduction of working processes in the areas of animal husbandry, agriculture, fishery, domestic activities, storage, and house construction. The base stock includes the products of rope-making, sewn bark vessels, various nets for fishing, as well as gathering activities and storage, remains of coil-built baskets, fabrics, and countless variations of twining (Fig. 3) used for textiles performing various functions. Their application varies from sieves through vessels to pieces of clothing.

The prehistoric pile-dwellings around the Alps, especially in Eastern Switzerland and Eastern France (Rast-Eicher 1994; 1995; 1997; Médard 2000a; 2000b; 2006; 2010; Rast-Eicher, Dietrich 2015), Southwest Germany (Feldtkeller, Körber-Grohne 1998), and Northern Italy (Bazzanella *et al.* 2003) have yielded a corpus of Neolithic and Bronze Age textiles which witness a highly-developed textile craft.

Prehistoric fabrics: manufacturing traditions from the Neolithic to the Iron Age

An examination of patterned fabrics from the Bronze and Iron Ages reveals their uncanny relations with Neolithic textile craft: a pattern of any given kind was worked into the fabric during its production. Subsequent decoration of textiles was uncommon (Banck-Burgess 1998; 1999; 2012; 2014; 2017). While the manufacturing techniques for weaving and colour patterns are self-evident, further research is still required in the case of the techniques for fabrics with additional pattern threads.

Bronze Age

The early Bronze Age fabric from Pfäffikon-Irgenhausen is one of the best-known finds that shows supplementary threads which were incorporated while weaving the ground weave.

The patterned weave was discovered in the 19th century. Fragments of it can be found in many museums all over the world (Altorfer 2010: 166–168; Altorfer *et al.* 2000/01). One fragment is dated to the Eearly Bronze Age, 1700–1440 BC (Rast-Eicher, Dietrich 2015: 55, 143). Emil Vogt already recognised that elaborate pattern had been woven into the fabric during production (Vogt 1937: 76–90). His detailed drawings show a weft-wrapping/soumak technique (Vogt 1937: Figs

Fig. 2. The ongoing process of reconstruction of the fabric from Pfäffikon-Irgenhausen/CH (Early/Middle Bronze Age; 1700-1440 BC). The pattern was worked into the fabric during weaving (Igel 2016).

120, 123–124, 127–128, 131–132, 133–138, 143, 149, 150). Simultaneously, his meticulous descriptions do not match the term 'brocaded' and its uses (Vogt 1937: 76–90). The term 'brocade' suggests that the supplementary threads are interwoven while weaving the ground weave. This is not the case for the fabric from Pfäffikon-Irgenhausen. There, the supplementary threads were looped in while the ground weave was woven.

The textile from Pfäffikon-Irgenhausen has been discussed from different perspectives concerning its manufacturing technique. While Antoinette Rast-Eicher still classifies it as embroidery (Rast-Eicher, Dietrich 2015; Rast-Eicher 2017), Hildegard Igel has demonstrated that the pattern was looped into the weave vertically, horizontally, and diagonally during weaving (Igel 2016; Banck-Burgess, Igel 2017). In a complicated experimental process, including cultivation of flax, the processing of the flax fibres, spinning, and dyeing, the fabric was reconstructed by Hildegard Igel in close cooperation with professional embroiderers (Igel 2016) (Fig. 2).

In this controversial discussion, Antoinette Rast-Eicher argues in favour of the following points: firstly, the decoration is embroidered because the ground threads are pierced; secondly, the design does not always follow the same shed in straight lines; thirdly, one direction of the weave is more stretched and must therefore be the warp. In this system the patterned threads lie. Therefore they could not be woven in (Rast-Eicher, Dietrich 2015: 96; Rast-Eicher 2017).

Hildegard Igel, who made different reconstructions of this weave, can oppose this view with the following counter-arguments: firstly, during weaving, it is not a problem to incorporate supplementary threads – looping around the warp and flowing further in the direction of the patterns until the next warp is looped; secondly, when fabrics are removed from the loom, a weaver calculates a 10% shrinkage for the warp but only a 5% reduction for the weft. This means that the system to which the patterned threads were added is undoubtedly the weft because it has less shrinkage, due to which it looks stretched. Thirdly, there are very few threads for which loose ends are visible, unlike what is characteristic for embroidery; fourthly, there are many floating threads on the back of the motifs of squares and dots, which an embroiderer would avoid to save time and yarn; fifthly, the repeated pattern on the horizontal and vertical borders would have been exactly the same if they had been embroidered. Weaving required to keep the pattern

Fig. 3. Countless variations of twining are characteristic for the prehistoric pile dwellings of Southwest Germany. The pile dwelling of Degersee (De19 527/477-1; Kat.-Nr.125; Banck-Burgess 2015: 270, Abb.10, Landesamt für Denkmalpflege Baden-Württemberg).

threads on the surface, which inevitably resulted in some kind of variations in the patterns; lastly, during the reconstruction small mistakes became noticeable after a few passages of the weft. Therefore, single pattern threads were pulled out and replaced. In this process the pattern thread sometimes pierced threads from the ground weave.

In connection with the Bronze Age find from the North Italian wetland settlement at Lago di Ledro (the province of Trento), where a tabby weave fabric featured an integrated elaborate diamond patterning (Perini 1970: 224–229; Bazzanella *et al.* 2003: 170–171), Barber posits that the origin of fabrics with complex float techniques may be traced back to finds from Neolithic wetland settlements in Switzerland (Barber 1991). In the meantime, it has been assumed within the discipline of textile archaeology that the twine-weave warp fabrics from Neolithic lakeside settlements represent the predecessors of those with complex float techniques (Fig. 3).

The finds assemblage from the Lago di Ledro includes another fabric with an inwoven pattern. While for a long time this fragment was not described as being embroidered (Bazzanella, Mayr 1995: 120; Bazzanella *et al.* 2003: 170–171), in 2012, in a short list of various textile finds, Bazzanella called it a "textile fragment with festoon embroidery" (Bazzanella 2012: 206). Presumably, this was done in regard to the fabric from Irgenhausen. Based on its similarities with the fabric from Irgenhausen, Rast-Eicher and Dietrich (2015: 109) described this find as embroidery.

Description of other fabric fragments with additional pattern threads poses similar difficulties. In the case of the Copper Age, one of the fabric finds from the Spanish cave 'Cueva Sagrad I', Sierra de Tercia (Murica; *c.* 2200 BC) was interpreted as embroidery (Rast-Eicher, Dietrich 2015: 109) – probably due to graphical rendering of the original illustration (Alfaro Giner 1992: 26, Fig. 8; 2012: 338, Fig. 16.4). Yet, the researcher editing these finds, Carmen Alfaro, has not mentioned the term 'embroidery' in any publication (Alfaro Giner 1992; 2005; 2012).

With other Bronze and Iron Age presumably embroidered fabrics it quickly becomes apparent that they in fact had nothing to do with embroidery whatsoever. A comparison with finds from the Nordic Bronze Age reveals that only selvedges, rather than 'real embroideries', have been recorded there, too. It was Margarete Hald who pointed out to the need to distinguish between ornamental embroidery, used purely as decoration, and ornamental seams, such as "overcast stitch, buttonhole stitch both free and as filling, pile sewing and cord sewing" (Hald 1980: 279, 281, 284, Figs 284–286, 297, 299) (Fig. 1). The functional significance can, of course, coincide with a decorative character, as in the case of the Early Bronze Age find from Skrydstrup in Jutland, which also had a decorative selvedge. Around the neck opening there was a seam construction (Broholm, Hald 1940: 93; Hald 1980: 279; Fossøy 2014: 79). Hald describes it as a "three-ply twine held down by cord sewing" (1980: 281, Fig. 285). Based on her view that the shape of this woman's garment resembled a half-skin poncho, Magarethe Hald discussed and named the upper garment from Skrydstrup a 'poncho'. She suggested that the decorated stitches on the upper arm were "perhaps the relic of a decorative detail camouflaging a gore in the skin to give it extra width" (Hald 1980: 345, 347, Figs 417, 426). However, there is no doubt that the part of the cloth showing decorative stitches is a construction component. The close connection between construction seams, stitches, and embroidery is also mentioned by Fossøy (2014) who notes: "Embroidery is defined here as seams that extend beyond what is necessary for the practical construction of the clothing and therefore have a decorative effect" (2014: 79).

Likewise, the finds from Skrydstrup, as well as other finds from the Scandinavian Bronze Age period, all demonstrate ornamental seams. In the case of Borum Eshøj and Egtved, there are blanket strokes "around the neck opening and the sleeve openings" (Broholm, Hald

1940: 85). True embroidery, such as the purely decorative stitches on the Viking-period fabric finds in Jutland (Munksgaard 1984), is not relevant for the Bronze Age. Real embroidered stitches are here interpreted as an ornament that rests on the basic fabric and is reduced to the function of a carrier of decoration.

In the case of the presumed blouse from Flintbek (North Germany, Period II) (Ehlers 1998: 162–165; Bergerbrant 2010: 22), we are dealing with stitched-on twines at the border of the fabric. Similarly, the twine fragments of the grave find from Heiligenthal in Lower Saxony also derive from a selvedge (Ehlers 1998: 166–170, NS 11.2b). The manner of their attachment remains unclear. The well-preserved fabric remains from Emmer-Erfscheidenveen in the Netherlands (province of Drenthe/13th century BC), considered to be a part of the garment of a male bog body, have also decorative border reinforcements. Comis describes them: "all the fragments have one or two hems finished with an embroidered decorative band made of very thin, dark brown Z-plied yarn" (Comis 2003: 194–197, especially 194).

Early Iron Age

Iron Age finds from Europe that have been published as embroideries (Hundt 1985: 108; Grönwoldt 1993: 23) are weaves where additional pattern threads were worked into the fabric during the manufacturing process. This method is known as 'the flying thread' and was frequently used for intricate pattern designs on fabric surfaces. The best examples for this are textiles from two Early Iron Age burial mounds: the early Celtic princely tomb in Eberdingen-Hochdorf, Kr. Ludwigsburg (Fig. 4) (Banck-Burgess 1999: 185, 281, Taf. 23) and the Hohmichele (Altheim-Heiligkreuztal, Kr. Biberach) (Fig. 5) (Banck-Burgess 1999: 56–58, Figs 18–23, 203) in Southwest Germany, both yielding textiles which used to be referred to as embroideries (Riek, Hundt 1962: 203; Hundt 1985: 108–110, Fig. 125). The technique of adding supplementary threads during the weaving process, which is often found described within the context of Egyptian textiles between the 4th and 9th century AD (Verhecken-Lammens 2013), was already practised during the Bronze and Iron Ages in Europe (Banck-Burgess 1999: 55–63*).*

The technique used in the manufacture of the Slovenian fabric fragment from Nové Zámky, found as a filler in a La Tène-Period bracelet and described as "embroidery" (Bender Jørgensen 1992: 107; Pieta 1992), was probably comparable to that used for the fabric from Pfäffikon-Irgenhausen, namely a combination of weaving and wrapping weaving techniques.

Examination of the Mediterranean area yielded similar information concerning the decoration techniques. In his study '*Beiträge zur griechischen Kunst*', one of the foremost connoisseurs of the Greek art, Ernst Buschor (1886–1961), pointed out that Homer did not mention embroidery anywhere, "but only ever speaks of weaving" (Buschor 1912: 30). Von Lorentz emphasises that in regard to the description of Greek finds it has been pointed out repeatedly that the patterns of these fabrics were inwoven and that up to the beginning of the Hellenistic period the Greeks had no word for 'embroidery' (von Lorentz 1937: 219). As far as there are detailed descriptions of Greek patterned fabrics, all which they mention is the tapestry weave, where piling threads are manually inwoven as required by the pattern width.

The famous linen fabric from Koropi in East Attica, referred to as embroidery and dated to the end of the 5th century BC, has not been subjected to dedicated analyses yet. The pattern is diamond-shaped and within each of the diamonds there is a walking lion depicted (Beckwith 1954: 114; Richter 1965; Banck-Burgess 1999: 227; Spantidaki 2016: 81, 112, Fig. A.67–75). Concerning the embroidery from Koropi, Stella Spantidaki refers to John Beckwith, who published the find in 1954. In her catalogue, she mentioned that "an analysis of traces of the thread used for the embroidery is necessary in order to have the complete picture" (2016: 12).

Stella Spantidaki also describes the difficulty with distinguishing between the terms 'weaving' and 'embroidery' in Greek, which denote two fundamentally different techniques. The term '*hyphanto'* (weaved) is currently used for embroidered decorations. Spantidaki expounds that the term '*katastikos*' (*κατάστικος*), which is the "closest term to embroidery in written sources", literally means to mark downwards, hence the connection to embroidery. In the same context, she notes that the decorative patterns that are visible in textile iconography could also be created using supplementary weft techniques (2016: 81, 153).

In the context of a richly decorated male tomb from Lefkandi on the Euboea, which is dated back to 825 BC, a piece of fabric with filled meander hooks was described. The pattern had been formed with additional floating threads in the chain (Popham *et al.* 1982; Barber 1991: 197; Banck-Burgess 1999: 229). Woven silver and gold threads were described in connection with silk fabrics from Nigrita in Tsagariin Nomos Serres, which were dated to the turn of the 4th and 3rd century BC (Walter 1940: 280; Granger-Taylor 1987: 29; Banck-Burgess 1999: 229).

Equally well-known is a magnificent fabric of purple and gold in which burned bones of a noblewoman in the royal tomb of Vergina (Macedonia) were hammered. The grave is dated to the 4th century BC. A fabric from a small gold shrine in the same grave is also described by Flury-Lemberg as tapestry weaving (1988: 234). Andronikos describes the pattern in the following way: "Spiral meanders border each of the four sides; within this are pliant branches, leaves, blossoms, flowers and rosettes amongst which sit two swallows" (1984: 194). Further finds from

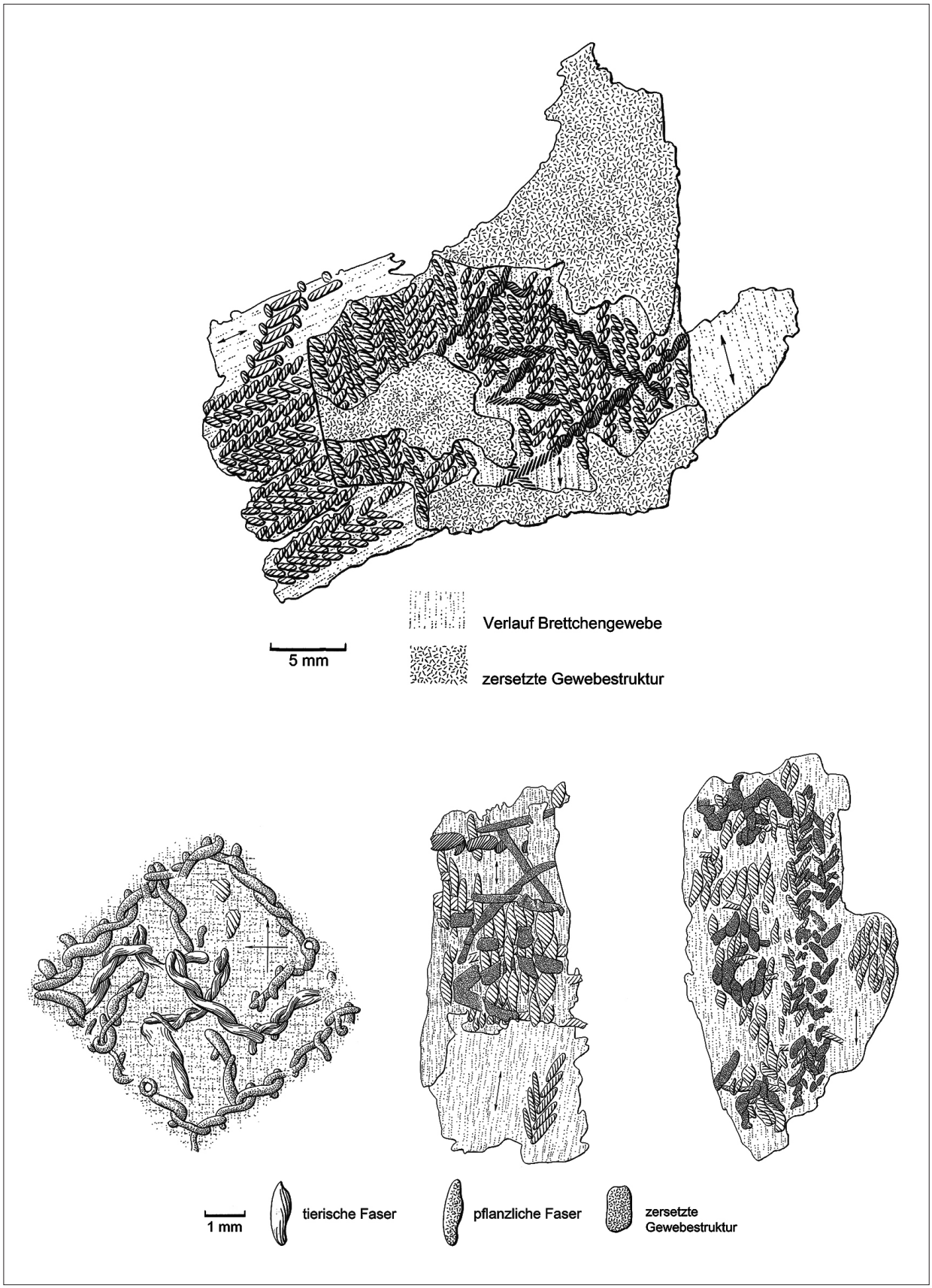

Fig. 4. Textiles from the Early Iron Age tomb Eberdingen-Hochdorf (Kr. Ludwigsburg): the additional pattern threads were worked into the fabric during manufacture (Soumak); a technique known as 'the flying thread' (Landesamt für Denkmalpflege Baden-Württemberg).

Greece and Italy (Banck-Burgess 1999: 227–232) demonstrate that all patterns which underwent a textile analysis are believed to have been woven into the fabric during production.

Nothing like textiles: on value and pattern hooping

Attempts at demonstrating the significance of archaeological textiles with reference to traditions of manufacturing techniques (not technical features) have so far received little attention. In present-day textile manufacturing, an imaginary guide to assessing its significance is either based on the material or a calculation of the time invested. It is difficult to prove what other aspects affecting the significance of prehistoric textiles were most relevant, but it is clear that material and investment in time were only two of the factors. Of equal importance was the manner or purpose of the production of the fabrics and patterns.

The example of the early Celtic textiles from the princely tomb at Hochdorf reveals an interesting phenomenon. While the production techniques represented indigenous traditions, foreign patterns were also assimilated (Banck-Burgess 1999: 52–89, esp. 53–65, 128). The notion that in European prehistoric textiles patterns were created predominantly during the production of the fabric structure suggests that textiles are set apart from other classes of material, such as ceramics or metal, as the surfaces on these objects were only decorated at a later stage, so they can be considered carriers of decorations. On the other hand, textiles are unique in that they possess an extremely mobile and communicative character in the form of garments and other similar products. Why then were other forms of decoration not chosen instead, such as embroidery, which, from a practical point of view, would have been simpler and significantly more time-saving?

This is what we are dealing with. A category of finds which retains its very own culture-specific attributes of production but at the same time acts as an important medium of communication. This demonstrates an inherent significance of this material category. There was no such thing as a textile carrier material that acted only as a medium for decoration, which means pattern hooping was used only under certain conditions. The answer to one of the research questions posed in the interdisciplinary CinBA-a HERA Research Project '*Exploring Creativity in Craft Production in Middle and Late Bronze*

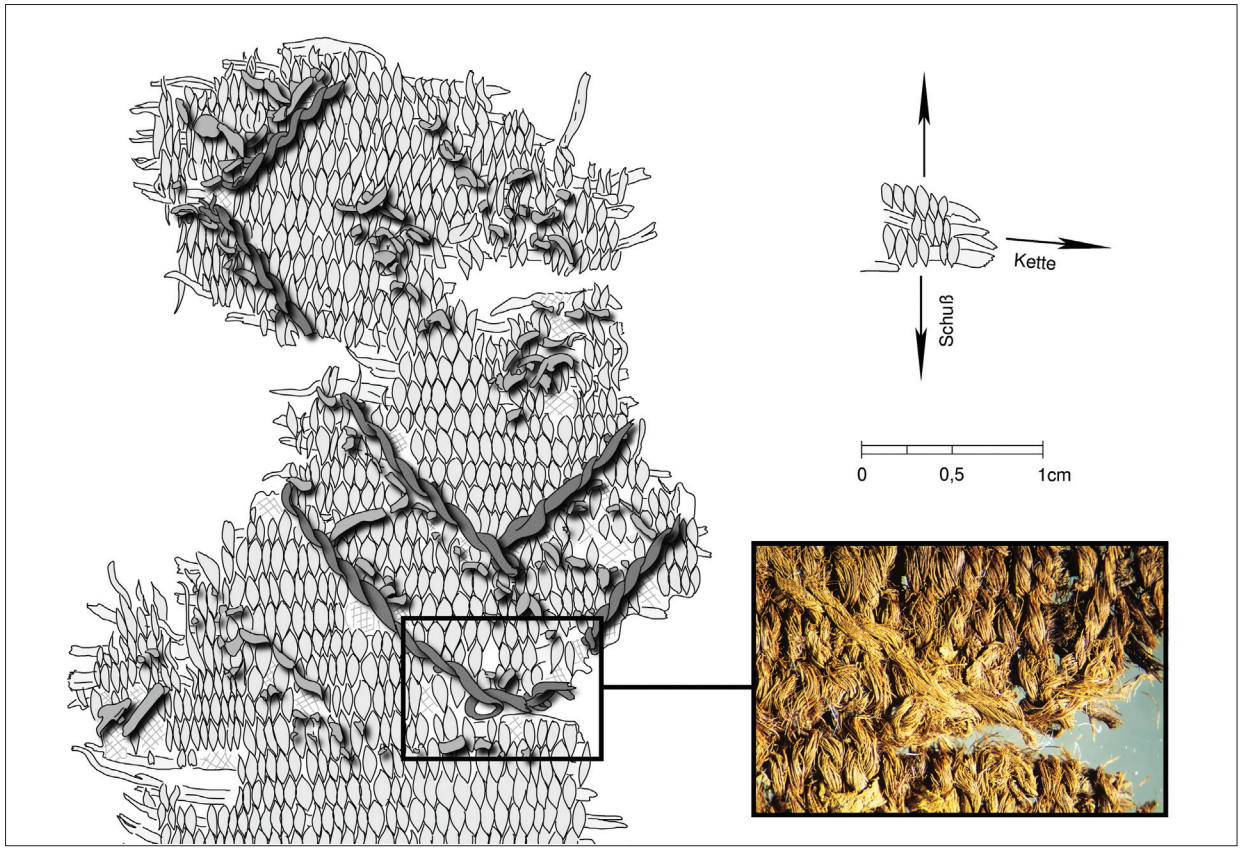

Fig. 5. Fabric from the Early Iron Age burial mound Hohmichele (Altheim-Heiligkreuztal, Kr. Biberach) shows the same technique: a combination of weaving and wrapping fabric techniques (Landesamt für Denkmalpflege Baden-Württemberg).

Age Europe', namely: "Do decorative motifs move between metals, pottery, and textiles?", can thus be restricted insofar as the realisation of decorative ornaments in textiles was governed by principles which were strongly influenced by traditions of manufacturing techniques (Bender Jørgensen *et al.* 2013).

While from a present-day point of view the crucial factors affecting evaluation are deemed to be the visual appearance of textiles or, at best, also their feel and material, it appears that for prehistoric fabrics the method of manufacture was of equal importance.

Conclusions

The derivation of weaving from wrapping weaving has now been universally accepted. Wrap-twining fabrics played an important role particularly during the Neolithic. The introduction of additional patterns in prehistoric textiles was frequently achieved by combining the techniques of weaving and wrapping weaving, like in the case of the Bronze Age fabric from Pfäffikon-Irgenhausen (CH), or the patterns of the Early Iron Age fabrics from the princely tomb in Eberdingen-Hochdorf (D). The fact that prehistoric textiles only have patterns which had been worked into the fabric during manufacture is a seminal discovery. It is thus possible to conclude that the method of production was of equal importance to the final appearance of the fabric. Subsequent decoration, as is common in embroidery, only existed in connection with selvedges. Although it is much easier and quicker to achieve patterns by embroidering rather than through a combination of weaving and wrapping techniques, the latter had largely been used in prehistory. Apparently, the significance of prehistoric textiles was predominantly associated with the traditional manufacturing techniques. Fabrics were not merely regarded as carriers of decoration, but were instead understood to be total objects. In regard to manufacturing techniques, it is often difficult to distinguish between embroidery and additional wrapping techniques. This contribution demonstrates that the majority of finds published thus far represent combinations of weaving and wrapping techniques.

It is not about proving that in prehistoric cultures there were no ornamental techniques in which a basic fabric was subsequently decorated. Instead, it should be rather understood that the production of prehistoric textiles is to be approached holistically, since the related manufacturing processes were just as important as the appearance of the finished fabric. That also means that the ground fabric was never reduced to the function of a mere decorative carrier. This understanding throws a completely new light on the social significance of textiles. In this context, the exchange or trade in textiles, and the transmission of old or the adoption of new production processes or pattern elements, have to be revisited from a new perspective.

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(ARCHÆOLOGICALsmallFINDS)

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„Textilkeramik“ – Textileindrücke auf bronzezeitlicher Keramik vom Fundplatz Bruszczewo

Zusammenfassung

Der Artikel stellt die Ergebnisse einer Studie zur „Textilkeramik“ – Abdrücke von Textilien auf Wänden keramischer Gefäße – aus der frühbronzezeitlichen befestigten Siedlung Bruszczewo (Großpolen) vor. Auf der Basis von Silikonabdrücken kann eine Analyse hinsichtlich der Spinn- und Zwirnrichtungen, Fadenstärke sowie der textilen Strukturen und Techniken durchgeführt und eine Einteilung in die Typen: Zwirn, Faden, Flächenbildung, Leinwandbindung und Sprang vorgenommen werden. Die Lage der Abdrücke auf der Gefäßoberfläche sowie die Diskussion über die praktische, ornamentale und symbolische Bedeutung der Abdrücke erlaubt Interpretationen hinsichtlich der Funktion und Verwendung von „Textilkeramik“. Nach der Einbettung der „Textilkeramik“ aus Bruszczewo in den Kontext nord- und zentraleuropäischer Materialien stellt sich heraus, dass „Textilkeramik“ das Wissensspektrum im Hinblick auf prähistorische Textiltechniken ergänzt und überwiegend zerschlissene Textilien sekundär für die Keramikproduktion in der Vorgeschichte verwendet wurden.

Streszczenie

„Ceramika tekstylna” – odciski tekstylne na naczyniach z epoki brązu ze stanowiska Bruszczewo

Artykuł prezentuje rezultaty badań nad „ceramiką tekstylną”, czyli odciskami produktów tekstylnych na naczyniach ceramicznych z wczesnej epoki brązu, z ufortyfikowanej osady w Bruszczewie (Wielkopolska). Dzięki zastosowaniu silikonowych odcisków możliwe jest przeanalizowanie kierunku skrętu i splotu oraz grubości nitek, jak również zastosowanych technik włókienniczych, oraz rozróżnienie typów skrętu, rodzaju przędzy, tkanin, wyrobów nietkanych i plecionek, jak *sprang*. Rozważania na temat umiejscowienia odcisków tkanin na powierzchni naczyń ceramicznych, jak również praktycznego, dekoracyjnego i symbolicznego znaczenia odcisków, pozwalają na interpretacje dotyczące funkcji i zastosowania „ceramiki tekstylnej”. Analiza zabytków z Bruszczewa na tle szerszego kontekstu Europy północno-środkowej pokazuje, że „ceramika tekstylna” uzupełnia naszą wiedzę na temat technik tekstylnych i produkcji ceramiki. Dowodzi także, że do wykonywania odcisków na prehistorycznej ceramice często wykorzystywano zniszczone już tkaniny.

Abstract

“Textile Ceramics” – Textile Impressions on Bronze Age Pottery from the Site of Bruszczewo

The article presents results of a study of “textile ceramics” – impressions of textiles on walls of ceramic vessels – from the Early Bronze Age fortified settlement of Bruszczewo (Greater Poland). On the basis of silicone impressions, an analysis of spinning and twisting directions, as well as textile density, structures, and techniques can be conducted along with their differentiation into twists, threads, non-woven fabrics, tabby weaves, and sprang. The position of impressions on the surfaces of the vessels, as well as a discussion concerning practical,

ornamental, and symbolic meaning behind the impressions, allow for formulating interpretations in terms of functions and use of "textile ceramics". A close examination of the "textile ceramics" from Bruszczewo against the broader context of the Northern and Central European material indicates that production of ceramics in prehistory was predominantly performed with secondarily used damaged textiles.

Keywords: „Textilkeramik", Silikonabdrücke, Bronzezeit, Bruszczewo, Polen, Europa

Einleitung

Die Erhaltung organischer Materialien, wie etwa prähistorischer Textilien, hängt von Klima, Bodenbeschaffenheit und Standort ab (pH-Wert, Sauer- und Nährstofflage, Wärme- und Wasserzufuhrbedingungen, siehe Grömer 2010: 32–34).[1] Aufgrund der widrigen Umstände sind prähistorische Textilien in Mitteleuropa nur selten erhalten. Häufig stellen sie Teile reicher Grabausstattungen dar, zum Beispiel im frühbronzezeitlichen Frauengrab von Franzhausen (Grömer 2010: 166–167) oder im hallstattzeitlichen Grab von Hochdorf (Grömer 2010: 275). Sie treten in diesen Kontexten in größeren Mengen auf und sind aufgrund einer höheren Wahrscheinlichkeit vorhandener Metallbeigaben häufiger auch dank Metallkorrosionen erhalten geblieben. Der Erhalt von Alltagstextilien oder Textilien aus Gräbern mit geringerer Ausstattung ist demgegenüber eher schwach ausgeprägt.

Der Erhalt prähistorischer Keramik gestaltet sich hingegen sehr gut. Dementsprechend geben uns Eindrücke von Textilien auf Keramikoberflächen – sogenannte „Textilkeramik" – die Möglichkeit, Informationen über die Textilien und Textiltechniken zu gewinnen, wenn das Originaltextil nicht erhalten geblieben ist. Die Hinzuziehung von „Textilkeramik" in die Forschungsdiskussion kann das Wissensspektrum entsprechend erweitern und erlaubt auch eine Betrachtung alltäglicher Textilien.

Bis vor kurzem wurde „Textilkeramik" in der Textilforschung des prähistorischen Europas weitgehend unterschätzt. Oftmals wurde die „Textilkeramik" nur beiläufig in der Literatur erwähnt oder in Einzelstudien diskutiert (z.B. Jaanousson 1981; Hulthén 1991; Gustavsson 1997; Fogel, Sikorski 2006; Rammo in diesem Band). Eine umfangreiche Studie liegt lediglich für die finnische „Textilkeramik" vor (Lavento 2001).

Dabei ist die Einbeziehung von „Textilkeramik" vor allem in Gebieten wichtig, in denen Textilien auf keine andere Weise erhalten sind. In Polen zum Beispiel ist das prähistorische Vorkommen von Textilien bis zur Hallstattzeit nur anhand von „Textilkeramik" ersichtlich (Maik 2012: 295–297; Schaefer 2016). Und auch in Estland sind direkte Nachweise von Textilien erst ab der römischen Eisenzeit vorhanden (Kriiska *et al.* 2005: 19; Lang 2007: 136–127; *cf.* Rammo in this volume).

In der frühbronzezeitlichen befestigten Siedlung Bruszczewo in Großpolen wurden etwa 600 textilbedruckte Scherben gefunden. Die Analyse eines Teils der „Textilkeramik" war Gegenstand der Masterarbeit der Autorin. Die Untersuchung des Materials aus Bruszczewo wirft viele Fragen hinsichtlich zeitlicher und räumlicher Verteilung, Produktion, Funktion und Bedeutung von „Textilkeramik" im Allgemeinen auf. Die diesem Artikel zugrundeliegende Masterarbeit befasste sich deshalb nicht nur mit der Analyse des Materials vom Fundplatz Bruszczewo, sondern auch mit dem Auftreten prähistorischer „Textilkeramik" in Zentral- und Nordeuropa im Allgemeinen sowie der Einbettung des Materials aus Bruszczewo in den zentral- und nordeuropäischen Kontext (Schaefer 2016).

Diese Abhandlung soll eine kurze Einführung in dieses Thema geben. Nach der Auseinandersetzung mit der Definition von „Textilkeramik" wird das Material vom Fundort Bruszczewo vorgestellt und unter spezifischen Gesichtspunkten analysiert. Die quantitative Darstellung der Analyse zur nord- und zentraleuropäischen „Textilkeramik", sowie ein Überblick über die „Textilkeramik" vom Fundplatz Bruszczewo im Kontext Nord- und Zentraleuropas, wird aufgrund der Größe der Datenbank nur zusammenfassend dargestellt.

Definition

Bei der Definition von einem Textil beziehungsweise textilen Techniken bedient sich diese Untersuchung der Definition von Banck-Burgess: „Unter T. [Textilien]

[1] Die Studie zum vorliegenden Artikel wurde durch den SFB 1266 und das Institut für Ur- und Frühgeschichte der Christian-Albrechts-Universität zu Kiel unterstützt.

werden hier alle Bestandteile oder vollständigen Objekte verstanden, bei denen einzelne oder mehrere Elemente, vorwiegend aus organischem Material, so miteinander verbunden werden, dass sie eine textile Struktur erkennen lassen“ (Banck-Burgess 2005: 372).

Dieser Definition entsprechend werden in der vorliegenden Studie bereits einfach verarbeitete organische Materialien, wie Fäden oder Zwirnungen, als Textil aufgefasst.

Der Begriff „Textilkeramik“ ist, aufgrund vielfältiger Bedeutungen, die diesem Begriff in der Literatur zugeschrieben werden, hingegen schwieriger zu definieren.

Einige Termini werden mit rein visuellen Attributen in Verbindung gebracht, wie z.B. im Fall der „Spunspeckled impressed pottery“ (SSP), wie sie von Patrushev (Patrushev 1992) definiert wurde: In seinem Aufsatz verwendet er den Begriff SSP anhand rein visueller Merkmale der Eindrücke (die meistens von gesponnenem Material stammen und scheinbar gesprenkelt auf der Keramikwand auftreten) und ohne Berücksichtigung der technologischen Aspekte. Definitionen, die auf rein optischen Parametern basieren und sich nicht mit den Textiltechniken befassen, sind jedoch nicht aussagekräftig genug.

Andere Begriffsdefinitionen sind sehr weit gefasst und werden nur für Materialien eines bestimmten geographischen Gebietes verwendet (wie die „Textilkeramik“ von Lavento in Finnland, Lavento 2001). Die Gleichsetzung mit einer „textilkeramischen Kultur oder die Einbeziehung von textilen Eindrücken in das Spektrum der für eine gegebene Kultur typischen Oberflächenbehandlungen erfolgt je nach Region unterschiedlich. Eine allgemeine Definition wurde bis zu dieser Studie nicht formuliert.

Die von den einzelnen Forschern verwendeten Bezeichnungen entstammen unterschiedlichen Definitionen, die sowohl funktionale als auch kulturelle Analysen umfassen. So trennt Lavento beispielsweise die Begriffe „textile ceramic“ [„Textilkeramik“] und „textile impressed ceramic“ [„textilbedruckte Keramik“], wobei letzterer den Textilabdruck als Oberflächenbehandlung meint. „Textile ceramic“ sei laut Lavento hingegen eine weiter gefasste Definition, die sich auf Keramiktypen mit kulturellen und chronologischen Verbindungen anwenden lasse, wie die Sarsa-Tomitsa-Keramik aus Finnland und der Republik Karelien (Lavento 2001: 20). „Textilkeramik“ muss laut Lavento nicht immer einen Textilabdruck haben, sondern kann auch eine glatte, eine anderweitig behandelte Oberfläche oder Ornamente wie Kammsticheindrücke haben (Lavento 2001).

Auch in anderen Literaturbeispielen wird der Textilabdruck oft als Merkmal einer typologischen Keramikgruppe herangezogen, die willkürlich „Textilkeramik“ (oder Textilkeramikkultur, *etc.*) genannt wird. Diese Parallelisierung ist schwierig, da Textilabdrücke auch in vielen anderen Keramikarten zu erkennen sind. Merkmale der Sarsa-Tomitsa-Keramik, die oft mit dem Begriff „Textilkeramik“ gleichgesetzt wird, sind auch im Rahmen der Pölja-Keramik oder Kiukainen-Keramik bekannt. Paradox ist auch, dass, laut Lavento, Textilabdrücke zum Beispiel in der Kiukainen-Keramik früher auftreten, als das eigentliche kulturelle Phänomen der „Textilkeramik“ (Lavento 2000: 105). Problematisch ist auch die Verwendung des Begriffs „Textilkeramik“, der mit einer entsprechenden kulturellen Identifikation verbunden ist, da sie fast überall und in der gesamten Prähistorie vorkommt (Schaefer 2016).

Aus diesem Grund werden z. B. von Russischen Forschern in der Literatur zu diesem Thema neutrale Begriffe verwendet, wie „Net Pottery“ [Netzkeramik] oder „Net Ware“ und manchmal auch „Wafer Ware“, die alle Gras-, Leder- oder Kammabdrücke umfassen, sowie verschiedene Textil- und Pseudotextiltechniken (Pseudotextiltechniken imitieren „Textilkeramik“, deren Eindrücke nachgeahmt wurden, d.h. sie stammen nicht von Textilien, sondern z.B. von Stempeln, Werkzeugen, Kiefernzweigen/Nadeln, *etc.*). Die Abdrücke können so angeordnet sein, dass sie eher als Dekor denn als Oberflächenbehandlung gelten können (Moora 1938; Carpelan 1970: 23–25; Okladnikov 1970: 69; Reisborg 1986: 91). In der Tradition dieser „Net“ Termini ist das einzige relevante Element, das einen Abdruck unter die Definition von „Textilkeramik“ fallen lässt, dass der Eindruck wie ein Netz aussieht (Kosmenko 1996: 51; Lavento 2001: 20, 36; Eriksson 2009: 134). Problematisch ist aber auch die Verwendung solch weit gefasster Begriffe, da eine Unterscheidung zwischen funktionalen Oberflächenbehandlungen und Ornamenten auf Basis dieser Definition überhaupt nicht möglich wäre.

In der polnischen Literatur wird häufig der Begriff „ceramika tekstylna“ verwendet, aber auch Begriffe wie „ornament tekstylny“ (z.B. Kostrzewski 1926: 212; Jasnosz 1974: 87, 91; Silska 2001: 72) oder „schropowacenie odcinkami tekstylnymi“ (Gedl 1975: 62; Silska 2001: 72) finden wiederholt Anwendung für „Textilkeramik“. Während letztere jedoch nur eine praktische Funktion dieser Abdrücke betont („die Oberfläche mit Textilfragmenten aufrauen“), unterstreicht „ornament tekstylny“ dagegen lediglich eine dekorative Rolle (Silska 2001: 72). Hinsichtlich der textilbedruckten Keramiken vom Fundplatz in Bruszczewo, verwenden Silska und Podkańska jenen undifferenzierten, ornamentbezogenen Begriff (Podkańska 2012).

Für die vorliegende Forschungsarbeit wird der Begriff „Textilkeramik“ wie folgt definiert: es handelt sich um eine Art der Oberflächenbehandlung von Keramik, die dekorativ und/oder symbolisch und/oder funktional sein kann, wobei die Textilabdrücke absichtlich oder zufällig erzeugt wurden. Der Abdruck stammt dabei von einem Textil, das der oben genannten Definition entspricht. Erst wenn das für den Abdruck genutzte Textil auch als

solches identifiziert werden kann, handelt es sich um „Textilkeramik".

Produktion und Funktion von „Textilkeramik"

Textilabdrücke auf Keramik entstehen beim Aufbauen und Formen eines Gefäßes, solange der Ton noch elastisch genug ist. Zufällige Abdrücke an der Gefäßwand (außen) lassen sich nur bedingt von gewollten Textilabdrücken unterscheiden. Solche zufällig entstandenen Abdrücke sind z.B. jene, die unter Zuhilfenahme eines Textils für das Aufbauen und die Formgebung des Keramikgefäßes entstanden sind und anschließend nicht oder nur teilweise geglättet wurden und so Spuren auf dem Gefäß hinterlassen haben. Präzise und umfangreiche Abdrücke hingegen deuten eher auf ein bewusstes Aufbringen hin. Intentionell aufgetragene Textilabdrücke können neben ornamentalen Gründen auch funktional bedingt sein, indem so die Oberfläche des Gefäßes vergrößert wird. Dies begünstigt die Emission der Wärmeenergie von Flüssigkeiten und erzeugt einen Kühleffekt. Darüber hinaus ermöglicht die Aufrauhung der Keramik durch Textilabdrücke eine bessere Handhabung des Gefäßes (Jaanousson 1981: 138–139; Hulthén 1991: 17). Auch kann ein frisch getöpfertes Gefäß mit einem Textil umwickelt worden sein, um den Trocknungsprozess zu verzögern und so Rissbildungen zu verhindern (Reisborg 1986: 93; Björck, Larsson 2007: 72; Eriksson 2009: 137–138) um dem Zerspringen des Gefäßes beim Brennen vorbeugen zu können (Pälsi 1916: 66–68). Auch ist eine symbolische Bedeutung der Textilabdrücke auf Keramikgefäßen denkbar. Beispielsweise könnte die Oberfläche eines Gefäßes, das durch Textilabdrücke modifiziert wurde, einen bestimmten Gefäßinhalt symbolisiert haben. Das Verwenden eines bestimmten Stils von Textilabdrücke auf Keramik kann auch als Identitätsmerkmal innerhalb einer Gruppe oder zwischen Gruppen gedient haben. Ein ethnographischer Vergleich aus dem Sudan (For im Jebel Marra) zeigt zum Beispiel, dass der Mattenabdruck, der zwangsläufig beim Aufbau und Formen von Gefäßen entsteht, als typische Signatur des Herstellers angesehen wird und je nach angestrebtem Glättungsgrad des Herstellers bewusst mehr oder weniger stark erhalten bleibt (Soeffing 1988: 65). In Dogon (Mali) hat das Aufrauen von Keramik mit Textilien zwei verschiedene Funktionen: Einerseits symbolisiert es das erste Menschenpaar (die Mattendrucke stellen Köpfe mit kurzen lockigen Haaren dar), andererseits bewirkt es den praktischen Kühleffekt (siehe oben) (Vorbrich 1980: 477).

Anhand der oben genannten Beispiele sind der Herstellungsprozess und die Funktion eines textilkeramischen Gefäßes individuell von Fall zu Fall zu analysieren, wobei das Design, die Positionierung, der Glättungsgrad und die Beziehung zwischen den Abdrücken und anderen dekorativen Elementen eines Gefäßes zu bestimmen sind. Erst dann lassen sich Rückschlüsse auf ornamentale, funktionale und symbolische Absichten ziehen und eventuell zufällige von intentionellen Abdrücken trennen.

Im folgenden Abschnitt wird der Fundplatz in Bruszczewo als Fallbeispiel für die Analyse von „Textilkeramik" herangezogen. Bevor die Analyse durchgeführt wird, werden das verwendete Verfahren und die Methodik beschrieben.

Fallstudie: Bruszczewo

Vom frühbronzezeitlichen Fundort Bruszczewo in Großpolen, einer befestigten Siedlung der Aunjetitz-Kultur (2300–2200 bis 1600–1500 v. Chr., *cf.* Jockenhövel 2013: 725), sind etwa 600 Scherben mit Textilabdrücken bekannt. Die Siedlung befindet sich auf einem Geländevorsprung, der spornartig in die Aue des Flusses Samica hineinragt. Unterhalb dieses Siedlungssporns wurden Reste weiterer Siedlungsaktivität in Feuchtbodenmilieu entdeckt. Rund 500 Scherben vom Sporn wurden von den polnischen Kooperationspartnern vom Institut in Poznan dokumentiert, während etwa 100 Scherben aus dem Feuchtbodenbereich unterhalb des Sporns stammen. Letztere bilden die Grundlage dieser Studie.

Die „Textilkeramik" weist im Feuchtbodenbereich der Siedlung eine nahezu gleichmäßige Verteilung auf und ist sowohl innerhalb als auch außerhalb möglicher Hausstrukturen zu finden. Eine Verbreitungskarte der gesamten „Textilkeramik" in Bruszczewo zeigt eine Hauptkonzentration im Zentrum der Siedlung und eine kleinere im östlichen Feuchtgebiet (Abb. 1).

Vorgehensweise und Methoden

Für eine genaue Analyse der einzelnen Abdrücke auf den Scherben wurden Silikonabdrücke verwendet. Hierfür wurde ein ursprünglich für Zahnärzte entwickeltes Zweikomponentenmaterial (Panasil contact plus X-light) verwendet. Sobald die beiden Komponenten miteinander vermischt sind, härtet das Gemisch aus und behält seine Form bei. Beim ersten Versuch wurde die Masse direkt auf die Keramik aufgetragen. Nach weniger als einer Minute war die Masse hart und konnte entfernt werden. Es wurde festgestellt, dass beim Ablösen des Silikons auch einige Partikel der Magerung von der Keramikoberfläche entfernt wurden. Zum Schutz der Keramik wurde eine 3%ige Lösung von Paraloid B44 in Lösungsmittel (z.B. Aceton) gelöst (3 g Paraloid pro 97 g Lösungsmittel) und vor der Silikonabformung auf

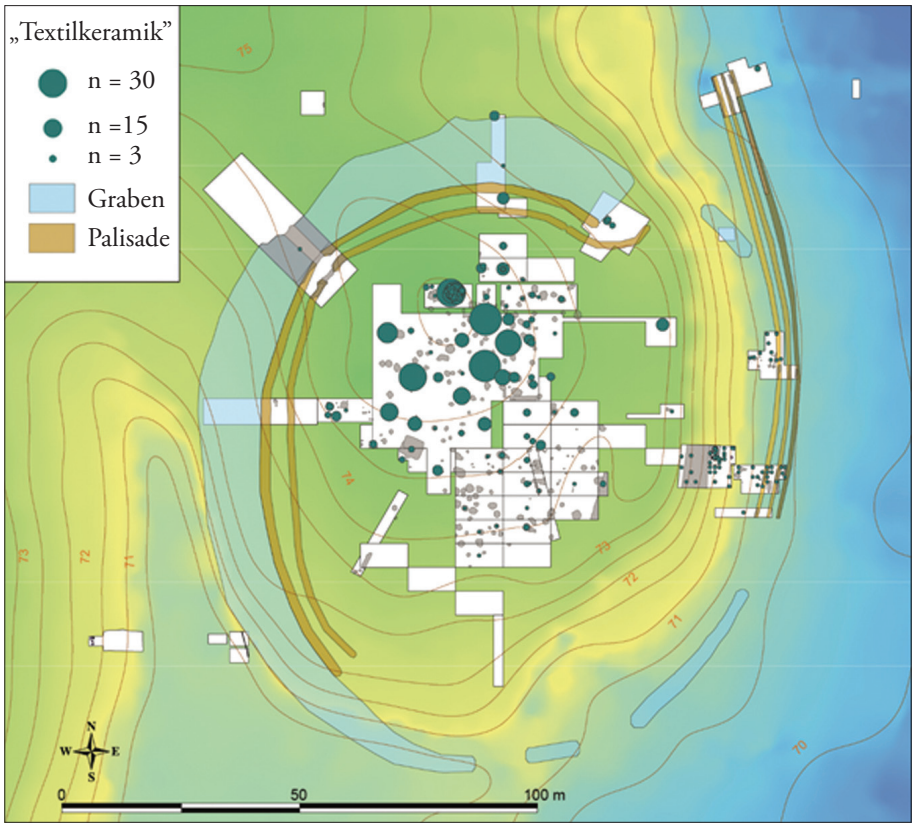


Abb. 1. Die Verbreitung der „Textilkeramik“ am Fundplatz Bruszczewo, Großpolen (Schaefer, Kneisel forthcoming).

die Scherben aufgetragen. Die keramische Struktur wird durch die Lösung verstärkt und Silikonöle können nicht mehr in den Ton eindringen. Die Lösung wurde bis zu siebenmal in dünnen Schichten mit einem Pinsel aufgetragen. Nach dem Auftragen verbleibt auf der Keramik ein leicht glänzender Film, der bei Bedarf entfernt werden kann. Anschließend konnte die Keramik nach einer Reaktionszeit von *ca.* 15 Minuten mit der Silikonmasse beschichtet werden. Nach dem Aushärten der Silikonmasse ließ sich die ausgehärtete Abformmasse problemlos von der Keramik entfernen. Als das Silikon von der Keramik abgelöst wurde, erlitt sie keinen Schaden mehr.

Damit stellt der Silikonabdruck nun das Positiv des Textils dar, mit dem früher der Abdruck auf dem Gefäß vorgenommen wurde. Für weitere Analysen ist der keramische Schrumpfungsprozess um ungefähr 10–20 Prozent während des Brennvorgangs zu berücksichtigen (Botwid 2016: 47). Vom Fundplatz Bruszczewo wurden von 92 textil-bedruckten Keramikfragmenten Silikonabdrücke angefertigt.

Unter einem beleuchteten Vergrößerungsglas (2-fache und 5-fache Vergrößerung) mit günstigem Seitenlicht wurden die textilen Strukturen anhand der Scherben (als Textilnegativ) und ihrer Silikonabdrücke (als Textilpositiv) analysiert: Einzelne Fäden, Fadenstärken, Spinn- und Zwirnrichtungen sowie textile Techniken sind im Silikonabdruck sehr gut sichtbar. Eine Analyse einzig und allein anhand des Abdrucks in der Keramikscherbe ist hingegen schwieriger, da die dunkle Färbung und unelastische Konsistenz des gebrannten Tons ungünstig sind. Das Silikon hat jedoch eine einheitliche Farbe und begünstigt die Analyse zudem durch seine elastische Beschaffenheit. Anhand der Silikonabdrücke konnten zu Beginn vier der Scherben aussortiert werden, da bis auf andere Oberflächenbehandlungen (z.B. mit Besen, Fingerspitzen, *etc.*), keine textilen Strukturen erkennbar waren.

Analyse der „Textilkeramik“ aus Bruszczewo

Nach der Erfassung der Charakteristika positiver und negativer Abdrücke konnten diese analysiert und in Typen eingeteilt werden, indem die verschiedenen genannten Parameter (Fadenstärke, Spinn- und Zwirnrichtung und das Zusammenspiel verschiedener Fäden zur Erkennung der dahinterliegenden Textiltechniken) berücksichtigt wurden.

Die Silikonabdrücke können auch zur Bestimmung der Spinn- und Zwirnrichtung verwendet werden, sofern Qualität und Größe der Textilkeramikprobe dies zulassen. Es wird unterschieden zwischen S- und Z-Spinn- und Zwirnrichtung. Die jeweilige Orientierung – erkennbar

an der Maschenbildung – gibt an, in welche Richtung das Garn mit Hilfe einer Spindel gedreht wurde (Barber 1991: 65–66; Grömer 2010: 80, Abb. 28). Das gesponnene Garn kann dann gezwirnt werden, was mindestens zwei gesponnene Fäden erfordert. Die Zwirnrichtung ist unabhängig von der Drehrichtung des Spinnvorganges. Gewöhnlich werden Fäden in die entgegengesetzte Richtung gezwirnt, in der sie vorab gesponnen wurden. Die Drehrichtung kann auch am Fadeneinzug erkannt werden. Bei einer S-Spinn- oder Zwirnrichtung ziehen die Fäden von links oben nach rechts unten ein und erinnern an eine S-Form. In Z-Spinn- oder Zwirnrichtung laufen die Garne und Fäden wie bei einer Z-Form von rechts oben nach links unten (Gleba, Mannering 2012: 9).

Die Abdrücke der „Textilkeramik" aus Bruszczewo zeigen, dass der Großteil der verwendeten Textilien (59 Scherben: 73%) aus S-gesponnenem Material hergestellt wurde. Nur in sechs Fällen (7%) konnte eine Z-Spinnrichtung erkannt werden. Bei 16 Scherben (20%) ist die Drehrichtung nicht erkennbar. Es kann also davon ausgegangen werden, dass die Textilien in Bruszczewo hauptsächlich S-gesponnen wurden.

Die Zwirnrichtung ist dagegen variabler. Eine knappe Mehrheit der textilen Strukturen von 35 Scherben (42%) wurde in S-Richtung verdreht. Die Z-gezwirnten Textilien treten in 32 Fällen (38%) auf. Bei 13 Proben (15%) scheint eine Zwirnung vorhanden zu sein, aber die Richtung der Verdrehung ist nicht erkennbar. Für vier Scherben (5%) wurden anscheinend Textilien verwendet, die eindeutig nicht gezwirnt waren. Die Textilien aus Bruszczewo wurden somit nahezu gleichmäßig in S- und Z-Richtung verdreht.

Die Spinn- und Zwirnkombinationen zeigen, dass S-Spinnen und S-Zwirnen mit 31 Proben (56%) dominieren. Es folgen S-gesponnene und Z-gezwirnte Strukturen mit 18 Scherben (33%). Z-Spinn- und Z-Zwirn-Kombinationen sind dagegen selten und mit nur 3 Scherben (5–6%) vertreten. Ähnlich verhält es sich mit verschiedenartigen Spinn- und Zwirnkombinationen, die nur selten auf Scherben zu sehen sind (3 Proben, 5–6%). Letzteres tritt häufig auf, wenn für die Abdrücke Textilien mit feinen und groben Strukturen verwendet wurden. Überraschend ist die vorherrschende Kombination von S-Spinn/S-Zwirn, da Textilien meistens in entgegengesetzte Richtungen gesponnen bzw. verdreht werden (Gleba, Mannering 2012: 9).

Die zur Herstellung der Abdrücke verwendeten Textilien weisen eine Vielfalt an Materialien und Fadenstärken auf (ohne Berücksichtigung des keramischen Schrumpfprozesses beim Brennen). Im zweistelligen Bereich der Scherbenzahl dominieren Verteilungen zwischen einem Millimeter und zwei Millimetern. Darauf folgen die Werte zwischen weniger als einem Millimeter. Messungen zwischen zwei und fünf Millimetern kommen seltener vor. Die Variabilität der Fadendicke verdeutlicht die Ungleichmäßigkeit der verwendeten Materialien. Ähnliche Fadenstärken zwischen 0,4 Millimetern und 3 Millimetern wurden auch auf der „Textilkeramik" von den polnischen Kollegen identifiziert (*cf.* Podkańska 2012: 213).

In einigen Fällen wurden nur gesponnene Fäden ohne sichtbare Struktur verwendet (*cf.* Abb. 2: F8549). Darüber hinaus können grobe und feine Garne oder Garnstrukturen an einer und derselben Scherbe, aber auch an verschiedenen Scherben bemerkt werden.

Ein textiles Gewebe kann nur in folgenden Fällen angenommen werden:

- Parallele Garnsegmente weisen Querfäden auf, die auf einfache Flächenbildungen hinweisen könnten. Das Gewebe besteht also aus parallel zueinander liegenden Kettfäden, die gelegentlich durch einen Schussfaden zu einem Flächengebilde zusammengehalten werden. In manchen Fällen ist der genaue Verlauf eines solchen Querfadens zu erkennen. So läuft z.B. der Querfaden im Textilabdruck der Scherbe F2055 immer über und unter zwei Kettfäden (*cf.* Abb. 2: F2055). Bei einer solchen Flächenbildung kann nicht ausgeschlossen werden, dass es sich um eine Panamabindung handelt. Da es sich jedoch bei den Scherben nur um winzige Ausschnitte vom tatsächlichen Textil handelt, ist es problematisch zu bestimmen, ob das Textil gewoben wurde.
- Zwirnstrukturen, die miteinander gekreuzt sind und eher diffus wirken, können auf eine Sprangtechnik hinweisen. Laut Schlabow können die Drehungen mehrmals wiederholt werden (Schlabow 1960: 51–56). Außerdem können die Fäden leicht übereinander geschoben werden, so dass ein Mehrschicht-Effekt entsteht. Allein durch das Vorhandensein eines Mehrschicht-Effektes kann jedoch nicht die Sprangtechnik vorausgesetzt werden, da für die „Textilkeramik" von Bruszczewo nicht ausgeschlossen werden kann, dass Textilien mehrmals hintereinander in den Ton eingedrückt wurden oder, dass mehrere Textilien übereinanderlagen. In drei Fällen (*cf.* Abb. 2: F4312, F12285) kann jedoch von einer Sprangtechnik ausgegangen werden, da es sich eindeutig um eine regelmäßige verkreuzte Struktur handelt. Eine Differenzierung verschiedener Arten von Sprangtechniken ist nicht möglich.
- Einzelne wellenförmige Drehungen, die in gestaffelter Anordnung liegen, könnten von Textilien in Leinwandbindung stammen. Trotz der Tatsache, dass die typische Gewebestruktur der Leinwandbindung (gleichmäßige Verkreuzung von Schuss- und Kettfäden) nicht sichtbar ist, ist es möglich, dass der letzte Schussfaden so stark angezogen wurde, dass keine Schussfäden sichtbar sind, sondern nur die Kettfäden. Bei dieser Struktur handelt es sich um das sogenannte Kettfadengewebe. Für einige Scherben

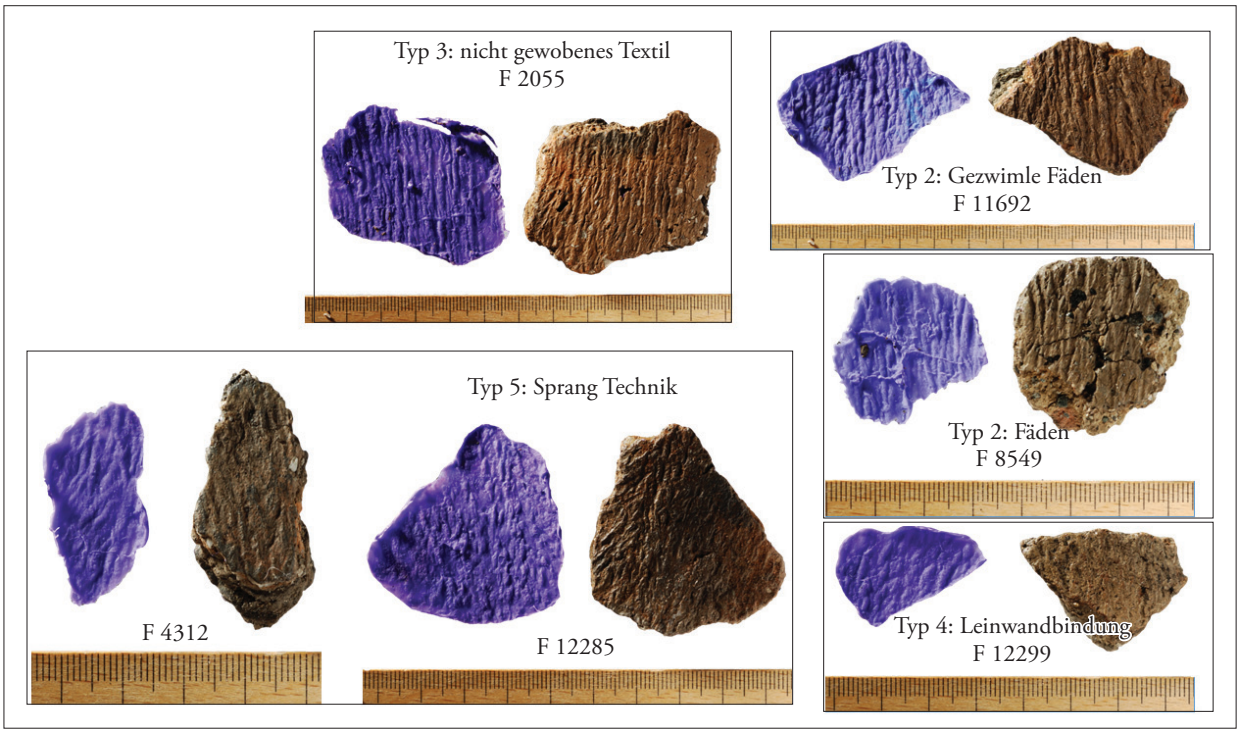


Abb. 2. Die Typen der Textilabdrücke auf Keramik vom Fundplatz Bruszczewo (Schaefer 2016).

kann eine Leinwandbindung angenommen werden (*cf.* Abb. 2: F12299).

Einteilung der „Textilkeramik“ aus Bruszczewo in Typen

Wie bereits in der vorangegangenen Analyse der textilen Strukturen angedeutet, lassen sich die Textilien, die für die Herstellung von „Textilkeramik“ aus Bruszczewo verwendet wurden, in Typen einteilen (Abb. 2):

- Typ 1: Zwirn
- Typ 2: Faden
- Typ 3: Flächenbildung
- Typ 4: Leinwandbindung
- Typ 5: Sprang

Die Mehrzahl der Abdrücke zählt zu den Typen 1 und 2 mit insgesamt 49 Scherben (47%) der einfachen Zwirn- und Fadenstrukturen, die sowohl in paralleler (a) als auch unstrukturierter (b) Anordnung auftreten können. Die Verdrehungen (Typ 1) wurden in den bereits beschriebenen Formen und Kombinationen (siehe oben) aufgeführt (*cf.* F11692). Bei Fadenstrukturen (Typ 2) handelt es sich um gesponnene Fäden. Die Zwirne und Fäden weisen keine genauen strukturellen Zusammenhänge auf (z.B. Querfäden), so dass unklar ist, ob oder in welchem Umfang die Schnüre und/oder Fäden in einem bestimmten Verbund vorliegen. Diese dominanten Typen können z.B. auch Fransen eines nicht erkennbaren textilen Gewebes sein, wie z.B. einer Quaste (Dumpe 2006: 80, Abb. 9:1) oder auch eine unklare strukturierte Webkante darstellen. Die Dominanz der Typen 1 und 2 ist auch darauf zurückzuführen, dass einige Keramikscherben aufgrund ihrer geringen Größe keine genauere Unterscheidung zuließen. Einige parallele Zwirnstrukturen könnten daher auch dem Typ 3 angehören. Insbesondere, wenn in einer sehr regelmäßigen Struktur parallele Zwirnstrukturen vorhanden sind, aber kein Querfaden sichtbar ist, könnte man auch von einem flächigen Gewebe ausgehen. Aufgrund dieser Unsicherheit wird eine solche Scherbe schließlich als Typ 1 oder 2 eingestuft. Nur in seltenen Fällen sind die Zwirnungen so parallel, dass eine gewebte Struktur als sicher angenommen werden kann. Gleichzeitig könnten lose Zwirn-Elemente auch Teil eines Zwirngeflechtes oder von Zwirnbindungen sein (Grömer 2006: 187).

Häufigkeit von „Textilkeramik“-Typen aus Bruszczewo

In der Analyse werden Abdrücke von Gezwirnen (Typ 1) und Fäden (Typ 2) zusammengefasst, da keiner der beiden Typen exakt identifizierbare textile Flächengebilde aufweist. Zusammengenommen hat diese Gruppe (Typ 1 + 2) einen Anteil von 50% an allen „Textilkeramik“-Scherben aus Bruszczewo.

Einzelne Zwirnstrukturen in paralleler Anordnung (1a) dominieren mit 11 Scherben (11%). Einfache Fäden in paralleler Anordnung (2a: 3 Scherben = 3%), Zwirnstrukturen in unstrukturierter Anordnung (1b: 2 Scherben = 2%) und Fäden in unstrukturierter Anordnung (2b: 1 Scherbe = 1%) sind die Minderheit.

Bei der Kombination der Typen auf ein und derselben Scherbe sind unstrukturierte Zwirnungen und Fäden (Typen 1b und 2b) mit 14 Scherben (44%) am häufigsten anzutreffen; an zweiter Stelle folgen parallele und unstrukturierte gezwirnte Fäden (Typen 1a und 1b) mit elf Scherben (34%). Parallele Zwirnstrukturen und Fäden (Typ 1a + 2a) sind nur an vier Scherben (13%) zu beobachten. Verdrehungen in unstrukturierter Anordnung (1b) und parallelen Fäden (2a) treten nur in drei Fällen (9%) auf.

Einfache Flächenbildungen (Typ 3) stellen mit 19 Scherbenfragmenten (18%) die zweite Hauptgruppe dar. In einigen Fällen ist das Gewebe durch Querfäden, die sich über und unter den Kettfäden winden, eindeutig erkennbar; in anderen Fällen ist das Gewebe undeutlicher und textile Strukturen scheinen vereinzelt abzubrechen, so dass ein beschädigtes Gewebe in Erwägung gezogen werden kann. Aus der Schweiz kennt man vergleichbare, gezwirnte Textilgeflechte, wie z.B. Vliesstoffgeflechte, die nur aus gesponnenem Material bestehen, das durch einen in Abständen eingelegten Zwirnstreifen zu einem einfachen flächigen Textil zusammengehalten wird (zu neolithischen Beispielen *cf.* Vogt 1937: 13, Abb. 15; S. 20, Abb. 32–33; S. 22, Abb. 38). Für die in Bruszczewo verwendeten Textilien können ähnliche Stoffe gemutmaßt werden.

Weiter folgt die Leinwandbindung (Typ 4) mit einem Anteil von zehn Scherben (10%). Auf drei dieser Keramikfragmente ist eine klare Leinwandbindung zu erkennen. In den übrigen sieben Fällen ist das Leinwandgewebe vermutlich nur noch in kleinen Bereichen erhalten, so dass eher von einem zerschlissenen Textilmaterial ausgegangen werden kann. Wie bereits erwähnt zeigen die Leinwandbindungen der „Textilkeramik“ von Bruszczewo nur Kettfaden-Gewebe.

Der fünfte Typ ist die Sprangtechnik, die auf drei Scherben (3%) vermutet werden kann. Die Kreuzungen der Struktur erscheinen in jedem der drei Fälle leicht v-förmig, was auf eine Überlappung der einzelnen Segmente hindeutet.

Sechs Scherben (6%) können erhaltungsbedingt keinem der fünf Typen zugeordnet werden.

Die restlichen 500 Scherben der „Textilkeramik“ aus Bruszczewo wurden von M. Podkańska (Podkańska 2012) aufgenommen und analysiert. Das Spektrum der von ihr festgestellten Textiltechnologie ist größer als das der in diesem Beitrag vorgestellten Textiltypen: Zusätzlich zu den bereits diskutierten Textiltypen (Typ 1 bis 5) identifiziert Podkańska die klassische Leinwandbindung (kein Kettfaden-Gewebe), Köperbindung,

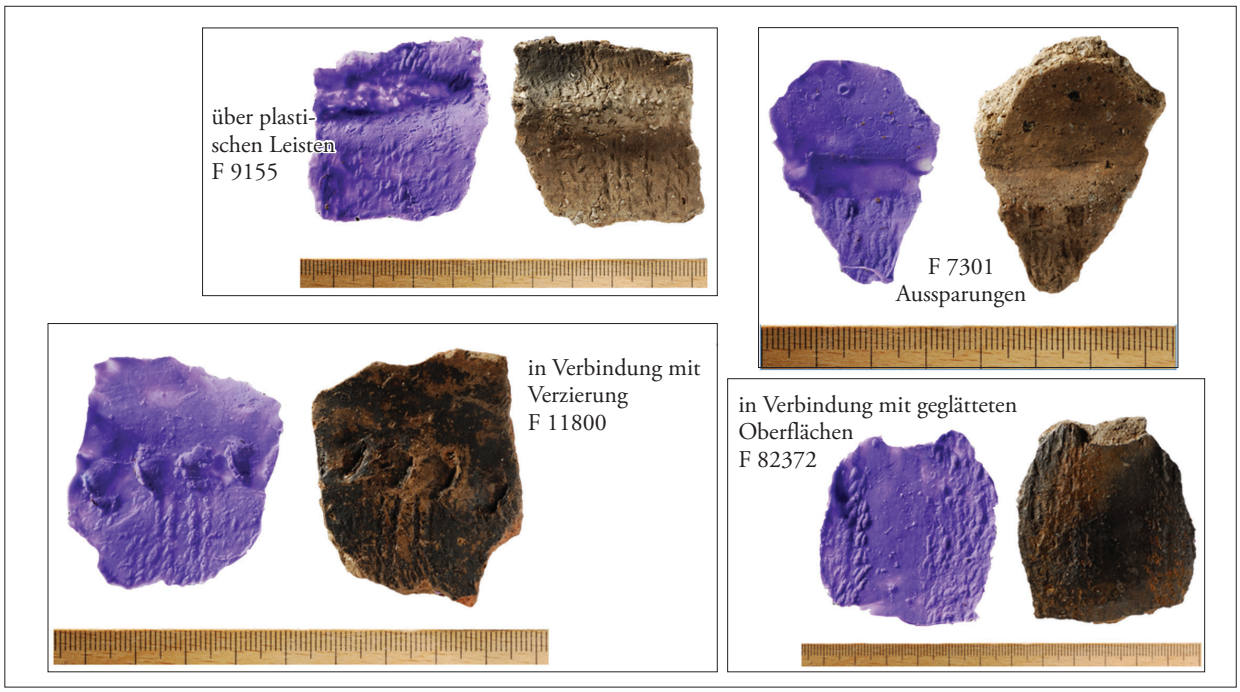


Abb. 3. Positionierung von Textilabdrücken.

Diamantköperbindung, Zickzack-Gewebe und verschiedene Sprangtechniken (Podkańska 2012: 207–213). Keine dieser komplexen Strukturen ist im Feuchtbodenbereich am Fundplatz von Bruszczewo vorhanden. Die Materialanalysen von Podkańska sind deswegen sehr überraschend. Sollte sich dieses breite Spektrum der von ihr erfassten Textiltechnologien bestätigen, würde sich das Wissen um die prähistorische Textiltechnologie der Bronzezeit in Polen radikal verändern.

Herstellung und Funktion von „Textilkeramik"

Ein erster praktischer Charakter der Textilabdrücke von Bruszczewo zeigt sich in der Ausführung dieser Abdrücke auf der Keramikoberfläche. Alle Abdrücke stammen von den Gefäßwänden. Abdrücke von Gefäßböden sind aus dem Feuchtbodenareal Bruszczewos hingegen nicht bekannt. Solche kamen aber an anderen Fundplätzen wie z.B. Hallunda (Jaanousson 1981: 44) vor. Auf den ersten Blick scheinen die meisten Textilien eher unstrukturiert und inkonsequent in den Ton gepresst worden zu sein, so dass es angesichts unseres heutigen ästhetischen Empfindens naheliegend erscheint, sie nur mit einem praktischen Grund zu rechtfertigen. Andererseits zeigen einige Muster sehr gleichmäßige Strukturen textiler Eindrücke.

Die Hauptfrage ist, ob die Textilabdrücke explizit hergestellt wurden oder ob es sich um einen sekundären Effekt der Keramikproduktion handelt. Die Analyse der Positionierung der Textilabdrücke leistet dazu einen entscheidenden Beitrag. Textile Abdrücke auf Keramik wurden teilweise über plastische Leisten (F9155) gedruckt, teilweise wurden plastische Leisten hingegen ausgespart (F7301) (Abb. 3).

Auch geglättete Flächen (F82372) oder dekorative Elemente wie Fingertupfenreihen (F11800) wurden oft von Textilabdrücken ausgespart. Manchmal scheinen sich die textilen Eindrücke an ornamentale Elemente anzulegen, indem sie wie Fransen entlang der Ornamentik des Gefäßes verlaufen. Diese Positionierung von Textilabdrücken spricht dafür, dass die Abdrücke nach dem Herstellungsprozess (Aufbau, Formgebung und Dekoration) ausgeführt wurden. Die einzige Möglichkeit, dass die Abdrücke Teil des Herstellungsprozesses waren, bestünde darin, dass das Keramikgefäß nach dem Formen und Dekorieren ein zweites Mal auf einem Textil nachgeformt wurde (da das Gefäß beim Auftragen plastischer Leisten oder anderer Elemente leicht deformiert werden konnte). Eine weitere Möglichkeit wäre, dass die Gefäße nach dem Formen und Dekorieren mit einem Textil umwickelt wurden, um den Trocknungsprozess zu unterstützen.

Bemerkenswert ist auch, dass einige der Gefäßränder, die dicker als die Gefäßwand gebaut wurden, ebenfalls von Textilabdrücken ausgespart worden sind. Der Rand könnte nach der Herstellung des Gefäßes und nach dem Einprägen der Textilien gebildet worden sein. Wie bereits erwähnt könnte dafür ein rein praxisorientierter Grund verantwortlich sein, da der Rand eine Schwachstelle des Gefäßes ist (Lavento 2001: 58). Alternativ kann in Betracht gezogen werden, dass der Rand auch nach dem Textilabdruck geglättet wurde.

Abdrücke, die sehr präzise auftreten, können absichtlich eingeprägt worden sein. Dies würde der These von Silska und Podkańska entsprechen, die davon ausgehen, dass die Abdrücke in den Scherben vom Sporn (Gegenstand ihrer Studie) nicht zufällig sind, sondern dass die Textilien sorgfältig in den Ton eingedrückt worden waren (Silska 2001: 72; Podkańska 2012: 213).

Es kann daher angenommen werden, dass die Textilabdrücke auf der Keramik von Bruszczewo eine praktische oder dekorative Funktion haben. Auch eine Kombination beider Eigenschaften wäre denkbar. Das Gefäß kann durch Aufrauhen der Wand leichter gehandhabt werden, die Oberfläche kann vergrößert worden sein, um einen Kühleffekt zu erzielen und das Gefäß kann gleichzeitig mit einer Dekoration versehen worden sein. Diese Ornamentik kann ästhetisch ansprechend gewesen sein und/oder einen bestimmten symbolischen Zweck oder Code mit sich gebracht haben. Gefäße mit Textilabdrücken in Bruszczewo, die „Textilkeramik" in Nord- und Zentraleuropa auf Basis der Datenbank (siehe unten) und ethnographische Vergleiche (vgl. Mershen 1988: 81–95; Soeffing 1988: 57–58) zeigen, dass „Textilkeramik" hauptsächlich zur Haushaltskeramik gehört – was die Autorin zu der Annahme veranlasst, dass textilbedruckte Keramik im Alltag eine besondere Funktion hatte. Beispielsweise kann es sich um den Behälter eines bestimmten Lebensmittels oder Rohstoffs handeln. Eine Kodierung (die nur von einer bestimmten sozialen Gruppe verstanden wurde) als möglicher Grund für die Abdrücke kann nicht vollständig ausgeschlossen werden. Die wichtige Rolle von Bruszczewo in der Siedlungsstruktur des Gebietes (in der Nähe von Łęki Małe; Nähe zu den Kommunikationswegen, Zentrum der Metallurgie; *cf.* Jaeger 2010: 815–814) lässt vermuten, dass in diesem Gebiet ein dichtes soziales Netzwerk existierte. Eine Verbindung zwischen diesen Aktivitäten und dem Vorhandensein der „Textilkeramik" ist möglich, so dass wir einer praktischen und dekorativen Funktion auch eine symbolische Funktion hinzufügen können.

Die Idee von zufällig entstandenen Textilabdrücken als Nebeneffekt des Produktionsprozesses kann mit Sicherheit ausgeschlossen werden, da einige Fragmente sehr präzise Abdrücke aufweisen (siehe oben).

Identifizierung von Rohmaterialen anhand von „Textilkeramik" – unmöglich?

Ein Großteil der Forschungsansätze, die sich bisher mit „Textilkeramik" beschäftigt haben, geht davon aus, dass es sich bei den verwendeten Materialien um pflanzliche Fasern handelt, weil der Abdruck von Wolle zu schwach wäre (Laul 1966: 99; Lavento 2001: 54). Dagegen zeigten die von Peet durchgeführten Experimente (Kriiska *et al*. 2005: 24–25), dass sowohl nasse als auch trockene Wollstoffe dazu neigen, einen ähnlich detaillierten Abdruck auf dem Keramikgefäß zu hinterlassen. Es ist daher auch möglich, dass Wollgewebe für die Herstellung von „Textilkeramik" verwendet wurden.

Nach meiner eigenen Erfahrung ist die Identifizierung der für die Abdrücke verwendeten Rohstoffe sehr problematisch. Anhand des Abdrucks kann lediglich zwischen kantigen und weichen also z.B. zwischen Gräsern und verarbeiteten Fasern (ob tierisch oder pflanzlich) unterschieden werden. Auf der Grundlage archäobotanischer und archäozoologischer Analysen kann jedoch auf die Verwendung einiger Materialien geschlossen werden.

Typische Faserpflanzen wie Flachs (*Linum usitatissimum*) oder Hanf (*Cannabis sativa*) kommen in Bruszczewo selten vor: Nur zwei Samen beweisen die Verwendung von Flachs als mögliches Rohmaterial für die Abdrücke (Kroll 2010: 265). Eine neue Studie (Bergfjord *et al.* 2012: 1–4) zeigt, dass in der Bronzezeit nicht nur kultivierte Textilfasern für die Textilproduktion verwendet wurden, sondern auch Wildpflanzen gezielt eingesetzt wurden. So hatte beispielsweise die Brennnessel (*Urtica dioica*) eine bedeutende Rolle in der Textilproduktion gespielt, so dass eine Neubewertung des Ressourcenmanagements für die Herstellung von Textilien in der Bronzezeit erfolgen muss. Nach wie vor ist es schwierig zwischen Flachs, Hanf und Brennnesselfasern zu unterscheiden, und die Fehlinterpretation von Textilien, die tatsächlich aus Wildpflanzen und nicht aus Kulturfaserpflanzen hergestellt wurden, könnte eine Rolle bei der möglichen Verzerrung früherer Darstellungen prähistorischer textiler Rohstoffe spielen.

Es ist eine wichtige Entdeckung, dass die Textilproduktion nicht unbedingt mit der Landwirtschaft und dem Anbau bestimmter Faserpflanzen verbunden sein muss. Darüber hinaus kann der Brennnessel eine höhere Bedeutung in der Vorgeschichte zugeschrieben werden: Für Textilien aus dem bronzezeitlichen Grab von Lusehøj wurde nachgewiesen, dass die verwendeten Brennnesselfasern aus der Region Kärnten-Steiermark importiert wurden, so dass davon ausgegangen werden kann, dass bestimmte Brennnessel-Textilien als eine Art Luxusartikel vermarktet wurden (Bergfjord *et al*. 2012: 3).

Auch aus Bruszczewo sind Überreste der großen Brennnessel bekannt (Kroll 2010: 269), so dass diese als Faserpflanze in Betracht gezogen werden kann. Darüber hinaus wurden verschiedene Gräser gefunden, die leicht zu bearbeiten sind und gewebt werden können, wie z.B. Seebinse (*Schoenplectus lacustris*) und Schneide (*Cladium mariscus*) (Kroll 2010: 261) sowie weitere Binsengräser (*Juncus sp.*) (Kroll 2010: 271), Schilfrohr (*Phragmites sp.*) (Kroll 2010: 269) und andere Gräser (Kroll 2010: 265–267). Darüber hinaus wurde auch Linde (*Tilia sp.*) (Kroll 2010: 267) identifiziert, deren Bast für die Herstellung von Textilien günstig ist. Die Nutzung von Linde zum Spinnen und Zwirnen ließ sich für die Vorgeschichte bereits nachweisen (Grömer 2010: 58–59). Die Verarbeitung der identifizierten Eselsdistel (*Onopordum acanthium*) ist ebenfalls möglich. Diese erhielt sich unverkohlt in dem feuchten Milieu. Kroll geht davon aus, dass die Eselsdistel nur unter anthropogener Einwirkung in dieses dauernasse Gebiet eingedrungen sein kann, da sie auf sumpfigen Böden nicht natürlich wächst. Es müsse demnach eine Erhaltungsauslese stattgefunden haben, sodass sich der Verdacht erhärtet, dass die Eselsdistel in Bruszczewo als Nutzpflanze gedient hat. Neben ihrer Funktion als Gemüse, Heil- und Ölpflanze kann auch eine Verwendung als Faserpflanze in Betracht bezogen werden. Die Pappushaare und der Filzbelag der Blätter könnten zu Garn gesponnen worden sein (Kroll 2012: 189–191).

Neben pflanzlichen Fasern können auch tierische Fasern verwendet worden sein. Die Verarbeitung von Wolle kann möglicherweise anhand gefundener Schafsknochen rekonstruiert werden (Makowiecki, Drejer 2010: 291–293). Berechnungen des Schlachtalters ergaben, dass Schafe wahrscheinlich als Lieferant von Fleisch, Milch und Wolle genutzt wurden (Müller, Czebreszuk 2003: 471). Zudem wurden Knochen von wilden Säugetieren wie Hirschen und Rehen gefunden (Makowiecki, Drejer 2010: 291–293). Auch die Verwendung von Ziegenhaar kann nicht ausgeschlossen werden.

In Ergänzung zu „Textilkeramik" und verschiedenen Pflanzen als Rohstoff für die Textilproduktion stehen auch Werkzeuge für die Textilherstellung als indirekte Nachweise der Textilgewinnung in Bruszczewo zur Verfügung.

Bislang wurden Nadeln, Spinnwirtel, spulen- und kegelförmige Webgewichte und ein mögliches Webschwert aus Holz gefunden. Diese Werkzeuge kennzeichnen sowohl die Materialverarbeitung (Spinnen) als auch die Textilproduktion (Weben am Webstuhl und Nähen).

Alles in allem lässt sich auf der Grundlage indirekter Nachweise (Pflanzenfunde, Tierknochenfunde, Textilwerkzeuge) vermuten, welche textilen Rohstoffe für die Herstellung von „Textilkeramik" genutzt worden sein könnten. Andererseits ist es nicht möglich, die verwendeten Rohstoffe anhand des Abdrucks der „Textilkeramik" direkt zu identifizieren.

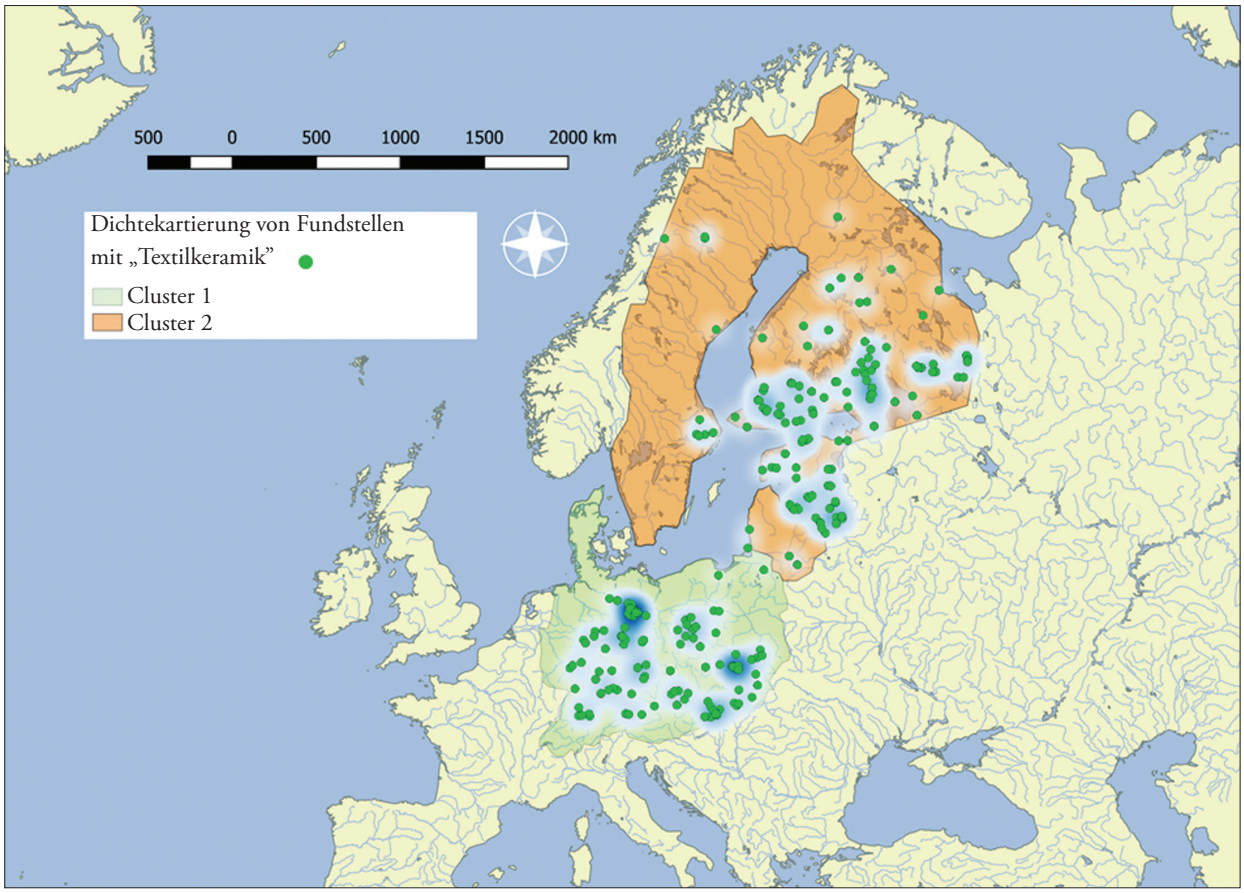


Abb. 4. Die Verbreitung von „Textilkeramik“ in Zentral- (Cluster 1) und Nordeuropa (Cluster 2) (Schaefer 2016).

Einführung in die quantitative Studie: „Textilkeramik“ in Zentral- und Nordeuropa

Die in dieser Studie verwendete Sammlung von „Textilkeramik“ besteht aus ca. 1000 Scherben von etwa 300 Fundorten aus Zentral- und Nordeuropa und umfasst den Zeitraum vom Neolithikum bis zum Ende der Bronzezeit/Beginn der vorrömischen Eisenzeit (Schaefer 2016) (Abb. 4; Tab. 2).

Die Studie konzentrierte sich auf eine große Region, die von Deutschland, Österreich und den Karpaten im Süden über Tschechien und die Slowakei, Polen und die baltischen Staaten im Nordosten bis nach Finnland, Karelien und Schweden im Norden reicht.

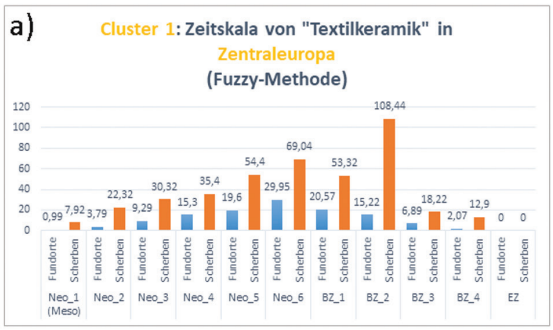
In der diachronen und räumlichen Verteilung der „Textilkeramik“ in Zentraleuropa gibt es während des Neolithikums einige territoriale Kontinuitäten. Während des Endneolithikums tritt die Verbreitung weitläufig auf. (*cf.* Tab. 1a). In Nordeuropa beginnt die Verwendung von „Textilkeramik“ mit der neolithischen Phase 3 und zeigt eine Verteilung nach Norden mit der letzten neolithischen Periode (*cf.* Tab. 1b). In der Bronzezeit nimmt die Verbreitung in Zentraleuropa mit der Phase 3 ab und endet mit der Spätbronzezeit (Tab. 1a). Andererseits zeigt sich in Nordeuropa eine weitläufigere und ansteigende Verbreitung innerhalb der Bronzezeit. Diese reicht bis in die vorrömische Eisenzeit (Tab. 1b).

Die Abdrücke des für diese Studie gesammelten Materials zeigen zum Teil die gleichen textilen Strukturen, die am Fundplatz Bruszczewo gefunden wurden. Zusätzlich zu diesen Techniken (Flächenbildung, Leinwandbindung, Sprangtechnik, gezwirnte und ungezwirnte Fäden) konnten weitere und komplexere Techniken entdeckt werden: Ripsbindung, Köperbindung, Nadelbindung, Abrollmuster und Korbgeflechte. Gezwirnte Fäden und Leinwandbindungen weisen den höchsten Anteil in der Studie auf. Faden- und Köperstrukturen treten seltener auf.

Die Verbreitung der Typen ist im untersuchten Gebiet sehr gleichmäßig. Nur in der südlichen Region der Slowakei, im Nordosten Deutschlands um die Elb-Havel-Region und in der Region um die Ostsee sind Unterschiede in der Typenvielfalt zu beobachten.

Alle textilen Techniken weisen zudem ähnliche zeitliche Verteilungen auf, aber in der Bronzezeit treten sie häufiger auf. Die Bronzezeit stellt die Hauptphase der „Textilkeramik“ in allen oben genannten Regionen dar.

Tab. 1. a) Datierung der „Textilkeramik“ in Zentraleuropa (Cluster 1) (Schaefer 2016); b) Datierung der „Textilkeramik“ in Nordeuropa (Cluster 2) mit Zeitskala (Schaefer 2016) (vgl. Tab. 2).



Neolithikum	Von (v. Chr.)	Bis (v. Chr.)
1 (mesolitisch)	9600	5500
2	5500	5000
3	5000	4400
4	4400	3500
5	3500	2800
6	2800	2300/2200
Bronzezeit	Von (v. Chr.)	Bis (v. Chr.)
1	2300/2200	1500
2	1500	1100
3	1100	740/750
4	740/750	500

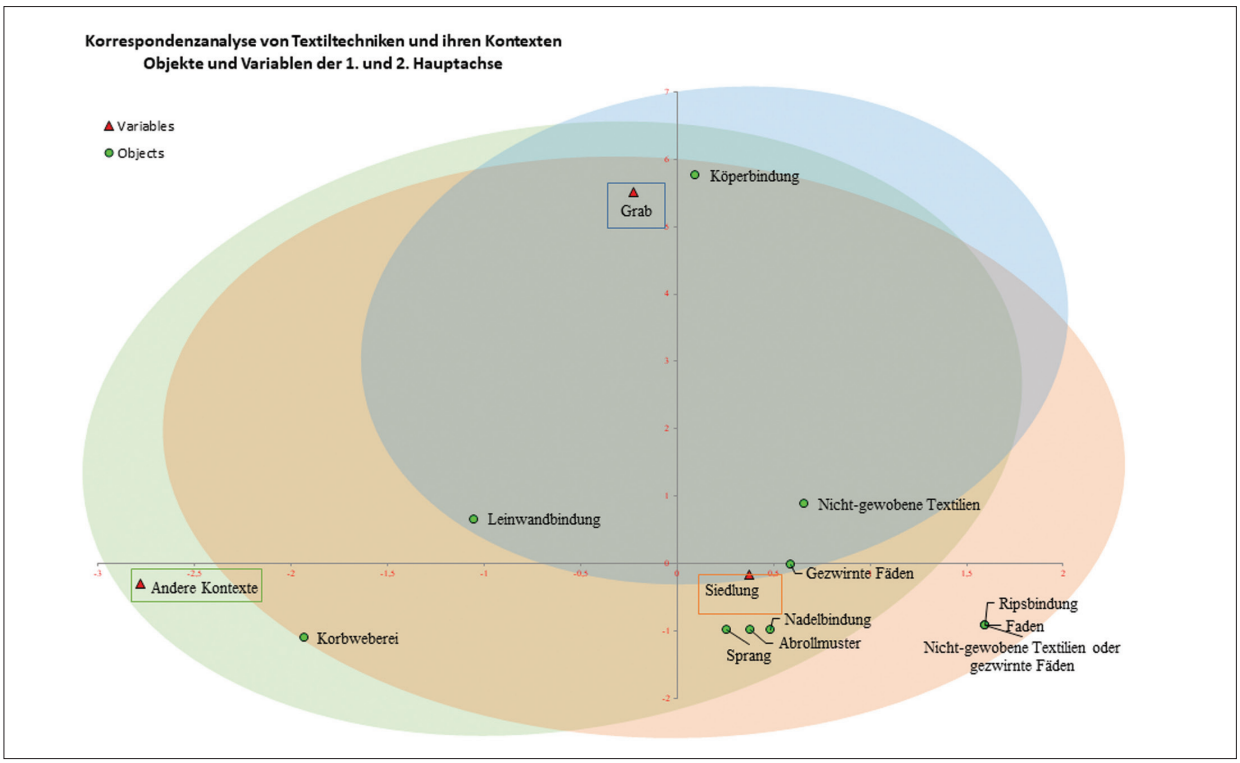


Abb. 5. Korrelation von Befundkategorien und Typen textiler Techniken der „Textilkeramik“ im Arbeitsgebiet (Schaefer 2016).

Es kann angenommen werden, dass die Rolle der Textilien bei der Keramikherstellung bzw. der Wissenstransfer über die Herstellung und Funktion der „Textilkeramik“ über Jahrhunderte andauerte.

Die quantitative Analyse zeigte, dass Textilabdrücke auf Keramik hauptsächlich aus Siedlungen stammen. Nur einige Scherben wurden in Gräbern entdeckt und in wenigen Fällen wurde „Textilkeramik“ aus anderen Kontexten (Einzelfunde, Erdwerke, etc.) geborgen. Es ist davon auszugehen, dass es sich bei „Textilkeramik“ überwiegend um Haushaltskeramik handelt (Abb. 5).

Schlussfolgerung

Ausgehend von der Analyse der „Textilkeramik“ aus Zentral- und Nordeuropa konnte festgestellt werden, dass in einer bestimmten diachronen Abfolge verschiedene Textiltechniken eingesetzt wurden und dass es in bestimmten Zeiträumen zu einer Spezialisierung hinsichtlich bestimmter Techniken gekommen sein könnte. Insbesondere die Verwendung von Faden- und Zwirnstrukturen zeigte sich häufig.

Die „Textilkeramik“ vom Fundplatz Bruszczewo fügt sich sehr gut in den zeitlichen und räumlichen Kontext Zentral- und Nordeuropas ein. Darüber hinaus scheint die „Textilkeramik“ von Bruszczewo aufgrund ihrer Verteilung in Häusern als Haushaltskeramik verwendet worden zu sein und passt damit in die überwiegend vorkommende Kategorie von Siedlungskontexten der „Textilkeramik“ Nord- und Zentraleuropas.

Die nachweisbaren Textiltechniken im Abdruck der „Textilkeramik“ aus Bruszczewo zeigen nur einen Teil der aus dem nord- und zentraleuropäischen Raum bekannten Textiltechniken. Die Variabilität der verschiedenen Textiltechniken an einem Standort ist jedoch selten so hoch wie in Bruszczewo (Schaefer 2016). Dies kann jedoch auch damit zusammenhängen, dass dieser Fundplatz umfangreich ausgegraben und erforscht wurde.

Die meisten der verschiedenen Textiltechniken des Materials aus Bruszczewo sowie des Materials aus Nord- und Zentraleuropa scheinen von einzelnen Fäden (gezwirnt/ungezwirnt) zu stammen, mal treten sie in einer Struktur auf, mal ohne strukturellen Zusammenhang. Es kann davon ausgegangen werden, dass die meisten der ausgefransten und überwiegend zerschlissenen Textilien für die Herstellung von „Textilkeramik“ verwendet wurden. Vielleicht haben wir es mit einem Phänomen des Recyclings zu tun:

Tab. 2. Die verwendete Zeitskala zur Datierung der „Textilkeramik“ vom Neolithikum bis zum Ende der Bronzezeit.

Neolithikum Phase	**Von (v. Chr.)**	**Bis (v. Chr.)**	**Literatur**
1 (mesolithisch)	9600	5500	Bender Jørgensen 1991: 16; Lüning 1996: 233; Schnurbein 2009: 42–44; Hinz 2014: 19, Fig. 3.6.
2	5500	5000	Lüning 1996: 233.
3	5000	4400	Lüning 1996: 233.
4	4400	3500	Müller *et al.* 2010: 2; Hinz, 2014: 15, Fig. 1.
5	3500	2800	Lüning 1996: 233; Ethelberg *et al.* 2000.
6	2800	2300/2200	Lüning 1996: 233; Ethelberg *et al.* 2000.
Bronzezeit Phase	**Von (v. Chr.)**	**Bis (v. Chr.)**	
1	2300/2200	1500	Vandkilde *et al.* 1996; Jensen 1997; 2006: 15; Kristiansen 1998: 32, Fig. 13; Ethelberg 2000: 143.
2	1500	1100	Vandkilde *et al.* 1996; Ethelberg 2000: 143; Jensen 2006: 15; Hornstrup *et al.* 2012: 48.
3	1100	740/700	Vandkilde *et al.* 1996; Ethelberg 2000: 143; Jensen 2006: 15; Hornstrup *et al.* 2012: 48; Kneisel 2013: 109–110.
4	740/700	500	Vandkilde *et al.* 1996; Ethelberg 2000: 143; Jensen 2006: 15; Hornstrup *et al.* 2012: 48; Kneisel 2013: 109–110.

Abgenutzte Textilien, die keine Funktion mehr hatten, wurden für die Keramikproduktion wiederverwendet.

Die Herstellung von prähistorischen Textilien war zeitaufwändig und arbeitsintensiv, einschließlich Materialverarbeitung, Garnherstellung, etc. Der Wert dieser Arbeit und dieser Zeitaufwand spiegeln sich im Umgang mit diesen Textilien wider. Grömer stellte das Recyceln von Textilien u. a. für einige Textilreste aus dem eisenzeitlichen Salzbergwerk in Hallstatt fest, die für unterschiedliche Zwecke genutzt wurden (zum Beispiel als Bindematerial, für hygienische/sanitäre Zwecke, *etc*.) (Grömer 2010: 281–283). Auch Ehlers betont mithilfe mehrerer Beispiele, dass das Verwenden von Stoffresten zeigt, dass die Gewebe voll ausgenutzt und nicht verschwenderisch behandelt wurden (Ehlers 1998: 280). Dass solche Textilien jedoch für die Keramikproduktion wiederverwendet wurden ist hingegen neu und nur anhand der „Textilkeramik" erfassbar.

Im Hinblick auf die Informationen über die Herstellung und möglichen Funktionen von „Textilkeramik" im Allgemeinen und speziell vom Fundplatz Bruszczewo kann nicht ausgeschlossen werden, dass sowohl die Herstellung als auch die Verwendung von „Textilkeramik" in der Vorgeschichte eine wichtige soziale und zwischenmenschliche Rolle gespielt haben. Es ist unklar, ob das Wissen über die funktionalen Eigenschaften von „Textilkeramik" (z.B. Kühlfunktion) oder das eventuelle Vorhandensein eines Codes in mehr oder weniger ausgedehnten Netzwerken zwischen einzelnen Siedlungsgebieten entstanden oder vorhanden war. Die weit verbreitete Verwendung von „Textilkeramik" muss also nicht zwangsläufig einen gemeinsamen Ursprung und/oder eine gemeinsame Bedeutung haben (einschließlich funktionaler und/oder sozialer Merkmale), sondern könnte auch eine Technologie darstellen, die entweder von Einzelpersonen und Gruppen im Raum verbreitet oder an verschiedenen Orten entwickelt wurde (Konvergenz vs. Diffusion). Die Lagerung von Lebensmitteln in Behältern mit textilen Eindrücken zu Kühlzwecken könnte daher eine Technologie sein, die sich zusammen mit dem Verhalten des Speicherns von Rohstoffen weiterentwickelt hat. Zum Beispiel: Es kann gemutmaßt werden, dass die Verbreitung der Sarsa-Tomitsa-Keramik (mit textilen Abdrücken) im Südwesten Finnlands mit dem Anbau und Speichern von Getreide in Verbindung stand. Dies zeigt sich anhand eines Großrestfundes von Gerste, der in einem textilbedruckten Gefäß in der Siedlung Kitulansuo in Ristiina (2990±60 BP) gefunden wurde (Lavento 2001: 61).

Die Bearbeitung von Gefäßen durch verschiedene Aufrauungsmethoden (Textilien, Besen, *etc.*) könnte auf einen sozialen Aspekt hinweisen. Ein Behälter mit Textilabdrücken kann daher einen anderen spezifischen Rohstoff enthalten haben als z.B. andere Gefäße mit einer Oberfläche, die durch Besen aufgeraut wurden.

Alles in allem hat die Untersuchung des Phänomens „Textilkeramik" ein noch nicht ausgeschöpftes und noch zu untersuchendes Forschungspotenzial offenbart. Mehr Forschungsintensität in einem breiteren räumlichen Kontext könnte letztendlich noch komplexere Schlussfolgerungen und die Überprüfung bestehender Thesen ermöglichen. Die Einbeziehung der „Textilkeramik" in die Forschungsdiskussion würde dann das Wissen um die prähistorische Textiltechnologie erweitern und auch einen tieferen Einblick in die Nutzung von Alltagstextilien ermöglichen. Darüber hinaus ist zu bedenken, dass „Textilkeramik" manchmal die einzige Quelle ist, um die Existenz prähistorischer Textilien in bestimmten Regionen nachzuweisen. In den Tab. 3a–c kann dieses Phänomen nachvollzogen werden.

Die Theorie, dass scheinbar überwiegend recycelte Textilien für die Herstellung von „Textilkeramik" verwendet wurden, ermöglicht es uns, neue Ideen und Hypothesen über den wahrgenommenen Wert der Textilien und den dahinterliegenden Arbeitsaufwand zu formulieren. Schließlich zeigt die Wiederverwendung von Textilien, dass sie – anders als heute – keine Massenware in der Vorgeschichte waren.

Tab. 3a. Neolithikum. Gegenüberstellung der Nachweise von Textiltechnologien des Neolithikums anhand direkter Textilfunde und der Nachweise von Textiltechnologien anhand von „Textilkeramik“ im Arbeitsgebiet auf Basis der Datenbank (Schaefer 2016).

Land	**Direkter Nachweis anhand von Textilfunden**	**Indirekter Nachweis anhand von „Textilkeramik“**	**Ausgewählte Literatur**
Finnland	Netz, Zwirn	Zwirn, Radialgeflecht, Flächenbildung; Leinwandbindung (u. a. Ripsbindung)	Burow 1973: 134; Möller-Wiering 2012: 379.
Estland	Keine Textilnachweise	Zwirn, Leinwandbindung, Ripsbindung, Nadelbindung, Flächenbildung, Sprang	Laul 1966: 96–98; Lang 2007: 19.
Lettland	Netz (Brettchenweben und Sprang werden vermutet)	Zwirn	Dumpe 2006: 73; Žeire 2012: 268.
Litauen	Fäden, Netz, Textilstücke (Brettchenweben?), Geflecht	Leinwandbindung, Flächenbildung, Sprang	Rimantienė 2005: 97.
Polen	Keine Textilnachweise	Zwirn, Radialgeflecht, Sprang, Leinwandbindung	Maik 2012: 293.
Deutschland	Zwirn, Geflecht, Leinwandbindung	Zwirn, Flächenbildung, Leinwandbindung, Radialgeflecht, Sprang, Köperbindung (vielleicht)	Bender Jørgensen 1991: 51–53; Möller-Wiering 2012: 367–369, 380.
Tschechien	Keine Textilnachweise	Zwirn, Leinwandbindung, Köperbindung	Belanová-Štolcová 2012: 306.
Slowakei	Keine Textilnachweise	Zwirn, Leinwandbindung, Ripsbindung	Belanová-Štolcová 2012: 306.
Österreich	Geflecht, Flächenbildung	Zwirn, Radialgeflecht, Köperbindung	Grömer 2006: 184–186.

Tab. 3b. Bronzezeit. Gegenüberstellung der Nachweise von Textiltechnologien der Bronzezeit anhand direkter Textilfunde und der Nachweise von Textiltechnologien anhand von „Textilkeramik“ im Arbeitsgebiet auf Basis der Datenbank (Schaefer 2016).

Land	**Direkter Nachweis anhand von Textilfunden**	**Indirekter Nachweis anhand von „Textilkeramik“**	**Ausgewählte Literatur**
Schweden	Leinwandbindung	Leinwandbindung, Zwirn	Gustavsson 1997: 66; Franzén *et al.* 2012: 353–354.
Finnland	Keine Textilnachweise	Zwirn, Radialgeflecht, Nadelbindung, Leinwandbindung	Lavento 2000; 2001.
Estland	Keine Textilnachweise	Zwirn, Leinwandbindung, Ripsbindung, Köperbindung, Nadelbindung	Laul 1966: 96–98; Lang 2007: 19.
Lettland	Keine Textilnachweise	Zwirn, Leinwandbindung, Sprang, Flächenbildung, Köperbindung	Žeire 2012: 269–271.
Litauen	Keine Textilnachweise	Sprang	Daugudis 1966: 38–41.
Polen	*Ab der Hallstattzeit:* Leinwandbindung, Ripsbindung, Korbgeflecht, Brettchenweben, Sprang, Köperbindung	Zwirn, Parallelgeflecht, Radialgeflecht, Leinwandbindung (ab der Frühbronzezeit), Sprang, Köperbindung	Jasnosz 1974: 87; Ziąbka, Maryniak 1988: 81; Bender Jørgensen 1991: 84–86; Maik 2012: 295–296.
Deutschland	Leinwandbindung, Ripsbindung, Sprang, Nadelbindung, Zwirn, Köperbindung, Diamantköperbindung, Brettchenweben	Zwirn, Leinwandbindung	Bender Jørgensen 1991: 51–53; Möller-Wiering 2012: 129–130, 134.
Tschechien	Leinwandbindung; *Ab der Hallstattzeit:* Köperbindung	Keine „Textilkeramik“ nachweisbar	Belanová-Štolcová 2012: 309.
Slowakei	Leinwandbindung; *Ab der Hallstattzeit:* Köperbindung	Zwirn, Flächenbildung, Leinwandbindung, Radialgeflecht, Sprang, Nadelbindung	Furmánek *et al.* 1999: 42; Belanová-Štolcová 2012: 309.
Österreich	Leinwandbindung, Ripsbindung, Köperbindung, Webkante	Leinwandbindung	Grömer 2006: 188–190; 2012: 30–32.

Tab. 3c. Vorrömsiche Eisenzeit. Gegenüberstellung der Nachweise von Textiltechnologien der Eisenzeit anhand direkter Textilfunde und der Nachweise von Textiltechnologien anhand von „Textilkeramik“ im Arbeitsgebiet auf Basis der Datenbank (Schaefer 2016).

Land	**Direkter Nachweis anhand von Textilfunden**	**Indirekter Nachweis anhand von „Textilkeramik“**	**Ausgewählte Literatur**
Schweden	Köperbindung	Zwirn, Köperbindung, Leinwandbindung	Eriksson 2009: 135; Franzén *et al.* 2012: 361.
Finnland	Keine Textilnachweise	Zwirn, Leinwandbindung	Lavento 2001.
Estland	Keine Textilnachweise	Zwirn, Leinwandbindung	Laul 1966: 96–98.
Lettland	Leinwandbindung	Zwirn, Leinwandbindung, Sprang, Flächenbildung	Cimermane, Snore 1966: 175–177; Žeire 2012: 270.
Litauen	Keine Textilnachweise	Sprang	Daugudis 1966: 38–41.
Polen	Leinwandbindung, Köperbindung, Ripsbindung	Keine „Textilkeramik“ nachweisbar	Bender Jørgensen 1991: 85–86; Maik 2012: 297.
Deutschland	Leinwandbindung, Ripsbindung, Köperbindung, Brettchenweben	Keine „Textilkeramik“ nachweisbar	Bender Jørgensen 1991: 51–53; Möller-Wiering 2012: 130–131, 134.
Tschechien	Leinwandbindung, Köperbindung, Geflecht	Keine „Textilkeramik“ nachweisbar	Bender Jørgensen 1991: 107; Rast-Eicher 1995: 167–169; Belanová-Štolcová 2012: 314–316.
Slowakei	Leinwandbindung, Köperbindung, Geflecht	Keine „Textilkeramik“ nachweisbar	Bender Jørgensen 1991: 107; Rast-Eicher 1995: 167–169; Belanová-Štolcová 2012: 314–316.
Österreich	Leinwandbindung, Ripsbindung, Köperbindung, gebrochenes Köpergewebe, Diamantköperbindung, Brettchenweben, Korbgeflecht	Keine „Textilkeramik“ nachweisbar	Grömer 2012: 44–45, 56–57.

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Wool Economy During the European Bronze Age

Abstract

A number of studies over the last decades have considerably increased our knowledge about production and trade of woollen textiles during the Bronze Age in the Near East, the Aegean, and continental Europe. In the wider Mediterranean area, thanks to the abundance of available evidence, it has been possible to use the concept of wool economy as a frame of reference to define the complex mechanisms behind production and trade of wool. The main aim of this paper is to reflect upon using the concept of wool economy to enhance our understanding of the relevant archaeological evidence from Bronze Age continental Europe.

Streszczenie

Gospodarka wełną w epoce brązu w Europie

W ostatnich latach znacząco wzrosła wiedza o produkcji wełny oraz handlu i znaczeniu ekonomicznym tekstyliów wełnianych na Bliskim Wschodzie, w Egei i Europie kontynentalnej w epoce brązu. W odniesieniu do licznych pozostałości z obszaru basenu Morza Śródziemnego, możliwie stało się wprowadzenie koncepcji gospodarki wełną, która stanowi ramy badawcze dla zdefiniowania złożonych mechanizmów decydujących o wymiarze produkcji i handlu wełną oraz wyrobami wełnianymi. Celem niniejszego artykułu jest próba odpowiedzi na pytanie, czy podobna koncepcja może mieć zastosowanie w odniesieniu do produkcji włókienniczej i wykorzystania wełny na obszarze Europy kontynentalnej.

Keywords: textiles, sheep/goat herding, textile tools, wool production, wool trade, craft specialisation, gender

Introduction

Studies on wool production and trade during the European Bronze Age have grown in number over the last years (*e.g.* Bender Jørgensen, Rast-Eicher 2016; Frei *et al.* 2015; 2017; Gleba 2008; Grömer *et al*. 2013; Kristiansen 2016; Rast-Eicher, Bender Jørgensen 2013; Sabatini *et al.* 2018). Among other things, they have demonstrated that wool as a raw material for the production of textiles was used already at the dawn of the 2nd millennium BCE (*e.g.* Bender Jørgensen, Rast-Eicher 2015; 2018; CinBa database; Gleba, Mannering 2012), and that by the 14th century BCE long-distance trade of woollen textiles also existed (Frei *et al.* 2015; 2017). However, the role of wool in the development of the economic and social organisation of European Bronze Age societies has not yet been addressed in a comprehensive manner. Bronze Age textile production in general and, as per the scope of this work, wool manufacturing in particular, are a complex and time-consuming endeavour (*cf*. Costin 2013). As it will be discussed in more detail in the following paragraphs, wool manufacturing requires specialisation, resource management, and long-term planning. It seems therefore hardly manageable without some form of political economic design and the interplay of a number of different factors. The aim of this paper is to explore the premises required for the rise of wool economy to be observable in the archaeological record from Bronze Age Europe. To this end, one major statement should be reflected upon beforehand.

It is necessary to question the relatively unchallenged view of prehistoric textile production as a typical household occupation generally carried out by women (*cf.* Costin 2013). The aftermath of such view is that prehistoric textile production has long been considered a secondary activity of little to no importance for political economic discourses. In fact, by considering textile making just as a part of the everyday household tasks, we limit our possibility to understand the tremendous political, social, economic, and cultural importance of textile manufacturing. It is hardly deniable that a large part of the Bronze Age textile tools has been discovered in household settings, and yet in pre-urban worlds households are to a significant degree the economic engine of society. It has been widely demonstrated that craft production in general tends to be highly gendered (Costin 2013: 183), and there is no reason to believe that Bronze Age Europe was any exception in that regard. However, there is no substantial archaeological evidence to draw any reliable conclusions as to the gendered nature of the necessary steps in local textile production and trade.[1] Thus, to think of Bronze Age wool craft as an everyday female-related household task, and as such not affecting the political economy of the continent, is unfitting the nature of the archaeological record we are dealing with.

A recent study discussing wool production at the Italian Bronze Age Terramare site of Montale (Modena province) suggests considering the local textile production as community-based (Sabatini *et al.* 2018). Differently from, for example, metal production, which appears to have been controlled and regulated by emerging elites, thus augmenting social and economic hierarchy all over Europe (*e.g.* Earle *et al*. 2015; Kristiansen 1987; *cf.* Earle, Spriggs 2015), textile craft, at least in the Terramare setting, does not seem to be equally controllable. Although further research is necessary and new case studies should be brought to the attention of the international scholarly community, the characteristics and distribution of the local textile-related material culture suggest that production was to a large extent a communal endeavour (see below). In other words, while in the socially more complex societies of the Eastern Mediterranean there is clear evidence of both attached and independent textile crafting,[2] the archaeological material from the continent does not enable to clearly single out any of the two modes of production. Specialised workshop environments or evidence of unfree labour, which are documented for instance in the Aegean and the Near East (*e.g.* Alberti *et al.* 2012; Breniquet, Michel 2014b; Sauvage, Smith 2016; Smith 2002; Stol 2016: 344–349), are largely missing in Bronze Age Europe. It is unlikely that local elites did not control decisions concerning the economic and productive spheres (compare with *e.g.* Earle *et al.* 2015; Kristiansen 2016; Rowlands, Ling 2013). However, the intensity of the textile-related labour, which must have involved large portions of local communities, possibly affected elites' control strategies (Sabatini *et al.* 2018).

Wool economy

A long chain of manufacturing processes and economic activities is necessary to deliver the final woollen products (*e.g.* Andersson Strand 2014; Barber 1991; Costin 2013; Gleba 2008; Sofaer *et al.* 2013: 477–482; see also below). It is, therefore, argued that a working definition of wool economy is that of the whole set of practices that characterise the wool crafting *chaîne opératoire* (from sheep herding to fibre preparation, spinning, weaving, post weaving treatments, tailoring, as well as trade and consumption patterns) and the political economic design behind it. Wool economy, as it is understood here, is not exclusive. It defines a specific economic activity (production and trade of wool and woollen

[1] That is not to say there were no women and/or men-dominated textile-related production activities during the European Bronze Age. Instead, the intention here is to call attention to the fact that we lack sufficient evidence for either proving or denying it. Common assumptions about the gendered nature of textile work are almost exclusively based on ethnographical material and on evidence from different areas and periods (*e.g.* Barber 1991; 1994; Costin 2013; Hoffmann 1974). It is only with the very end of the Bronze Age and the beginning of the Iron Age – roughly from the 1st millennium BCE onwards – that in certain areas of the continent textile tools such as for example spindles, spindle whorls, and distaffs become regularly present in women's graves signalling also some form of a status of the deceased (*e.g.* Gleba 2008; 2013; Grömer 2013; 2016: 270–273). Likewise, it is not before the beginning of the 1st millennium BCE that women's contribution to textile production (mostly spinning and weaving) started being reflected on various objects and representations (*e.g.* Barber 1991; 1994; Gleba 2008; Grömer 2013; Turk 2005).

[2] Attached specialists are skilled artisans producing wealth items under the direct control of ruling elites. In the Eastern Mediterranean and Aegean regions during the Bronze Age, some textile production was likely attached and physically carried out within palace and citadel settings (Alberti *et al.* 2012; Sabatini 2016; Siennicka 2014; Tournavitou *et al.* 2015). Independent specialists produce goods on demand and may possess various skill levels. Studies on Late Bronze Age Cyprus have shown that growing textile production is accompanied by widespread presence of workshops and/or specialised activity areas in private household contexts (*e.g.* Sabatini 2018; Sauvage, Smith 2016; Smith 2002). *Cf.* Brumfiel, Earle 1987 for a theoretical discussion on the distinction between attached versus independent production.

textiles) which coexisted and intermingled with other possible 'economies' and productive activities.

Archaeological evidence for wool textiles and clothing from the continent suggests that by the mid-2nd millennium BCE wool was a well-known fibre in the local patterns of textile consumption (*e.g.* Bender Jørgensen, Rast-Eicher 2018; Broholm, Hald 1940; Gleba, Mannering 2012; Grömer *et al.* 2013). Raw wool during the Bronze Age was relatively precious and difficult to obtain (*e.g.* Andersson Strand 2014; Barber 1991: 20–32; Costin 2013; Gleba 2008: 72–75). To be produced in large quantities, not to mention high quality, it requires access to conspicuous numbers of woolly sheep/goats, whose management and organisation needs well-organised strategies of production and thus precise political economic choices. Hence, it is likely that in Bronze Age Europe, where the power of palace authority and pre-state societies were absent, wool production could be 'afforded' only when specific environmental and political pre-requisites created favourable conditions for its development (see Sabatini *et al.* 2018).

When adopting such a wide definition, one necessarily faces a problem of scale, since it is unlikely that all the phases of wool economy can be registered in one and the same Bronze Age European context. Additionally, when studied individually, each stage often reveals a further set of more specific sub-stages sometimes requiring *ad hoc* locations and tools. It is also important to remember that each of these steps could be carried out not only in separate settings, but also by different actors and in different periods of the year (*e.g.* Andersson Strand 2014; Barber 1991; 1994; Bender Jørgensen 2012a; 2012b; Breniquet, Michel 2014a; Carrer, Migliavacca in press; Gleba 2008). Therefore, wool economy is a complex economic phenomenon, which demands a variety of actors and places, all necessarily linked together and actively, albeit differently, contributing to it.

Archaeological evidence in the study of European Bronze Age wool economies

In order to study European Bronze Age wool economies one can rely on a limited set of direct and indirect evidence (Tab. 1). Direct records are the archaeological evidence informing about the existence of wool either as a raw material or as a fibre or textile (faunal remains of sheep and textile fragments). Among the direct evidence contemporary written texts have been included. They represent self-sufficient sources of information addressing wool economy issues and have been used as such in the wider Mediterranean context (*e.g.* Breniquet, Michel 2014a; Michel, Veenhof 2010; Nosch 2014a), but as to the study of Bronze Age Europe they are of a solely comparative value. Indirect evidence comes from the archaeological record showing textile production in general but not unveiling the kind of fibres that were used. From a methodological point of view, it is necessary to have a combination of evidence in order to argue for the existence of a working wool economy. Without local written sources, the available evidence provides a potential, but not undisputed, proof for such economy in Bronze Age Europe.

One of the main difficulties in the study of European Bronze Age wool economy is distinguishing it from a more general textile economy. There is plenty of evidence for other fibres being used to produce textiles (*e.g.* Barber 1991: 9–35; Bazzanella *et al.* 2003; Bender Jørgensen, Rast-Eicher 2016; 2018; Bergfjord *et al.* 2012; Gleba 2008: 63–75), thus, the parallel production of different sets of products should not be ruled out. Why then distinguish between wool and other types of textile economy? The answer lies in the fact that despite some parts of the *chaîne opératoire*, such as spinning and weaving, possibly indeed being similar for all fibres, the production of the raw material, the processing technologies, and the value of the finished products varied so much between different animal and vegetable fibres that they must have necessarily fuelled different economies. Hence, it is argued that the introduction of sheepherding geared towards wool production and consequent remodelling of animal and landscape management must have represented an economic, social, and cultural innovation, likely in a similar fashion to what happened in Mesopotamia by the 3rd millennium BCE (*cf.* Bender Jorgensen, Rast-Eicher 2016; Breniquet, Michel 2014b: 2; McCorriston 1997).

Contemporary written sources from the wider Mediterranean area

The path that leads to the current understanding of Bronze Age wool economy was beaten largely thanks to the progress in interpreting eastern Mediterranean and Near Eastern written sources from the 3rd and 2nd millennia BCE (*e.g.* Breniquet, Michel 2014a; Killen 2007; Michel, Nosch 2010; Nosch 2011; 2015; Waetzoldt 1972). Although they refer to more complex societies than those of Bronze Age Europe, they provide a rich account of the complexity of prehistoric wool economy. Their translations proved, in the first place, that wool production was a major activity moving tons of raw and manufactured material and requiring, among other things, a consistent and multifarious workforce (*e.g.* Biga 2011; Del Freo *et al.* 2010; Killen 2007; Maiocchi 2016; Nosch 2011; Peyronel 2014; Rougemont 2009; Stol 2016: 344–349). Indeed, without texts we would not have been able to grasp the revolutionary force of wool. Most of the known written sources represent a unique record as to the very existence of this specific material (*e.g.* Burke 2010; Breniquet, Michel

2014a; 2014b; Foster 2014; Killen 1964; McCorriston 1997; Michel, Nosch 2010; Nosch 2014b; 2015). There are hardly any preserved textiles from these areas, and practically all of the known fragments were made of vegetable fibres (Skals *et al.* 2015). In other words, without the texts we would have no clear indications of the role that wool played in the Bronze Age economy of these regions, including long-distance trade ventures such as those documented by the Assyrian merchants' letters found in the Anatolian site of Kaneš/Kültepe (*e.g.* Michel, Veenhof 2010; Lassen 2010).

All in all, despite the texts providing fundamental information as to the organisation of textile-making, which would have been hardly obtainable relying solely on the archaeological evidence, several questions remain open. On the Late Bronze Age Greek mainland a vivid contrast exists, for example, between the abundant written evidence for large-scale textile production and the apparent lack of storehouses for textiles or raw materials and specialised workshops or industrial areas (*e.g.* Burke 2010: 437; Tournavitou *et al.* 2015: 262). It has been proposed that such absence should be interpreted as an indication for textile production carried out extensively in different places, including households and minor settlements (*e.g.* Siennicka 2014). The widespread presence of spindle whorls, though generally in rather small concentrations and accompanied by other so-called small finds and tools within several Mycenaean citadels, has been interpreted as the evidence of attached craft being carried out in small-scale multifunctional workshops producing specific and probably exclusive products of various kinds (*e.g.* Alberti *et al.* 2012; Rahmstorf *et al*. 2015; Sabatini 2016), including textiles. How the system as a whole functioned in practice and how its specific products were manufactured remains an important question for archaeological research.

In continental Europe, where contemporary written sources are altogether lacking, the information provided by these texts offers a useful guidance and comparative material. In particular, one should emphasize the fact that Bronze Age wool fibres from the continent seem to be very similar to those that could be obtained from the so-called primitive sheep, such as the modern Soays (see below). Since the yearly wool harvest from Soay flocks appears similar or comparable to the kind of animals that are recorded, for example, in Linear B tablets (*e.g.* Del Freo *et al.* 2010), any Bronze Age wool economy on the continent would depend on relatively similar underlying conditions – at least as far as the raw material production was concerned – to those that Aegean wool economies had to face.

Textiles and textile fragments made of wool

Woollen textile fragments from across various parts of Europe (Bender Jørgensen 1992; Bender Jørgensen, Rast-Eicher 2015; 2018; Broholm, Hald 1940; CinBa database; Gleba, Mannering 2012; Grömer *et al*. 2013; Rast-Eicher, Bender Jørgensen 2013) suggest that early in the 2nd millennium BCE wool was already known and used. With the exception of the famous collection of complete cloths found in the Danish Early Bronze Age oak-log coffins (*e.g.* Bender Jørgensen 1992; Broholm, Hald 1940), the many textiles from the Austrian Hallstatt mines (*e.g.* CinBa database; Grömer 2016; Grömer *et al.* 2013), and the cloth from the Pustopolje tumulus 16 in Bosnia-Herzegovina (Bender Jørgensen, Grömer 2013; Harding 1995; Marić Baković, Car 2014), most of the known woollen textiles from the continent consist of relatively small fragments. Despite limitations, various types of analyses and studies of such material have provided data regarding:

- The geographical distribution of wool consumption
- The techniques used to manufacture the woollen textiles
- The characteristics of the wool used to produce them
- The local or non-local character of the raw material.

Similarly to the Mediterranean (*cf*. Skals *et al.* 2015), also in Europe there is a relatively large number of preserved prehistoric textile fragments made of vegetable fibres (*e.g.* Bazzanella *et al.* 2003; Bazzanella, Mayr 2009; Gleba, Mannering 2012), which provide, at least from the perspective of this work, invaluable information about known and practiced manufacturing techniques. Without the linen textiles from the Alpine lakes, we would, for example, not be able to infer that embroidery, brocade, and patterns of concentric lozenges made in a sort of twill weave were used during the Bronze Age and were likely already known since the Neolithic (*e.g.* Barber 1991: 133–144; Bazzanella *et al*. 2003; Bazzanella, Mayr 2009). A recent study focusing on the 1st millennium BCE and on the archaeological evidence from the Italian Peninsula and the Aegean has pointed out how the numerous textile fragments from both regions allow assigning to each area a specific textile tradition (Gleba 2017). The manufacturing techniques employed to produce textiles in the Italian Peninsula clearly appear to be a part of the prehistoric tradition with roots in the European Bronze Age world until the beginning of the local orientalising period (around the 7th century BCE). This study – although indirectly – supports the idea of European Bronze Age wool economies by suggesting that prior to the 1st millennium BCE woollen textiles had a distinct character from that of the nearby Aegean world, and thus that continental systems of demand, production, and supply likely already existed.

As mentioned, one of the relevant conclusions offered by the study of the continental textile fragments consists of the data about the characteristics of the wool used to produce them (*e.g.* Barber 1991: 125, 176–185; Bender Jørgensen 1992; Gleba 2008; 2012a; 2012b; Grömer *et al.* 2013; 2016; Rast-Eicher, Bender Jørgensen 2013). The Italian Peninsula has offered some of the earliest continental evidence of spun wool fibres (Bazzanella 2012; Bazzanella, Mayr, 2009: 35, 41–46, 79–78; Bender Jørgensen, Rast-Eicher 2015) found in Alpine lake dwellings and dated to the Early Bronze Age (Polada Culture, *c.* 2200–1650 BCE). The earliest pure woollen fabric which underwent microscopic (SEM) analyses is a fragment from the Terramare settlement of Castione dei Marchesi (Parma province), dated approximately to between 1650 and 1300 BCE (Bazzanella 2012: 209). The scientific investigations performed on its fibres suggest that the wool came from sheep resembling today's Soays (Gleba 2012a: 328–329), which moult once a year to yield 0.3–0.9 kg of wool (Robson, Ekarius 2011: 195). This figure corresponds to the wool unit in Aegean archives, expressed by the sign *145/LANA, which seems to signify a wool sack of *c.* 3 kg, containing four adult sheep fleeces of *c.* 750 g or 10 fleeces of *c.* 300 g from mixed flocks (Del Freo *et al.* 2010: 340–344).[3] According to a neo-Sumerian source, as much as 4 kg of a fourth class wool (valued on one [royal] to five [poorest quality] scale) are necessary to obtain an average (*guz-za*) fabric of *c.* 3.5 x 3.5 m (*e.g.* Andersson Strand, Cybulska 2012: 113–118). Thus, emerging continental Bronze Age wool economies – just as in the Eastern Mediterranean (*e.g.* Biga 2011; Firth 2014; Halstead 1999) – would need large numbers of sheep and consequently precise political economic choices and well-organised strategies of production.

Finally, the somehow revolutionary possibility to investigate the strontium isotope signal of ancient textiles has recently opened a new avenue for understanding the European wool economy during the Bronze Age. Strontium isotope tracing methods provide information regarding the geology of the regions where a given living being did actually spend its life (Frei 2012). Wool coming from sheep contains the same strontium value as the animal that it originally covered, and thus indicates the region were it grazed. Strontium does not single out the area of origin, since many regions have similar geological characteristics and thus strontium signals, however, it would tell if the area in which the examined material has been found is compatible or not with the obtained results. A series of analyses of the wool from the Early Bronze Age Danish oak-log coffin cloths (Frei *et al.* 2015; 2017) have brought to the attention of the international community of scholars the fact that most of the analysed material is actually made of wool coming from animals that have not lived within the present-day Denmark's territory. Considering that no convincing archaeological evidence exists for textile production in Bronze Age Scandinavia (*e.g.* Bergerbrant 2007: 49; Sofaer *et al.* 2013: 480), the isotopic analyses provide invaluable evidence to support the hypothesis of a continental Bronze Age wool trade at least during the 14th century BCE.

Faunal remains and reconstructions of animal populations and kill-off patterns

Wool production is necessarily dependent on access to sheep. Therefore, the study of faunal remains and of the prehistoric animal population provides a very important set of direct evidence for wool production. Indeed, the pioneering work of Michael Ryder (*e.g.* 1964; 1974; 2005) on the evolution of sheep fleece has opened for the first time an avenue for better understanding of the characteristics of primitive sheep. Later studies revealed that Ryder's model provides a somewhat simplified picture of past sheep and that a new set of previously overlooked factors should be also taken into account (*e.g.* Gleba 2008; 2012b; Rast-Eicher, Bender Jørgensen 2013; Skals *et al.* 2018). All in all, the debate about Bronze Age wool is far from exhausted. Although it is generally accepted that the annual yield per animal was very limited, the characteristics of the wool and the possibly existing sheep breeds remain a matter of debate. Ongoing attempts to study the DNA of ancient sheep (Brandt, Allentoft in press; Brandt *et al.* 2011) and recent investigations of ancient protein residues (Di Gianvincenzo *et al.* in press) will hopefully soon provide new datasets to work with.

As per the scope of this paper, the very amount of sheep/goat remains appears to be of greatest importance for assessing local engagements in wool economy. Since, as repeatedly mentioned, large herds are necessary to produce wool and woollen textiles, sites with a high preponderance of sheep/goats over other taxa become likely candidates for such production. It has been pointed out how sheepherding geared towards wool production would ideally require specific kill-off patterns since most wool is obtained from, for example, wethers, followed by

[3] One might, however, consider that these figures are probably not universally valid and some adjustments are necessary from case to case. Although Eurasian Bronze Age sheep in general seem to produce limited amounts of wool, it has been calculated that Mesopotamian sheep already at the very end of the 3rd millennium BCE provided a slightly higher wool yield (between 0.7 and 1.12 kg of wool per year) than their later counterparts in the Aegean (Andersson Strand 2014: 44).

adult ewes (*e.g.* Barber 1991: 25–28; Halstead, Isaakidou 2011; Payne 1973). The presence of a large number of wethers would therefore suggest wool production more than anything else. A large amount of young animals would instead indicate that herds were mostly kept for milk and meat consumption. The precisely recorded information from the Linear B archive of Knossos (Del Freo *et al*. 2010) shows that the palace was well aware of these factors and that specialised wool flocks existed; however, the very same sources show that even in the very well-organised case of Knossos, and despite its large demand for wool, one could hardly escape a mixed economy and thus flocks with animals of different ages, including the young, were also taken care of.

The study of the archaeozoological remains from the Bronze Age site of Százhalombatta-Földvár (Pest province, Hungary) revealed an enlightening pattern suggesting that a clear shift in the political economy of the site occurred at the onset of the 2nd millennium BCE. From the 3rd millennium BCE, the prevalence of cattle became rapidly replaced by sheep/goat herding accompanied by changes in sheep kill-off patterns, which suggests that raising sheep became geared towards wool production (*e.g.* Vretemark, 2010: 163–166; see also Bender Jørgensen, Rast-Eicher 2015). Interestingly enough, on the very Százhalombatta-Földvár tell a conspicuous number of Middle Bronze Age textile tools were also found (Bergerbrant 2018). It is therefore likely that Százhalombatta-Földvár was one of those European communities that took advantage of local favourable conditions to engage in one of the earliest wool economies of the continent.

Another example of a community likely engaging in wool economy is represented by the Bronze Age Terramare site of Montale (Modena province) in northern Italy (*e.g.* Cardarelli 2009).[4] The site has been recently subjected to a series of investigations aiming at understanding the characteristics of the local textile production (*e.g.* Sabatini in press; Sabatini *et al.* 2018). During more than a hundred-years-long chain of excavations and collecting of archaeological material at the site, an outstanding number of textile tools have been gathered (see below). Archaeozoological studies of the animal remains from the site, although published only preliminarily, show that at any given time sheep/goats not only represented the local largest taxa (with a long-term average of *c.* 50% of all the animal remains), but also suggested that the number of sheep/goats increased over time and during the first part of the Italian Recent Bronze Age (*c.* 1325/1300–1225/1200 BCE), which is the site's final phase, constituted up to over 60% of the local animal population (De Grossi Mazzorin 2013; De Grossi Mazzorin, Ruggini 2009).

Textile tools

Costin (1991: 1) considers craft specialisation ideal for archaeological investigation because of the rich evidence that tools leave in the archaeological record. And indeed, tools for production of textiles, such as spindle whorls and loom weights, which were normally made of non-perishable material such as clay or stone, were widespread on the continent since before the Bronze Age (*e.g.* Gleba, Mannering 2012). A crucial issue for the present work is that while they unmistakably document textile production, they do not, however, account for wool economy, unless it is possible to correlate their presence with other significant evidence. They are, therefore, to be considered essential but indirect evidence. In the absence of any other record (such as textile fragments or faunal remains of sheep/goats), textile tools alone cannot be used to presume wool economy.

On the other hand, textile tools can provide very good evidence for understanding the scale of local textile production (*e.g.* Andersson Strand, Nosch 2015). A careful documentation of the textile tools excavated at the mentioned site of Montale in northern Italy demonstrates that specialised textile production can be archaeologically detected far from the known Eastern Mediterranean centres of the time (Sabatini *et al.* 2018). Over 4500 spindle whorls were recovered at the site, suggesting more than anything else that textile production was close to an industrial scale and that a large portion of the local population (estimated to a maximum of *c.* 125–130 individuals per generation, *cf.* Cardarelli 2015: 167) must have been involved in textile production. The information obtained by the analysis of craft specialisation at the site, when combined with the mentioned analysis of the faunal remains (De Grossi Mazzorin 2013; De Grossi Mazzorin, Ruggini 2009), leaves little doubt regarding the possibility that the local population was engaged in wool economy. Studies on the characteristics of the settlement patterns in what could be considered Montale territory and neighbouring areas suggest that community specialisation may have taken place (*cf.* Costin 1991: 8) with a division of labour between the settlement on the plain (specialised in textile production) and those in the mountainous area to the south of the plain (involved, among other things, in seasonal sheepherding) (*cf.* Cardarelli 2006; Cavazzuti, Putzuolo

[4] The Bronze Age chronology for mainland Italy can be summarised as follows (see also Cardarelli 2015): Early Bronze Age (*c.* 2200–1700/1650 BCE); Middle Bronze Age (*c.* 1700/1650–1325/1300 BCE); Recent Bronze Age (*c.* 1325/1300–1150 BCE); and Final Bronze Age (*c.* 1150–950/925 BCE).

2015). Montale is unique due to the enormous amount of spindle whorls found at the site, but it is likely not an isolated case. Across the Po plain and the Terramare area in northern Italy, a number of site-specific publications suggest that textile production in general was practiced widely, although with different intensity at various sites (Bernabò Brea *et al.* 2003; Bianchi 2004; Desantis 2011; Lincetto 2006; Sabatini in press).[5] It is also clear that generally sheep/goat is a very common taxa all over the plain, thus engagement in wool economy may have taken place in different forms. One hypothesis could be that there was a production system (*cf.* Brumfiel, Earle 1987) with independent communities able to exploit local environmental, technological, and organisational advantages to meet a wider demand. Alternatively, one could think of a network system in which production was somehow coordinated between settlements, some of which were specialised, like Montale. Such questions necessarily represent an important avenue for future studies.

Discussion

The very aim of the present paper is to discuss how and on what basis wool economy can be investigated in Bronze Age Europe. Wool economy has been successfully used to define the systems of manufacture, exchange, and consumption that characterise the Near Eastern and Aegean regions during the 3rd and 2nd millennia BCE (*e.g.* Breniquet, Michel 2014a; Nosch 2014a; 2014b). In this period, the characteristics of Bronze Age societies in continental and northern Europe are not comparable in terms of socio-cultural and political complexity to those from the Mediterranean area; however, during the 2nd millennia BCE they came to know and appreciate wool and woollen products. Studies on the characteristics of local weave and thread preparation suggest that textiles from Bronze Age Europe have a distinct 'continental' character, which lasted until the Early Iron Age (Gleba 2017) and thus likely did not depend on supplies from the Mediterranean world.

Considering that Bronze Age sheep in Europe were apparently rather similar – at least as far as wool yield is concerned – to those that are recorded in, mostly Aegean, written sources, wool production required access to large herds. The presence of large numbers of animals, in turn, directly raises issues of landscape management and maybe seasonal exploitation of different territories. As there is no evidence for dominant elite groups controlling attached textile productions, it seems that continental wool economies were managed at the community level (Sabatini *et al.* 2018). Moreover, sheepherding and raw wool production are just the initial steps of any wool economy. Once wool is collected, textile production is a time-consuming, year-round activity which engaged a considerable number of workers, for example in the documented case of the Near East and the Mediterranean economies. There is no evident archaeological record suggesting large scale unfree labour in Bronze Age Europe, therefore it is likely that craft specialisations must have followed precise political economic choices at the community level. The presence of wool textiles and wool fragments in several parts of the continent, including Scandinavia where strontium tracing analyses unveiled that wool was largely imported (*e.g.* Frei *et al.* 2015; 2017), strongly supports a twofold hypothesis. On the one hand, the evidence proves the existence of continental wool trade (see *e.g.* Kristiansen 2016; Kristiansen, Stig Sørensen in press), *i.e.* one of the last necessary steps for a working wool economy. On the other hand, it also suggests that there must have been centres of production able to provide woollen textiles to areas where wool was consumed but not manufactured, at least not on a large scale (see also Bergerbrant in press; Sabatini, Melheim 2017).

From a methodological point of view, the study of any wool economy would benefit from the possibility to single out centres of production. As Costin (1991: 1) points out, tools are the primary source of information for the study of craft specialisation, but as far as Bronze Age wool economy is concerned, we lack specialised tools. Paradoxically, the very same primary evidence for textile production is alone not sufficient to suggest engagement in wool economy! Only when it is combined with another set of direct data (see Tab. 1) can we attempt envisioning such economy. Keeping an eye on the informative but only comparative sources from the wider Mediterranean area, the coexistence of archaeological records of textile tools and archaeozoological data suggesting large numbers of sheep provides the most successful combination of evidence to suggest local engagements in wool economy. The presence of woollen textile fragments is very important but more problematic for discourses on the political economy of the continent. Nonetheless, thanks to recent advances in strontium isotope tracing analyses, such fragments have become crucial for unveiling the existence of wool and woollen textile trade.

[5] As far as the textile production is concerned, beside Montale, we have accurate information from modern excavations at the sites of Poviglio (Bernabò Brea *et al.* 2003; Bianchi 2004; Lincetto 2006: 114–127, 193–218), Beneceto (Bernabò Brea *et al.* 2003; Lincetto 2006: 138–156), and Fraore (Lincetto 2006: 180–186), in the Parma province from Anzola (Desantis 2011), and Borgo Panigale (Lincetto 2006: 219–225) in the Bologna province.

Tab. 1. Available archaeological evidence for studies on the European Bronze Age wool economies.

Evidence	Type of evidence	Information provided	Observations and problems
Written sources	(Direct)/ Comparative	• evidence for existence of wool economy • information on intensity/ organisation of labour • data on production *chaîne opératoires* • 'quantities'/figures related to production and trade	Written sources provide direct evidence for wool economy in the contexts where they have been found. Beyond the coasts of the Mediterranean they have but a comparative value.
Textiles and textile fragments made of wool	Direct	• data on the use of woollen textiles • characteristics of the wool • characteristics of the weave and thread preparation techniques – potentially characteristics of a local fashion • the potential evidence for trade (strontium isotope analyses)	Textile remains potentially but not necessarily account for production in the contexts in which they have been found, since they may have been produced somewhere else.
Faunal remains and reconstructions of sheep/goat populations and kill-off patterns	Direct	• potential evidence for existence of raw material (wool) production	High percentages of sheep/goat bones hint at wool production, although not necessarily (milk, meat, and leather might be the actual production) or exclusively.
Textile tools	Indirect	• evidence for existence of textile craft in general	Archaeologically common Bronze Age tools such as spindle whorls and loom weights do not indicate which kind of fibres were manufactured.

Concluding remarks

Continental wool production and trade during the Bronze Age likely reached complexity and extension that necessitate major scientific attention not only regarding the phenomenon *per se* but also its prominent historical role. Wool economy, as discussed in this paper, could represent a useful framework for further studies on the subject. There is no space to expand this discussion much longer, but it should be finally emphasised that the hypothesis of wool economy as a result of precise political choices largely involving Bronze Age communities gives the possibility to link it back to the gender issue touched upon at the beginning of this paper. It has been suggested that for a better understanding of Bronze Age wool production it would be necessary to question general assumptions on the gendered nature of the textile-related work during prehistory. Differently from what appears common in later periods, the available archaeological evidence suggests that during the Bronze Age wool production likely required community specialisation and engaged significant parts of local populations. Gendered tasks presumably existed during the Bronze Age but become variously manifested in the archaeological record only at a later stage, roughly by the beginning of the 1st millennium BCE. It is not possible to address the issue here, however, the evidence would suggest that substantial social transformations occurred at the time and appear to chronologically coincide with the possible introduction of woollier sheep (*e.g.* Gleba 2012a: 333) and thus with considerable transformations in raw material production systems.

To conclude, the production of woollen textiles requires a complex organisation of labour and resource management. Thus, European Bronze Age societies would probably not engage in such complex *chaîne opératoires* if they were not aware of the value of this production and the benefit that its outcome may have had, for instance as an export commodity (*e.g.* Sabatini *et al.* 2018). The introduction of wool production and trade must have therefore been a result of precise political economic choices. Adopting the wool economy perspective for the study of the relevant material culture from continental Europe shall help posing insightful questions and

enhance understanding of the prominent historical role of this craft specialisation for the development of Bronze Age societies.

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Innovative or Traditional? Diachronic Approach to Weaving Technology in Bronze Age Greece

Abstract

This paper aims at recognising potential innovations in weaving technology that may have occurred in Bronze Age Greece. It discusses whether these assumed developments may be examined diachronically. This discussion is based on archaeological evidence of textile implements, such as loom weights and presumed traces of warp-weighted looms, as well as knowledge of traditional craft and experimental archaeology. After a short introduction discussing how technical innovations could possibly be recognised in weaving, the paper explores possible changes in the construction and functionality of the warp-weighted loom and potential uses of other types of looms in Greece. A distribution pattern of specific forms of a loom weight, *e.g.* discoid loom weights in particular, is examined as an innovation responding to the demand for fabrics of specific technical qualities and appearance, possibly associated with a spread of new weaving techniques which accompanied the transmission of these tools. Social relations and modes of organisation of textile production are considered factors that must have had a significant impact on creativity and innovativeness in weaving technology. However, the final conclusion is that specific relations between the organisation of weaving and the occurrence of innovative processes cannot be clearly recognised based on the available evidence.

Streszczenie

Innowacyjna czy tradycyjna? Technologia tkacka w epoce brązu w Grecji w ujęciu diachronicznym

Celem artykułu jest próba rozpoznania innowacji, jakie zajść mogły w technologii tkackiej w epoce brązu w Grecji, oraz prześledzenie potencjalnych zmian w tradycjach tkackich w szerszej perspektywie czasu i przestrzeni. Podstawę dla dyskusji stanowią pozostałości archeologiczne, takie jak ciężarki tkackie i ślady po krosnach, analizowane w odniesieniu do rzemiosła tradycyjnego oraz archeologii eksperymentalnej. Po krótkim wprowadzeniu określającym czym mogły być innowacje w tkactwie, analizowana jest budowa i funkcjonalność krosna ciężarkowego, jego ewentualne zmiany w czasie oraz inne typy krosien, które być może były znane w Grecji. Geograficzne rozmieszczenie określonych typów ciężarków tkackich, jak np. dyskoidalnych, omawiane jest jako innowacja odpowiadająca zapotrzebowaniu na tkaniny o specyficznej strukturze i wyglądzie, odzwierciedlająca, być może, rozpowszechnienie się określonych technik tkackich. Stosunki społeczne i tryby produkcji rozważane są jako czynniki o istotnym znaczeniu dla kształtowania innowacyjności i kreatywności, z końcowym wnioskiem jednakże, że bezpośrednie relacje pomiędzy trybem produkcji a innowacyjnością, przy obecnym stanie badań nad włókiennictwem w Grecji epoki brązu, nie mogą być czytelnie rozpoznane.

Keywords: Bronze Age Greece, textile technology, weaving, warp-weighted loom, loom weights, innovation, tradition

To the memory of Jo Cutler

Introduction

Weaving in Bronze Age Greece has been acknowledged as an advanced technology that enabled production of substantial quantities of highly valued, fine quality textiles – goods of key importance to local economies (*cf.* Barber 1991; Tzachili 1997; Burke 2010; Shaw, Chapin 2016).[1] However, diachronic developments of weaving techniques are not easy to recognise or track through the archaeological evidence, neither are the potential innovations that may have enhanced growth in production and improvements in the quality of fabrics. Several elements in the archaeological evidence suggest that weaving was a rather traditional and, technically, unchanging craft, whereas others point out to innovativeness and dynamics of weaving (*cf.* Nosch 2015). All this makes the general picture of developments in weaving technology in Bronze Age Greece rather ambiguous.

The traditional and conservative character of weaving technology may be suggested, *e.g.*, by the continuous use of the warp-weighted loom. This type of loom, attested archaeologically by the presence of loom weights, had already been in use in Greece since the Neolithic and continued well after the end of the Bronze Age[2] (*cf.* Hoffmann 1964; Barber 1991; Andersson Strand, Nosch 2015a; Siennicka *et al.* 2018). Also, the parameters of archaeological textiles from Greece (*e.g.* choice of fibres, structure of yarns, and density of fabrics, that is a number of warp and weft threads per cm) seem to be rather homogenous throughout the entire Bronze Age (Spantidaki, Moulherat 2012: 187–194; *cf.* Skals *et al.* 2015 for an overview of archaeological textiles in the Neolithic and Bronze Age Mediterranean). Significant improvements in the quality of textiles and threads (increased density of fabrics, finer yarns, and different structure of yarns) and an increased number of woollen fabrics have only been observed at the transition from the Bronze to Iron Age, *e.g.* in the assemblage of textiles from the necropolis of Lefkandi (Spantidaki, Moulherat 2012: 194, 197, Tabs 7.2, 7.3). Yet, the actual textiles are rarely preserved in Greece and, due to the limited number, their technical parameters and structure cannot be seen as fully representative of the wide variety of fabrics that must have been produced in the Bronze Age. Moreover, with the notable exception of Akrotiri on Thera, the majority of preserved fabrics come from the funeral contexts where the preserved textiles were used to wrap mouths of clay jars or bronze objects (*cf.* Moulhérat, Spantidaki 2007; Spantidaki, Moulherat 2012).

Significant changes or developments may be observed in the exploitation of raw materials and in the growth of wool economy (Breniquet, Michel 2014; Nosch 2015), in the distribution pattern of loom weights and introduction of new loom weight forms, the organisation and scale of production, as well as the social relations of production and the mechanisms of transmission of knowledge and skills (*cf.* Burke 2010; Cutler 2012; 2016a; Andersson Strand, Nosch 2015a; Gorogianni *et al.* 2015; Ulanowska, Siennicka forthcoming).

Moreover, the iconography of textiles, especially those depicted in wall paintings, shows a variety of patterned fabrics, confirming the existence of textiles that were more sophisticated products than those that had actually been preserved (Jones 2015; Shaw, Chapin 2016; *cf.* Moulhérat, Spantidaki 2007; Spantidaki, Moulherat 2012: 187–188). Linear B tablets enumerate a variety of textile types and several professional designations of textile workers, which implies complex specialisation of the textile production that was controlled by the Mycenaean palaces (Killien 2007; Bruke 2010; Del Freo *et al.* 2010). All this suggests that textile production was actually dynamic and diversified, and innovations resulting in transmission of new skills and new weaving techniques occurred extensively during the Bronze Age.

Certainly, this paper does not attempt to explain all the ambiguities that have been briefly outlined above. It aims at examining what kind of potential technical developments in weaving may actually be recognised on the basis of the available archaeological evidence and experimental archaeology. It also discusses whether the assumed innovations may be traced diachronically and placed within a specific timescale, and, possibly, be related to a certain mode of organisation of textile production.

[1] This paper was based on the research carried out by the author during the internship grant at the Centre for Research on Ancient Technologies of the Institute of Archaeology and Ethnology, Polish Academy of Sciences, awarded by The National Science Centre in Poland (DEC-2015/16/S/HS3/00085). I would like to express my thanks to the anonymous reviewer for their helpful comments and suggestions. I also thank Paul Barford for improving my English.

[2] The Bronze Age in Greece is divided into three main chronological phases, *i.e.* Early Bronze Age (EBA): 3100 – 2200/2050 BCE, Middle Bronze Age (MBA): 2200/2050 – 1700/1675 BCE and Late Bronze Age (LBA): 1700/1675 – 1075/1050 BCE (Manning 2010: Tab. 1).

What are we looking for? About recognising potential inventions and innovations in weaving technology

In archaeology, an 'invention' may be defined as an event that creates a new concept in technology "that makes a new construction or system possible" (Kristiansen 2005: 113) and is substantially different from the technologies already existing. By adding a new solution, built upon the already existing structures or components, the invention introduces new social and economic practices (*cf.* Kristiansen 2005: 113–116; Hollenback, Schiffer 2010: 332; Burmeister, Bernbeck 2017). On the other hand, 'innovation' is a process that adds new methods, ideas, or practices to the existing technology and, by creating new varieties, leads to improvements, *e.g.* refining routines or increasing efficiency, and technological differentiation. As a result of innovations, technology is gradually modified and diversified (Kristiansen 2005: 113; Hollenback, Schiffer 2010: 332; see Jeffra 2011: 17–26; Bender Jørgensen *et al.* 2018 for a general discussion on the concept of innovation and creativity).

According to these definitions, all societies are, in general, more innovative than inventive, yet, according to K. Kristiansen, "the number of inventions increases with the development of complex societies and states which have not only new needs but also potential to fulfil them" (2005: 113, for a quotation see: 114). Both inventions and innovations require new skills and motor habits that have to be embodied and then transmitted. Both may change the perception of the environment and the manner in which the environment is manipulated and exploited (*cf.* Cutler 2016a: 174–175; Burmeister 2017: 31).

In weaving technology, the greatest invention may possibly be recognised in the creation of a loom – the first machine that, by a mechanism for shed changing, made weaving automatic (for a loom as "one of the first machines in human history" see Grömer 2016: 93; for an overview of "advanced textile techniques", including weaving, *cf.* Desrosiers 2010: 27, 39–45, Fig. 3.4). The date of this major invention has generally been placed in the Neolithic period and related to the creation of small implements for weaving narrow fabrics that preceded bigger looms (Broudy 1979: 9–11, 14–20; Barber 1991: 79–83, 254). The creation of the big looms, such as a horizontal ground loom and a warp-weighted loom, being dated to between the 7th and 6th millennia BCE (*cf.* Andersson Strand 2018; Siennicka *et al.* 2018 for the recent overview of the evidence), would thus be an important innovation that facilitated weaving of large pieces of fabric.

Other possible innovations may be sought in technical improvements of the existing looms (*e.g.* adding more heddles to the warp-weighted loom), introduction of new types of looms (*e.g.* a two-beam vertical loom), and introduction of new weaves, such as twills (*cf.* Nosch 2015). The knowledge of twill weaves and use of multiple heddle bars (or heddles) have already been attested in Bronze Age Central Europe and are considered a major technical innovation of this age (Bender Jørgensen, Rast-Eicher 2016: 80–86), whereas the two-beam loom, a new type of loom in the Egyptian weaving tradition, was in use in Egypt since *c.* the 15th century BCE (Broudy 1979: 44–46; Barber 1991: 113). An introduction of new types of loom weights may also be seen as a technical innovation responding to the demand for fabrics of a specific structure and appearance (*cf.* Andersson Strand, Nosch 2015a). Whether and when these important innovations may have occurred in Bronze Age Greece is discussed in the following sections.

According to Anne Brysbaert, "As such, creativity can sit in the organizing processes, resulting in the connecting efforts between tool, material and actors" (2017: 21). Therefore, substantial changes in the social relations of production and development of new modes of production that result in the increase of production or enhanced efficiency may also be seen as developments, even if they were not accompanied by any specific innovations in technology.

Construction of the warp-weighted loom in Bronze Age Greece

The general construction of the warp-weighted loom and the mechanics of its use in weaving have been recognised on the basis of evidence from observation of its traditional craft use, historical and iconographic records, and experimental archaeology (*cf.* Hoffmann 1964; Broudy 1979; Barber 1991; Tzachili 1997; Andersson Strand, Nosch 2015a). The construction of the warp-weighted loom that was specific for a certain period and area may be reconstructed based on *in situ* remains of the warp-weighted loom, such as loom weights or traces of loom uprights, and relevant iconography.

Archaeological evidence suggesting the general construction and size of the warp-weighted loom

In archaeological contexts from Bronze Age Greece, *in situ* discoveries of the warp-weighted looms have been rare. They are attested by the rows or concentrations of loom weights (*cf.* Kastanas: Aslanis 1985: 49–51, Abb. 23–24; Mauel 2009; 2012; Tiryns: Siennicka 2012: 67; forthcoming; Chania: Brunn-Lundgren *et al.* 2015: 199–200; Sitagroi: Elster *et al.* 2015: 305) and postholes or remains of wooden parts of the loom (for possible traces of decomposed or carbonised wood from looms, *cf.* Carington Smith 1975: 303–304; Myrtos: Warren 1972: 53; Barber 1991: 102; Lerna: Wiencke 2000:

Fig. 1. Two types of warp-weighted looms of modern construction: a) the Scandinavian type used in the Institute of Archaeology, University of Warsaw (photo by the author), b) the free standing type used in the Biskupin Archaeological Museum (photo by Łukasz Gackowski).

140–142, Plan 26; Aghia Triada: Militello 2012: 205; Chania: Brunn-Lundgren *et al.* 2015: 199–200).

Since loom weights are often found scattered, it has been assumed that textile production may have been located on the upper floors of houses and workshops, especially in Crete and at Akrotiri, where good lighting could be provided by windows (*cf.* Carington Smith 1975: 302–303; Tzachili 1990; Sakellarakis, Sapouna-Sakellaraki 1991: 89; 1997: 225, 320; Gorogianni *et al.* 2015: 900–902; Militello *et al.* 2015b: 223; Poursat *et al.* 2015; Cutler 2016b; Hitchcock 2016). Sometimes, the looms were placed in rooms with an oven or hearth, *e.g.* in Room M, House I at Kastelli, Chania (Brunn-Lundgren *et al.* 2015: 198). Finally, larger concentrations of loom weights were often found in a storage facility, *e.g.* gathered together in – unpreserved now – baskets, cupboards, or shelves (*cf.* Burke 2010: 53, 56–58; Brunn-Lundgren *et al.* 2015: 200–201; Militello *et al.* 2015a: 209; 2015b: 223; Papadopoulou *et al.* 2015: 294; Poursat *et al.* 2015). Therefore, the exact position of the warp-weighted loom(s), as well as potential spatial arrangement of a workspace or traces suggesting a specific construction of the loom, have only been recognised occasionally.

The evidence suggests that two types of warp-weighted loom may have existed. The first type, such as the loom in Room 143 in Early Bronze Age Tiryns, was placed close to a wall (Siennicka 2012: 67; forthcoming) or pillars (Mauel 2009: Abb. 59; 2012: Pl. XXXVIb), and this was possibly similar to the Scandinavian warp-weighted loom that was supported by its upper part leaning against a wall. The second type, of a possibly freestanding construction, was placed in an open space (Militello 2012: 205; Brunn-Lundgren *et al.* 2015: 200) (Fig. 1). In *Casa delle Sfere Fittili* at Aghia Triada on Crete, four of the postholes in Room 9 were interpreted as possible remains of a warping frame that may have been placed in the vicinity of the warp-weighted loom (Militello 2012: 206–207).

The width of the warp-weighted loom, calculated on the basis of the width of the concentration of loom weights or distance between two postholes, could range between 89.5–100 cm (Chania, Brunn-Lundgren *et al.* 2015: 200) and 110 cm (*Casa delle Sfere Fittili*, Aghia Triada, Militello 2012: 206).

Heddle bar(s) and the number of rows of loom weights

The general construction of the warp-weighted loom allows the separation of the warp threads into two layers tensioned by two rows of loom weights accordingly. The front layer hangs over a shed bar, whereas the back layer hangs freely. This creates a natural shed. By means of the heddles knitted to a heddle bar, the warp threads from the back layer are moved back and forth (Fig. 2). This way an artificial or a counter-shed is created and weaving is made

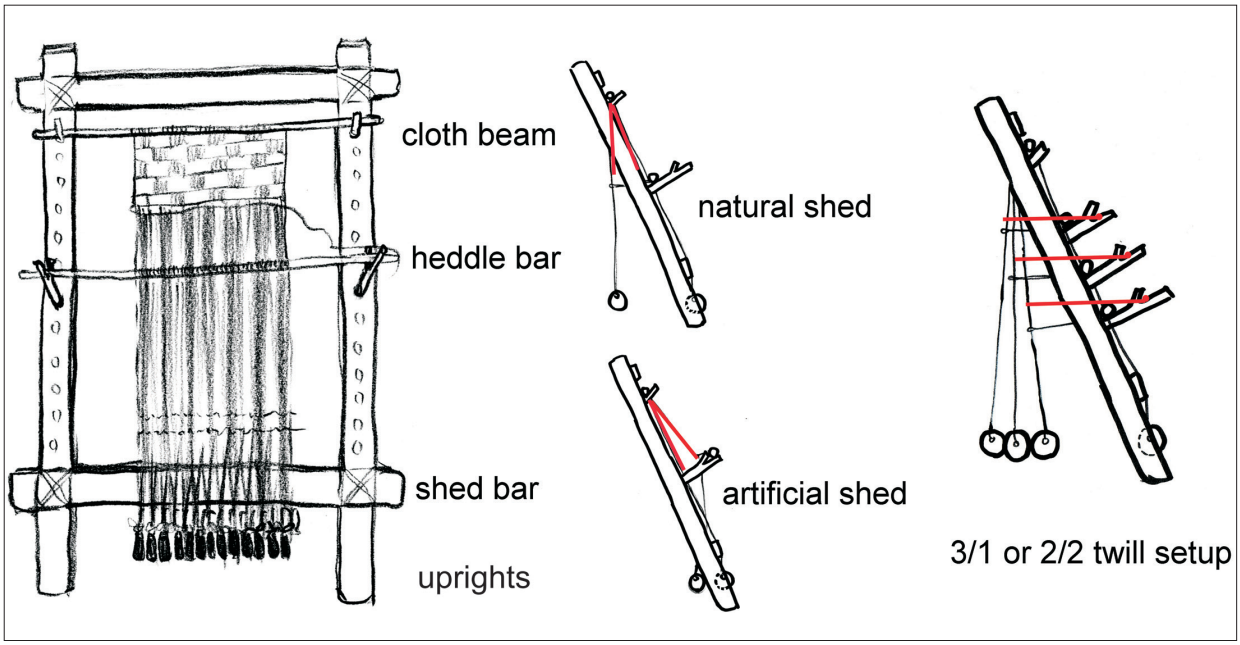

Fig. 2. The basic mechanics of the warp-weighted loom: construction of the loom, natural and artificial shed, setup for 3/1 or 2/2 twill weaves.

fully automatic. In more complex weaves, such as twills, the warp threads are divided into three or four layers and the heddle bar is multiplied to two or three accordingly.

Schematic depictions of the warp-weighted loom and bars with loom weights have been recognised in the imagery of the Middle Bronze Age seals from Crete (*cf.* Burke 1997: 418–419; 2010: 45–47; Ulanowska 2016; 2017) and in a graphic form of the Linear A sign 54 (Barber 1991: 91; Militello 2007: 41; Burke 2010: 48–49; Del Freo *et al.* 2010: 351–353, Fig. 17.11; Nosch 2012: 304–305, Fig. 1; Petrakis 2012: 78–79, Pl. CXXVI 1) (Fig. 3). Although details explaining the mechanics of the loom are generally absent in these simplified depictions, the presence of a bar or two bars above the loom weights motif on the Middle Bronze Age Minoan prismatic seals has been interpreted by the author as a possible indication of a heddle bar (Ulanowska 2017: 61–62). Also, a sporadic duplication of the loom weights motif on a seal face may be seen as a schematic reference to two rows of loom weights and a set-up for a tabby weave (Ulanowska 2017: 62–63).

The spatial distribution of the loom weights found *in situ* may also indicate whether the loom weights had been set-up in two rows for a tabby or for twill weaves when three or four rows of the loom weights are expected (for the *in situ* discoveries of the loom weights set-up for twill weaves, *cf.* Lassen 2013: 84; 2015: 127; Bender Jørgensen, Rast-Eicher 2016: 86–97; *cf.* Firth 2015: 181–184). However, no spatial distribution of loom weights that may clearly be connected with the set-up for twill has been compiled so far for Bronze Age Greece.

Functionality of the warp-weighted loom

The warp-weighted loom may be used to weave fabrics of various structures (*e.g.* tabby weave and, especially, twill weaves or possibly tapestry) of different parameters (from coarse to fine) and sizes (*cf.* Hoffmann 1964; Carington Smith 1975; Barber 1991; Tzachili 1997; Andersson Strand, Nosch 2015a; Andersson Strand 2018). In my own, still unpublished, experiments, I have used the warp-weighted loom to weave also gauze weaves and patterned textiles in tabby with supplemental weft. These possibly multifunctional uses may explain the wide dispersal of the warp-weighted loom in Europe and the Mediterranean. However, unless archaeological textiles are also preserved, it is difficult to reconstruct specific weaving technique(s) related to this implement.

The width of a fabric woven on the warp-weighted loom is related to its construction and the width of the cloth beam. In the case of the looms from Chania and *Casa delle Sfere Fittili* at Aghia Triada, it may be suggested that fabrics of more than 60 cm wide could have been woven. The length of a fabric depends on the length of the warp threads. Thus, it may exceed the height of the loom if the long warp threads are stored above the loom weights, *e.g.* by a chain stitch, and unravelled successively while weaving. However, there are no data that may suggest the length of fabrics woven in Bronze Age Greece.

Regardless of the technique, weaving on the warp-weighted loom has to be performed while standing and a textile is made from the top of the loom downwards (Figs 1, 2).

New types of loom weight as technical innovations

Complex and comprehensive analyses of the function of loom weights have been undertaken within the research programme 'Tools, Textiles, Texts and Contexts', carried out by the Centre for Textile Research in Copenhagen between 2005–2010 (Andersson Strand, Nosch 2015a). These studies were based on data comprising 3896 loom weights from Bronze Age Aegean and Eastern Mediterranean, together with the results of archaeological experiments, as well as the contextual analyses of tools (Andersson Strand, Nosch 2015c: 149, Fig. 5.1.7; Andersson Strand, Nosch 2015a). This research has demonstrated that functionally three main categories of loom weights should be distinguished: spherical, pyramidal, and discoid (Andersson Strand, Nosch 2015b: 371). These three basic forms, each comprising loom weights of different types, "mark the most distinct functional features" (Andersson Strand, Nosch 2015b: 371), *i.e.* the specific relationship between the weight and thickness of a loom weight which results from its geometry and determines what kind of textile may be produced using it (Andersson Strand, Nosch 2015b: 371; *cf.* Firth 2015: 168–180; Olofsson *et al.* 2015: 87–97). According to E. Andersson Strand, the variety of types within these basic forms of a loom weight reflects cultural and personal choices rather than any specific function (Andersson Strand, Nosch 2015b: 371; *cf.* Andersson Strand forthcoming).

Thus, according to this general understanding of the functionality of loom weights, an introduction of a new functional form, *i.e.* pyramidal, spherical, or discoid, may be considered as a technical innovation. In Greece, pyramidal and spherical loom weights were already present in the Neolithic (Carington Smith 1975: 122–123, 135–138, 154–157, 186; Barber 1991: 99–100), however, the discoid loom weights were a Bronze Age innovation.

Discoid loom weights

Discoid weights were recovered first at Mytros Phournou Koriphi on Crete, in an Early Bronze Age context (EBA II) (Warren 1972). By the transition from the Middle to the Late Bronze Age (MBA III/LBA I), they had spread all over Crete, the south-central Aegean islands, and the shores of Asia Minor (*cf.* Burke 2010: 56–58; Cutler 2012; 2016a; Pavúk 2012; Gorogianni *et al.* 2015; Kremer 2017). This has been thought to indicate 'Minoanisation',[3] if not traces of a physical presence of the Minoans (Carington Smith 1975: 276; Cutler 2012; 2014; 2016a; Gorogianni 2016). Moreover, since at the majority of sites in the southern Aegean the discoid weights are the only types of loom weights recovered, their transmission has been connected with the introduction or re-introduction of the warp-weighted loom technology in this area (Cutler 2016a: 172). In the Late Bronze Age, the discoid loom weights were still in use on Crete, in the southern Mainland, and in Troy (Carington Smith 1975: 276–286; 1992: 687–691; Tzachili 1990; Evely 2000: 498; Burke 2010: 56–58; Cutler 2012; 2016a; Pavúk 2012; Kremer 2017).

The wide distribution of the discoid loom weights has been seen as a result of the transmission of specific textile techniques that originated on Crete and were accompanied by the introduction of these tools (Cutler 2012: 149; 2016a). According to J. Cutler, the 'horizontal' transmission of technical skills (and the discoid loom weights) between members of the same generation in various communities resulted from the mobility of

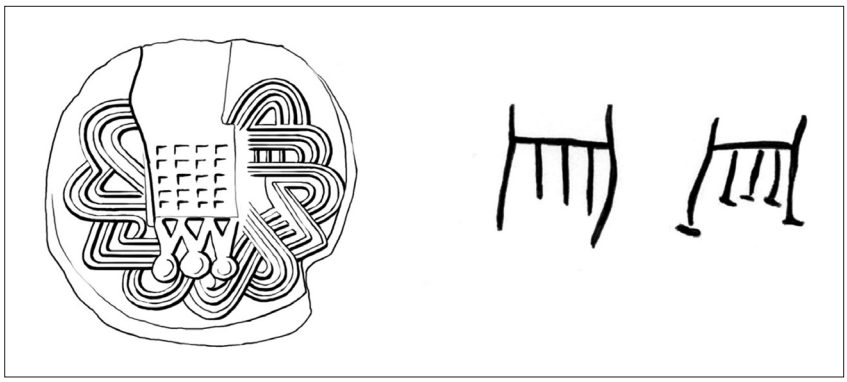

Fig. 3. Iconography of the warp-weighted loom in Minoan glyptic: face a of the cuboid seal from Aghia Triada (drawing by M. Jagodzińska after CMS II.1 64a) and Linear A sign AB 54 (drawing by the author after Del Freo *et al.* 2010: Fig. 17.11).

[3] On the processes of Minoanisation and Mycenaeanisation, *cf.* Gorogianni *et al.* 2016.

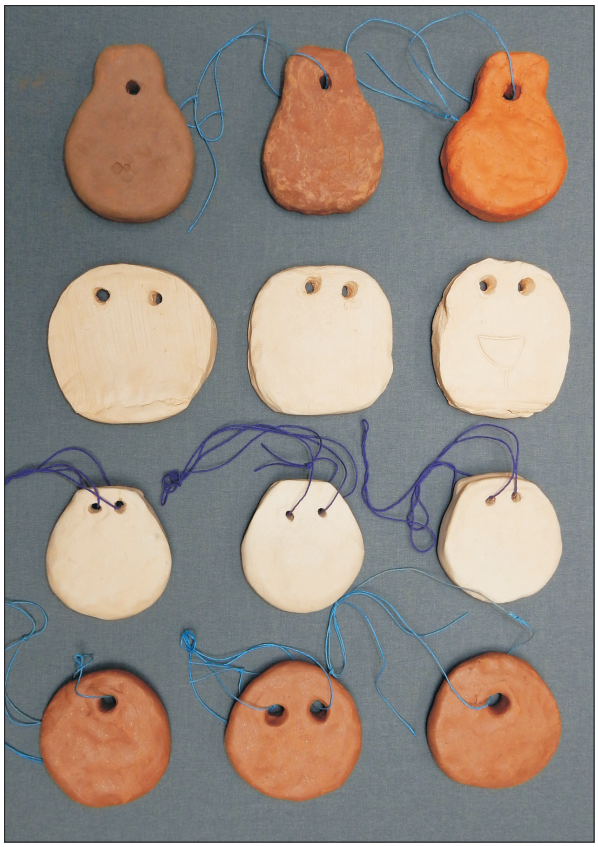

Fig. 4. Different forms of copies of discoid loom weights made by students of the Institute of Archaeology, University of Warsaw. The top row: weights modelled after a template from the Loom Weights Basement in Knossos (Burke 2010: 57, Fig. 36); the third row: weights modelled after a template from Myrtos, cat. no. 75 (Warren 1971: 243, Fig. 96); the second and fourth rows: weights modelled from rolls of clay cut into slices with a string (for the production method, *cf.* Cheval 2008) (photo by the author).

female weavers, originally from Crete and then from the southern Aegean communities that had already adopted Cretan weaving techniques. These weavers travelled around the Aegean as brides, migrants, captives, slaves, or as textile workers exchanged by the elites (Cutler 2012: 150; 2014: 139; 2016a: 175; Gorogianni *et al.* 2015).

Since the discoid loom weights were sometimes found in large concentrations, comprising hundreds of weights (*cf.* Tzachili 1990; Burke 2010: 56–58; Andersson Strand, Nosch 2015a), it may also be suggested that they were expedient tools for a larger scale textile production. Recently, the broad distribution of the discoid weights in the Mediterranean has also been connected to the transmission of the purple-dye technology from Crete (Kremer 2017: 101).

The discoid weights are flat discs featuring one to three perforations. The general category encompasses rounded, elliptical, pear-shaped ("discoid tabulated"), trapezoid, rectangular, and semi-discoid shapes (Mårtensson *et al.* 2009: Fig. 2; Andersson Strand 2015: Fig. 5.1.4) (Fig. 4). The diameter of these tools ranges between 5–11 cm, their weight between 50–350 g, and thickness between 1.5–3 cm (Carington Smith 1975: 276-277; Tzachili 1990: 383; Evely 2000: 498; Cheval 2008: 19; Burke 2010: 57; Firth 2015: 170–173, Fig. 5.2.20). The generally low weight cluster of the discoid loom weights (the majority of them weigh between 100–200 g), their small thickness (mostly ranging between 2–3 cm), as well as the small thickness/weight ratio makes them suitable for weaving low-tension, dense, possibly warp-faced fabrics, *i.e.* with more warp threads than wefts per cm (Andersson Strand 2015: 143, Figs 4.5.5, 4.5.6; Firth 2015: 170–173, Fig. 5.2.23; Ulanowska forthcoming).

It may be suggested, therefore, that the introduction of the discoid weights was related to the need for the manufacture of more dense and fine textiles (*cf.* Andersson Strand, Nosch 2015a). However, based on the functional analysis of the discoid weights and experimental archaeology, it is difficult to recognise clearly any specific weaving techniques that may have been used to make these fine fabrics, *e.g.* tabby, twill weaves, or tapestry (Andersson Strand 2015; Firth 2015: 170–173; Ulanowska forthcoming).

The use of the discoid loom weights continued in Archaic, Classical, and Hellenistic Greece (*cf.* Quercia, Foxhall 2014; Lawall 2014: 161–166; Spantidaki 2016: 180–213), but it should be noted that it is not possible to prove a direct continuation of this form from the Bronze Age to later Antiquity.

Specific forms for specific techniques? Cuboid and crescent-shaped loom weights

Despite the functional relation between the form of a loom weight and the structure and appearance of a woven fabric, certain forms of the loom weights, *e.g.* crescents and four-holed cubes, have been acknowledged especially expedient for specific weaving techniques (on the crescent-shaped weights, *cf.* Lassen 2013; 2015; Ulanowska 2018; Grömer forthcoming; on the cuboid weights, *cf.* Carington Smith 1975: 186–187, 294; Burke 2010: 60; Ulanowska forthcoming).

The cuboid weights with four perforations appeared first in the Middle Neolithic stratum at Knossos on Crete (Evans 1964: 180, Pl. 56.2, 57.2; Carington Smith 1975: 185–186). Continuation in the use of this form from the Middle Neolithic to the Middle and Late Bronze Age in Crete has been regarded possible (Carington Smith 1975: 186; Evely 2000: 498; Burke 2010: 59). The use of the cuboid weights as tablets in tablet weaving has been

primarily suggested on the basis of the number of perforations (Carington Smith 1975: 186–187). Generally, the cuboid form demonstrates functional parameters similar to the spherical loom weights (Firth 2015: 176) and is optimal for weaving balanced or weft-faced fabrics.[4]

Crescent-shaped weights

Based on experimental archaeology, several specific uses of the crescent-shaped weights have been suggested. *Inter alia*, they have been recognised as tools suitable for creating an off-loom device for band weaving made of two crescents and heddles (Feldtkeller 2003; Grömer 2006; 2016: 100, Fig. 51; 2018; Ulanowska 2018). They have also been considered practical as possible weights tensioning warps on a twining frame. In this case, the crescent-shaped weights, while being turned around their axes, twined the warp threads they tensioned (Grömer 2018).

The crescent-shaped loom weights have been acknowledged as practical for making tabby and twill weaves in weaving on the warp-weighted loom (Cornaggia Castiglioni 1964; Baioni *et al.* 2003; Lassen 2013; 2014; Ulanowska 2018). In both techniques, each crescent-shaped weight tensions two layers of warp threads. For the 2/2 or 3/1 twill weaves and four layers of warp threads, two sets of the crescent-shaped weights are required (Lassen 2013; 2015) (Fig. 5). For the 2/1 twill and three layers of warp threads, one set of the crescents should be combined with another type of a loom weight that is tensioning the front layer of warp threads, *i.e.* the one hanging over the shed bar (Firth 2015: 181; Ulanowska 2018) (see Fig. 5).

In Greece, only a few crescent-shaped weights have been discovered in contexts dating to the Early Bronze Age, with the largest number recorded at Tiryns (*cf.* Siennicka 2012: 70; Rahmstorf *et al.* 2015: 272). Although it is impossible to say with certainty for what

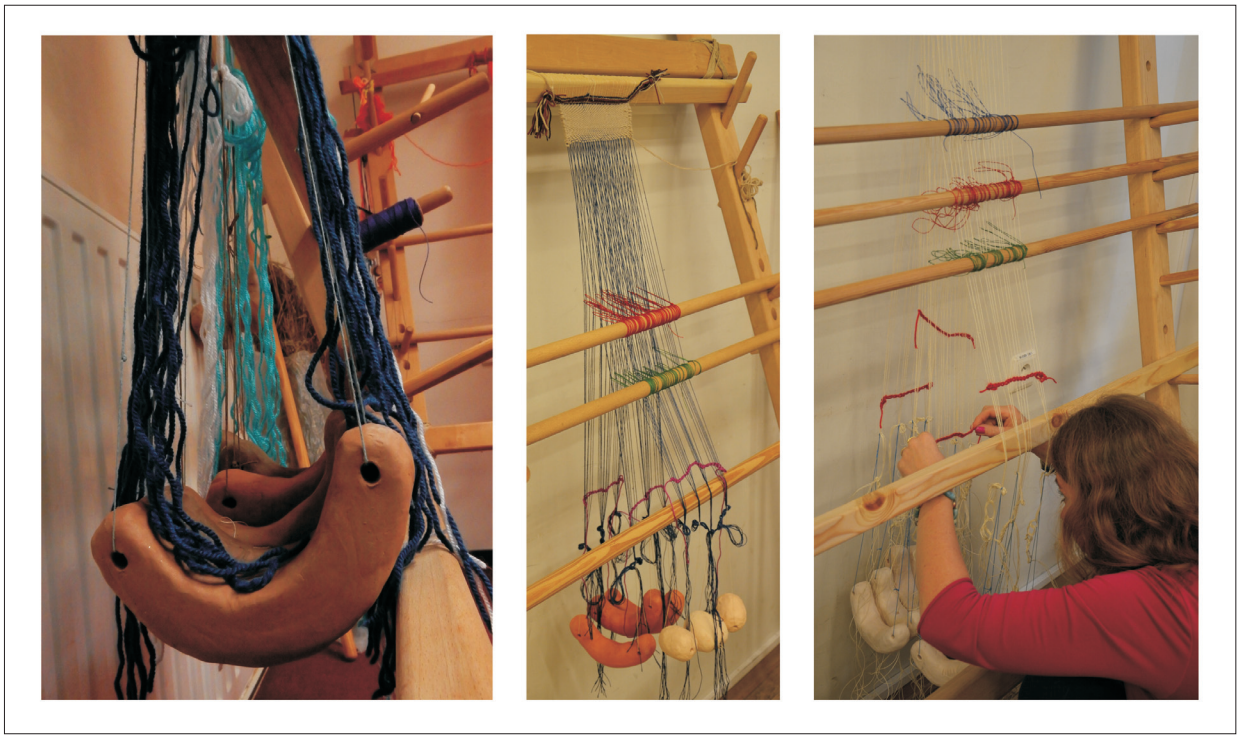

Fig. 5. Crescent-shaped weights used as loom weights in the setup for tabby and twill: 2/1 twill in combination with spherical eights; 3/1 and 2/2 twill (photos by the author and K. Żebrowska).

[4] In my unpublished weaving experiments with the cuboid loom weights, I used them to weave open tabbies (by setting up one row of large cuboid weights for tensioning the front and back warp layers simultaneously, and by setting up two rows of small weights for the front and back warp layers separately). They were also used for twill weaves (small weights, 2/2 goose eye twill). They also appeared practical when used as tablets, however, according to our experience, turning more than four small unsupported cuboid weights cannot be controlled securely. Braiding with two or four small cubes was very effective and simple.

Fig. 6. The manner of suspension and the use-wear marks on the copies of the crescent-shaped weights from Tiryns used for tabby and twill weaving (photos by the author, M. Bogacki, and M. Dąbski).

textile technique these crescent-shaped weights were used, the archaeological context of the crescent-shaped weights found *in situ* in Demircihüyük, in Early Bronze Age Anatolia (Korfmann 1981: 33–34, Fig. 45), indicates that the crescent-shaped weights were indeed used as loom weights, most probably for 2/1 twill weaving (*cf.* Lassen 2013; 2015; Firth 2015: 181–186). The observed use-wear marks on the actual weights from Tiryns, and their copies used in experimental weaving carried out by the author, additionally imply that these tools functioned as loom weights (Ulanowska 2018) (Fig. 6). However, no difference in use-wear that may reflect the type of weave produced, *e.g.* tabby or twill, has been observed on the copies of the tools.

Potential use of other types of looms

An apparent lack or noticeably reduced number of loom weights in archaeological contexts dating to the Middle and Late Bronze Age on the Greek mainland, and prior to the Middle and Late Bronze Age in the southern Aegean, suggests diachronic and regional variability in the use of the warp-weighted loom in Bronze Age Greece. This may imply that other types of looms might have been known and used at this time (*cf.* Andersson Strand, Nosch 2015b; Cutler 2016a). But it also suggests that the warp-weighted loom technology may have been temporarily neglected and then again adopted in several regions of Greece (*cf.* Cutler 2016a).

The use of different types of looms has been attested in many societies of the past (*cf.* Broudy 1979; Andersson Strand 2018). Thus, in the Late Bronze Age, the horizontal ground loom and the vertical two-beam loom were used simultaneously in Egypt, albeit by different weavers who, it is assumed, would have specialised in producing different types of textiles (Broudy 1979: 38–47; Barber 1991: 83–91, 113–116; Andersson Strand 2018). However, according to E. Andersson Strand and M.-L. Nosch, the Neolithic depiction of possibly two different looms on a bowl from Badari may suggest that the use of two implements beside each other goes back to much earlier times (Andersson Strand, Nosch 2015b: 362). The simultaneous use of different types of looms, *e.g.* the horizontal ground loom and the vertical loom, as well as possibly the warp-weighted loom or the two-beam loom, has also been discussed in regard to Bronze Age Mesopotamia (Breniquet 2008: 140–149, 157–166, 175–180, 297–303, 326–328).

Although in Bronze Age Greece no direct evidence suggesting any other specific type of loom has been discovered, the horizontal ground loom and the two-beam loom are considered possible choices (Carington Smith 1975: 403-410; Tzachili 1990: 386; Pavúk 2012: 123–126; Andersson Strand, Nosch 2015b: 362). Both implements were in use in the neighbouring areas that were connected with Bronze Age Greece via networks of various economical and socio-political contacts (*cf.* Antoniadou, Pace 2007).

A potential use of a type of the horizontal loom has also been proposed in relation to numerous finds of spools or reels from mainland Greece and the north-central Aegean dated to the Middle Bronze Age (Carington Smith 1975: 403–410; Pavúk 2012: 123–126; Cutler 2016a: 174; Siennicka, Ulanowska 2016: 33). According to J. Carington Smith, a special kind of a spool which is characterised by a narrow waist and

flaring ends may serve as a part of *διάστρες* – a device for measuring equal lengths of the warp threads that are required for setting up the horizontal loom (Carington Smith 1975: 404–405, 408–409). The potential use of the vertical two-beam loom has been specifically discussed in regard to sail production at Akrotiri (Tzachili 1999: 859; *cf.* Tzachili 2007: 192) and the introduction of the technique of tapestry (Andersson Strand, Nosch 2015b: 362; *cf.* Broudy 1979: 44–47; Barber 1991: 158; Smith 2012; 2013).

Organisational modes of textile production

By analysing particular components of textile production, *e.g.* its location and intensity, surplus, standardisation of tools and products, specialisation of production, *etc.*, various modes of production have been distinguished (*cf.* Costin 1991; 2005; 2007; Andersson 2003; Andersson Strand 2011; Andersson Strand, Heller 2016). These defined modes, such as household, individual, or embedded production, individual specialisation, also ritual production, and finally attached production controlled by palaces, proved to be useful in analysing archaeological and textual evidence from Bronze Age Greece (Ulanowska, Siennicka forthcoming). However, even when specific evidence indicates a certain mode of production, the dynamics of organisation of textile production cannot be seen as linear, evolutionary developments. On the contrary, several modes of production, while being complex, multifarious, and largely overlapping processes, may have coexisted at the same time (Ulanowska, Siennicka forthcoming). What may be suggested, however, is a diachronically increasing scale of textile production, with the assumed peak represented by the industrial level of textile production controlled by the Mycenaean palaces (*cf.* Barber 1991; Burke 2010; Nosch 2014; Rougemont 2014).

The question whether and how a specific production mode and the social relations related to it may have prompted creativity and technical innovations in weaving lies beyond the scope of this paper (*cf.* Gorogianni *et al.* 2015; Cutler 2016a). Moreover, since the possible innovations in weaving technology may only exceptionally be attributed to a certain site or *loci*, the available data for attributing a specific innovation to a specific production mode and a specific social context seems generally insufficient.

However, if the discoid loom weights were indeed introduced at Myrtos Phournou Koriphi on Crete, this innovation may possibly be related to the household mode of production or to household industry, *i.e.* the mode in which production is still undertaken on the household basis but exceeds the needs of producers (for textile production components and social relations at Myrtos, *cf.* Warren 1972; Whitelaw 1983; 2007; for household and household industry mode of production, *cf.* Andersson 2003: 47, Fig. 1; Andersson Strand 2007: 151–152).

Moreover, the wide distribution of the discoid loom weights throughout the southern Aegean in the Middle and the early Late Bronze Age may be tracked chronologically. As J. Cutler has demonstrated, the weights at first appeared at Aghia Irini, Kolona, Ialysos, and in the northern part of Rhodes, Miletus, and Lerna (early Middle Bronze Age). They then appeared at Phylakopi and Liman Tepe (MBA), at Koukonisi and Akrotiri (late MBA), at Kastri, Iasos, and Vathy Cave on Kalymnos (at the transition from the Middle to the Late Bronze Age), and finally in the Late Bronze Age at Teichioussa and Çeşme-Bağlararasi (early LBA I), at Serraglio on Kos, Heraion on Samos, and possibly on Anitikythera, Naxos, and Karpathos (later phases of LBA I) (Cutler 2016a: 175). The overall timespan of their spread may thus be estimated to a period of *c.* 250 years, which corresponds roughly to *c.* 10 generations, starting from the moment of the first appearance of these loom weights outside Crete.

Since the discoid loom weights were also found in large concentrations, the transmission of these weights may have reflected an increasing scale of production. Yet, at some sites, *e.g.* at Phylakopi on Melos, only a few discoid loom weights were discovered suggesting that the adoption of new weaving techniques could have been on a limited scale (Cutler 2016a: 175–176, 181). Thus, the archaeological context of the discoid loom weights, *e.g.* Northern Sector at Aghia Irini, Kea (Gorogianni *et al.* 2015), may suggest a household industry as well as more complex modes of organisation of production, *e.g.* in the Loom Weight Basement at Knossos (*cf.* Burke 2010: 57–58) and at four houses at Akrotiri: West House and Complexes A, B, and Δ (*cf.* Tzachili 1990; 1997: 190–192; Karnava 2008; Tzachili *et al.* 2015; Cutler 2016a: 175–176; Hitchcock 2016).

Therefore, the transmission of the discoid loom weights could have possibly been connected with the production of technically similar, perhaps standardised fabrics, undertaken within various modes of production, such as household, as well as, for instance, workshop production for trade, individual specialisation, or even attached production (*cf.* Andersson 2003: 47, Fig. 1; Andersson Strand 2007: 151–152; Cutler 2016a; Ulanowska, Siennicka forthcoming). As suggested by J. Cutler, the fabrics woven with the discoid loom weights may have had a 'Cretan-like' visual appearance and reflected a desire to copy 'Cretan' cloth worn by the Minoans and by the local elites at a later date. Yet, since more types of loom weights were in use on Crete

and, presumably, more diversified fabrics were produced, Minoan weaving technology was only partially adopted outside Crete (Cutler 2016a: 176–178, 181).

Conclusions

Although the available evidence does not allow the reconstruction of any detailed outline of technical developments in weaving throughout the Bronze Age in Greece, certain technical innovations may be recognised and placed geo-chronologically within a time scale.

The conservative, traditional character of weaving has been suggested by the continued use of the warp-weighted loom from the Neolithic throughout the entire Bronze Age to the Iron Age, Classical Greece, and later. However, the presence of loom weights in archaeological contexts provides convincing evidence for such an uninterrupted weaving tradition only on Crete. At several sites of mainland Greece, the warp-weighted loom technology may have been rejected for *c.* 700 years, with a possible break dating from the end of the Early Bronze Age to the Late Bronze Age II (*cf.* Cutler 2016a: 178).[5] In the southern Aegean, however, the warp-weighted loom technology may have only appeared at the end of the Middle Bronze Age together with the discoid loom weights. Potential re-introduction of the warp-weighted loom technology in the areas where it was already in use demonstrates that, in the *longue durée*, once acquired and adopted weaving traditions could be rejected and acquired again according to, for example, the technical, economic, cultural, or aesthetic choices of the craftspeople or the organisers of production and their customers.

The temporal ratio of the transmission of the discoid loom weights and warp-weighted loom technology into the southern Aegean, counted in years and generations, suggests that this innovative 'package' has been acquired at a slow speed. However, according to my teaching experience,[6] the warp-weighted loom technology is not very difficult to acquire, since it does not require any specific manual dexterity. Again, based on my experience, I would suggest that a period between three to six months would be enough to acquire some proficiency in weaving tabbies by modern and unexperienced novices. More time would be required to weave twills and patterned textiles, *e.g.* with a supplemental weft. Thus, the long period of transmission of the new weaving techniques seems to reflect socio-cultural and economic processes, such as the speed of the mobility of individual weavers and culturally-biased (un)willingness to acquire a new technology, rather than the time required for the mere transfer of the new weaving skills.

The invention of a new functional form of loom weight, *i.e.* the discoid loom weight, may be seen as one of the most successful and long lasting innovations in weaving dated to the Aegean Bronze Age. This innovation reflects not only the need for finer and denser, and perhaps standardised, textiles, but also the high expediency of the discoid weights in the warp-weighted loom technology. The technical success of the discoid loom weights may be analysed further to explain the engendering of the craft of weaving, the social processes standing behind the transmission of textile knowledge and skills, and the general mechanism of acculturation (*cf.* Cutler 2012; 2013; 2016a; Gorogianni *et al*. 2015).

On the other hand, the limited distribution of the crescent-shaped weights in the Early Bronze Age may be seen as a reflection of a rejected innovation that, despite the potential (multi)functionality of these tools, was seemingly not much appreciated or required.

Except for the changes in the form of loom weights, potential modifications of the loom itself, *e.g.* its construction and size, are not traceable through time.

The suggested introduction of other types of looms may have been another important technical innovation, yet it is difficult to date. If spools with narrow waists and flaring ends could indeed be related to the use of the horizontal loom, this innovation must have been quite widespread in Middle Bronze Age mainland Greece and the Aegean. The potential introduction of the two-beam loom cannot be related to any specific area. Technically, it may have accompanied the transmission of more sophisticated weaving techniques, such as tapestry, and thus could possibly be dated, like in Egypt, to the first half of the Late Bronze Age (*cf*. Broudy 1979: 44–46; Barber 1991: 157–162).

This paper aimed at recognising possible innovations in weaving technology based on archaeological evidence combined with experimental archaeology. However, the phenomenon of the embodiment and transmission of innovations may be analysed in a broader socio-cultural context (*cf.* Cutler 2012; 2016a; Gorogianni *et al.* 2015). The wide adaptation of certain textile techniques, or

[5] For a possible use of spools as loom weights, *cf.* Cutler 2016a; Siennicka, Ulanowska 2016.

[6] This observation is based, at present (*i.e.* May 2018), on my seven years' experience in academic teaching about textile technology and hands-on experience in weaving on the warp-weighted loom with *c.* 116 students of archaeology and scholars.

certain types of fabrics, may reflect the transmission of fashion and a specific cloth or textile culture (*cf.* Cutler 2016a: 176–177). The term "cloth culture", originally coined by S. Harris (2012: esp. 62–63), now encompasses the practical use of fibres, skins, and textiles, as well as the cultural preferences for specific raw materials, cloths and fabrics, aesthetics, and values (Harris 2012; Gleba 2017: esp. 1206). It seems that the transmission of a technological 'package', comprising the mobility of the craftspeople with specific textile knowledge and skills, tools, and possibly raw materials, was an inevitable part of the process of Minoanisation (*cf.* Gorogianni 2016; Gorogianni *et al.* 2016). However, other possible patterns of the transmission of weaving techniques, to be traced on the basis of archaeological evidence, cannot be presently related to any specific socio-cultural contexts.

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Beyond Textiles: Alternative Uses of Twisted Fibres and Evidence from Akrotiri, Thera

Abstract

Fibre crafts are among the oldest technological practices of mankind. Although commonly associated with textile manufacture, twisted fibres in the form of threads have always had a wider range of use in everyday life. Strings and ropes constitute a humble but essential category of fibre products deriving from the same technology and organic matter as threads. Due to their organic nature, however, they are rarely preserved in the archaeological record, unless special environmental conditions occur. This paper explores the research potential of the imprints of threads and strings in a study focusing on the alternative uses of fibre-spun artefacts. The focus is on the Bronze Age Aegean imprints of threads and strings preserved on objects made of clay and on wall paintings recovered at Akrotiri on Thera. The technical properties of the original threads and strings are evaluated through observation of their imprints, and the fibre technology used for their production is assessed. The methodologies of spindle whorl metrology and experimental spinning are also integrated in the discussion. Ultimately, the use of threads and strings for a variety of purposes, including but not limited to textile production, is discussed.

Streszczenie

Nie tylko tkaniny – alternatywne zastosowania skręconych włókien i pozostałości z Akrotiri, Thera

Rzemiosło włókiennicze należy do najstarszych technologii znanych ludzkości. Skręcone nitki, chociaż zwykle kojarzone z tkaninami, miały znacznie szersze zastosowanie w życiu codziennym. Wyroby powroźnicze, takie jak sznury i liny, stanowiły bardzo istotną kategorię produktów, którą łączyły z produkcją tkanin technologia i surowce. Jednakże ze względu na organiczne pochodzenie surowców, wyroby tej kategorii bardzo rzadko zachowują się w materiale archeologicznym, o ile nie znalazły się w szczególnych warunkach środowiskowych. Artykuł analizuje potencjał badawczy odcisków nitek i sznurków w odniesieniu do różnych zastosowań wyrobów powroźniczych. Badany materiał pochodzi z odcisków w glinie i tynku malowideł ściennych ze stanowiska Akrotiri na Therze, datowanego na epokę brązu. Parametry techniczne i technika produkcji odciśniętych wyrobów zestawione są następnie z danymi metrologicznymi przęślików z tego stanowiska oraz rezultatami badań eksperymentalnych. W artykule analizowane jest szerokie spektrum zastosowania nitek i sznurków, również poza produkcją włókienniczą.

Keywords: thread, string, imprint, Akrotiri, wall paintings, clay sealings

a) Introduction[1]

The production of yarn was a vital component of prehistoric textile industries and was comprised of a complex multi-stage operational sequence, which began with the procurement of plant or animal fibres and culminated in twisting them into threads (Barber 1991: 9–22, 41–42; Tzachili 1997: 81–118; Andersson Strand 2015: 39–60). The technique of twisting fibres is called spinning, and it aims at providing length and coherence to the individual fibre elements and strengthening the end product (Barber 1991: 52). Ethnographers have recorded traditional and primitive spinning techniques which may vary to a degree in different periods and cultures (Crowfoot 1931). These ethnographic studies have advanced the interpretation of archaeological data which provides indirect evidence, usually in the form of textile tools and iconography, for the operational sequence of prehistoric thread manufacture in the Old World (Barber 1991: 42–78). Thus, two basic categories of prehistoric spinning have been distinguished by analogy to the ethnographic record – twisting fibres by hand and twisting fibres with a spindle – of which further varieties may be recognised (Crowfoot 1931). An alternative technique of prehistoric thread manufacture was splicing strands of fibres instead of twisting them (Andersson Strand 2015: 45–46). Splicing is archaeologically detected only through the end product, and in the Eastern Mediterranean and Near Eastern prehistoric contexts it has so far been documented only in Egypt, through the discovery of textiles woven with spliced threads (Barber 1991: 44–51). On the other hand, the implementation of the spindle may leave clear traces in the archaeological record, even if cloth is not preserved, in the form of spindle whorls – small clay, stone, or bone weights adjusted on the spindle shaft to enhance its rotation and ensure making a strong homogeneous thread.

In recent years, functional studies on textile tools from prehistoric sites in the Aegean and in the wider Eastern Mediterranean have opened new avenues in the investigation of textile technologies (Andersson Strand, Nosch 2015). Building on earlier ethnographic and archaeological works, the Centre for Textile Research (CTR) at the University of Copenhagen has set to test various hypotheses regarding the function of spindles and spindle whorls through experimental archaeology. Within this research framework, the correlation between spindle whorl size and an end product thickness was empirically confirmed, although further insights into the type of fibres spun cannot be gained by spindle whorl analysis alone (Andersson Strand 2015: 48). Furthermore, comparative functional studies of spindle whorls (*e.g.* Vakirtzi 2015) have made clear that spinning was employed not only for the production of textile threads but also for coarser types of products. Thus, archaeological assemblages of spindle whorls may attest not only to textile thread production but also to the manufacture of strings, cordage, and ropes.

Strings and ropes have been called "the unseen weapon that allowed the human race to conquer the earth" (Barber 1994: 45) and ironically remain 'the unseen' aspect of fibre crafts in the wake of the renewed interest in textile archaeology.[2] They were manufactured according to the same basic principle of twisting fibres, but in this case either coarser materials were used or primary spun strands were plied into thick cords. Strings and ropes are considered a significantly earlier invention than woven textiles. Elizabeth Barber coined the term "String Revolution" to denote a stage in the techno-economic evolution when indirect evidence for the use of string and rope appears in the archaeological record of the Upper Palaeolithic, and she has argued that this invention was a catalyst for cultural acceleration (Barber 1994: 42–70). In extremely rare circumstances, strings and ropes have survived from that period (Adovasio *et al.* 1996) and provide a direct testimony of Palaeolithic fibre crafts. In that early pre-domestication age, these products, as well as mats, were presumably manufactured of wild plant fibres and tree bark (Barber 1994: 42–70; Rast-Eicher 2005: 117–118) and must have had a wide use, from simply "tying things up" (Barber 1994: 45) to manufacturing secondary objects, such as jewellery and tools. Similar uses may be postulated for the Neolithic and the Bronze Age as well, so that string and rope can be seen as one of the oldest and most persistent technological achievements of humanity. Thus, the manufacture and use of strings and ropes in prehistory is an important research topic in its own right but also in relation

[1] We would like to thank Assistant Professor A. Ulanowska and Associate Professor M. Siennicka, the organisers of the Session TH1–13 ('*Tradition and Innovation in Textile Technology in Bronze Age Europe and the Mediterranean*') of the 22nd Annual Meeting of the European Association of Archaeologists (Vilnius, Lithuania, 2nd–4th September 2016), for inviting us to participate in this important meeting of textile specialists. Our warmest thanks go to the director of the Akrotiri Excavations, Professor Emeritus C.G. Doumas, for entrusting us with the study of material from the site and for his support throughout the years. We would also like to thank the anonymous reviewers for their valuable suggestions on this paper.

[2] Notable exceptions to this tendency are papers such as Hardy's (2008) and Grömer and Kern's (2010), which focus on the study of strings and cordage. The latter, in particular, presents experimental work on the analysis of string imprints.

to textile archaeology: textile thread production and string or rope production must have had some degree of overlap and interdependence, at least in terms of raw materials procurement, sharing of technological know-how, and labour organisation. Therefore, a holistic understanding of prehistoric textile production calls for the exploration of alternative uses of twisted fibres as well.

To address prehistoric fibre crafts beyond textiles, it is necessary to advance the systematic collection and study of archaeological data providing information on the processes involved and the end products. The difficulty of such an endeavour lies in the intrinsically limited preservability of ancient organic material, which survives only under exceptional climate and soil conditions. Whereas actual prehistoric threads, strings, ropes, and textiles are rare archaeological finds in general, their imprints comprise a relatively large body of evidence. Depending on their preservation status, imprints of threads, strings, or ropes may retain technical characteristics of the original artefact such as structure (single and multiple spin or ply), direction of spin or ply, angle of spin, twists per centimetre, as well as thickness. The features of these negatives may then be assessed to infer the technical properties of the original artefact, which are essential to obtain knowledge on prehistoric fibre crafts or to re-evaluate and refine general patterns. For example, there is a widespread and long-standing opinion that in prehistory European and Anatolian techniques of spinning resulted in z-spun threads, while Egyptian techniques resulted in s-spun threads.[3] Thus, the direction of primary spin is considered a cultural variable that has been related to distinct technological traditions involving a variety of spindles used in the respective cultural spheres (low-whorl spindle in the Eastern Mediterranean *versus* high-whorl spindle in Egypt), as well as to the gestures and body movements necessary to handle each type of spindle (Crowfoot 1931; Barber 1991: 65). However, it is difficult to corroborate generalisations on such issues, since actual prehistoric textiles and threads are scarce finds in Europe, Anatolia, and the Near East compared to the bulk of material preserved and excavated in Egypt.[4] The imprints of spun products may potentially enrich the datasets from all regions, so that systematic comparisons can produce statistically reliable results. Therefore, as archaeological research on textiles and fibre crafts advances, imprints of textiles, threads, strings, and ropes emerge as an important category of evidence to consider in theoretical discussions and integrate in research methodologies.

This paper addresses the use of twisted fibres beyond textile production. Thus, its aim is twofold. Firstly, to present examples of alternative uses of fibre craft products; secondly, to explore the research potential of a specific category of archaeological evidence of prehistoric fibre crafts, namely string imprints from the Aegean region in the Eastern Mediterranean. The focus is on the Bronze Age and in particular the first half of the 2nd millennium BC, as the investigated material was found in the Late Cycladic town of Akrotiri on the island of Thera. Fibre crafts at Akrotiri have been studied so far in relation to textile production (Tzachili 1990; 1997; 2007a; Vakirtzi 2015; forthcoming a). Textile production and consumption have a prominent place in the wider scientific discussion regarding the cultural relations between Thera and Crete during this period. The main issues in question are when, how, and to what degree the local Theran technological textile traditions were replaced by their Cretan counterparts. It is thus not a coincidence that the string imprints chosen for presentation and comparison in this study have survived on two categories of artefacts: produced locally and imported from Crete.

b) The archaeological context of the study

Excavations in the Late Cycladic harbour town of Akrotiri on Thera have provided rich and diverse archaeological evidence for the study of textile production and consumption at this site: artistic representations of cloth and garments on the exquisite wall paintings (Doumas 1992) and textile tools (Tzachili 2007a) are the most explicit testimonies of the aesthetic and technological choices of the inhabitants of Akrotiri with respect to their textile culture.[5] The Linear A tablets discovered in the town, including among the recorded items at least 200 cloth products (Boulotis 1998), testify to economic

[3] The letters s and z are used in the textile technical terminology to describe the clockwise and the counter-clockwise direction of spin respectively, which results in the configuration of a thread with a slant similar to the central part of these two letters (Barber 1991: 65–66; Andersson Strand 2015: 46; Gleba 2017: 1206). Furthermore, the convention adopted by the Centre for Textile Research is to denote primary spin with lowercase letters and secondary plying with capital S and Z (Skals *et al.* 2015).

[4] For an updated survey of ancient textile fragments, especially from Europe, *cf.* Gleba, Mannering 2012. This volume highlights recent studies of s-spun threads outside the sphere of Egyptian influence in a wide time-frame ("from prehistory to AD 400"). The z-spin direction, therefore, does not appear to have been an exclusive technique in European textiles. However, with regard to Egyptian prehistoric textiles, a re-evaluation of the s-spin direction as the dominant spinning technique has not yet been published in a recent synthesis.

transactions involving textiles. On a different level, bioarchaeological remains such as bones of ovicaprids and fibre plant seeds may be informative in regard to husbandry and agricultural practices which are often relevant to the economy of textile fibres. Thus, analyses of the archaeozoological remains found at Akrotiri indicate local wool production (Trantalidou 2001; 2008), while linseed identified among carbonised seeds supports the hypothesis of local flax cultivation (Sarpaki 1992). An extremely rare and lucky find, a moth cocoon found at the site, has triggered a scientific discussion on the possible use of wild silk as a textile fibre in the Bronze Age Aegean (Panagiotakopulu *et al.* 1997; Panagiotakopulu 2000). Last but not least, the recent discovery of textile fragments and threads positively demonstrated the use of linen and woollen cloth in Late Cycladic Akrotiri (Moulhérat, Spantidaki 2008; Spantidaki, Moulherat 2012).

Synthesis of the data has allowed for a reconstruction of the local textile industry whose scale and intensity are exemplified by the large assemblage of loom weights found in the 'West House' (Tzachili 2007a). The level of specialisation is likewise indicated by the distribution of textile tools in just some of the excavated buildings (Tzachili 2007b). The skill of the weavers and the fineness of the fabrics woven at Akrotiri is suggested by the garments depicted on the wall paintings, such as the transparent bodice of the so-called 'necklace-swinger', a female figure among the 'Adorants' which decorated the walls of the Lustral Basin in 'Xeste 3' (Doumas 1992: 128–129; 136–139). Textiles were woven *en masse* to meet the demand not only for elaborate garments, furnishings, and beddings but also for sails, a type of cloth which would have been indispensable for islanders as soon as the sailing ship was adopted in the Aegean at the turn of the 3rd to the 2nd millennium BC (Broodbank 2000). The upright warp-weighted loom equipped with discoid loom weights, a technology adapted from Crete (Tzachili 1990), was an effective solution for such textile production and was introduced in Thera at the beginning of the Middle Cycladic period (Vakirtzi forthcoming b).

The thread manufacturing technique, on the other hand, was a traditional technology used at Akrotiri at least since the beginning of the Early Bronze Age (Vakirtzi forthcoming a), and in the Cyclades, more generally, ever since the islands were permanently settled in the Late Neolithic (Evans, Renfrew 1968; Vakirtzi forthcoming c). This technology consisted of twisting fibres with a spindle equipped with a spindle whorl. The corpus of the spindle whorls collected from the excavations of Late Cycladic Akrotiri has amounted to forty-one specimens so far. Six of them, originating from the excavation of the 'West House', have been published (Tzachili 2007a). The remaining were studied in the frame of a doctoral dissertation on prehistoric yarn production (Vakirtzi 2015). In the latter study, functional analysis has shown that a variety of spun products was manufactured in the town. Tools vary from extremely small and light (Vakirtzi 2012) to large and heavy.[6] The analogy between whorl size and thread thickness allows us to postulate general types of products from tools in comparative terms: a small and light whorl was suitable for the manufacture of a fine thread, while a considerably bigger and heavier specimen would have been used for thicker products (Andersson Strand 2015: 48), some of which may have been used beyond textile weaving. Strings and ropes have indeed been found at Akrotiri in a relatively good state of preservation. Some of them were studied in a preliminary manner by Youlie Spantidaki and Christophe Moulhérat (Spantidaki, Moulhérat 2006). The researchers reported five cases of strings made of plant fibres, most often of primary z-spun threads plied into S-plied strings. Plant fibres are confirmed as a basic raw material, while primary twist supports, in all of these cases, the z-direction technique.

c) Materials and methods

Complementary evidence for fibre crafts can be sought in the form of imprints of spun products (threads or strings) preserved in the archaeological record at Akrotiri. This study discusses two main categories of archaeological finds from the Late Cycladic town revealing two distinct uses of spun products and originating from different localities. The first category includes a Theran cultural product, the wall paintings, where string has been used as a drafting device. The second category includes sealings made of unfired clay, for which string had been used as a binding medium. These sealings originate from Crete and were imported to Thera. Therefore, the comparison of the fibre-spun products in the form of their imprints is meaningful in view of the question of the technological traditions of the two islands and the cultural relations between them. This paper does not intend to offer an exhaustive presentation of all the imprints available. Instead, it offers a preliminary study providing some examples for further research and highlights the challenges emerging from this kind of approach to the archaeological investigation of the fibre crafts.

[5] On the term 'textile culture', *cf.* Gleba 2017: 1206.

[6] See below, part *f.*

With regard to the reconstruction of the technical properties of the impressed threads and strings, we have adapted our technical description from the methodology for yarn description developed by the CTR. Within the CTR's project '*Textiles, Tools and Contexts*', experimental spinning was undertaken with the aim to test the function of prehistoric spindle whorls. Spinning samples made of wool and flax were produced by using spindles equipped with replicas of prehistoric spindle whorls, and a protocol for the evaluation of the spinning samples was developed. This evaluation involved systematic observation and description of the yarn according to three main criteria: thread diameter, spinning angle, and thread fuzziness – the latter being a non-quantifiable variable. It was also decided that at least 20 points of observation and measurements should be determined along the length of a spinning sample. The main objective of the evaluation of the spinning samples was to estimate what the experimentally produced threads could reveal about prehistoric techniques (Möller-Wiering 2015).

A basic difference between describing spinning samples and describing archaeological threads or imprints lies in the fact that the latter may be biased by the state of preservation: it is often the case that very small fragments of threads survive or that imprints do not run at length on the artefact which preserves them. Another factor, which influences the evaluation of imprints, is the degree of direct accessibility of the researcher, often depending on the fragility of the artefact.

In this preliminary study all the imprints were examined macroscopically. The observations in the case of the wall paintings were made directly on the archaeological material, but the extremely fragile nature of the sealings did not allow for their repeated direct manipulation; therefore, high resolution photographs of the imprints and their casts were chosen instead. The number of points of observation and measurement were dependent in each case on the quality of a particular imprint. The objectives were to a) measure the width of the imprint which corresponds to the original thickness of the spun product, b) distinguish its structure, whether single-spun or plied, c) define the twist direction as preserved on the imprint or as recreated on the cast of the imprint, and d) measure the number of twists per cm, thus assessing how tightly or loosely spun the original product was.

d) Wall painting imprints

Wall paintings

In the Theran wall paintings production, preparation of the wall surface by a painter was followed by a tripartite separation of the surface dedicated to the drawing with the use of string imprints on the still humid plaster (Georma 2009: 84). The separation of the surface was a basic rule and procedure in the Theran wall painting production, as it made managing the drawing easier for the painter: the upper part would be dedicated to floral and stripe decoration, the central part to the main configuration, while the lower part would provide a solid base for the representation.

The separation was executed by the use of a string, stretched from side to side between two vertical edges of the wall painting and subsequently pressed on the humid surface of the plaster. The exact moment of this procedure has not yet been verified, but certainly the degree of humidity of the plaster was important: if it was more humid than necessary, the imprint would vanish (Asimenos 1978: 575). Therefore, the string imprint was probably created on a surface nearly but not fully dry.

At Akrotiri on Thera the string imprint technique was very common and facilitated the drawing procedure. Conversely, in Egyptian wall painting production string imprints for the division of the plaster surface were not common, while red colour was instead used to prepare the drawing with the same result (Shaw 2003: 186).

On the material from 'Building Beta', the case study of the wall paintings for the present article, an extended use of string imprints was noted, especially on the frescoes from Room 1: the groups of the 'Antelopes' and the 'Boxing Boys' have a continuous tripartite division of their surface with a unified drawing on the upper and lower parts and a different representation in the central parts (Georma 2009: 86). The string imprints, in this case, were very helpful to ensure morphological homogeneity of the drawing, while technically the imprints, were very well-made and preserved well enough to enable observation.

On the other hand, in Room 6, due to adoption of a more free representation as the main configuration of the tripartite division, *i.e.* monkeys on a rocky landscape, the painter applied string imprints only on the upper part for the execution of a severe drawing with colourful stripes where the adoption of the string guidelines was inevitable.

The use of the string for the organisation of the drawing surface is attested more or less in the majority of the uncovered plaster material at Akrotiri: 'West House', 'Xeste 3', 'Xeste 4', 'House of the Ladies' (Doumas 1992), and was therefore considered by the Theran artists as a very useful instrument for painting preparation.

Imprints

To evaluate the technical properties of the strings used in the creation of these frescoes, we focused on selected areas where the imprints are well-preserved. It should be stressed that imprints are negatives, so that the twist direction of the original product was the exact opposite of the one observed on the imprint.

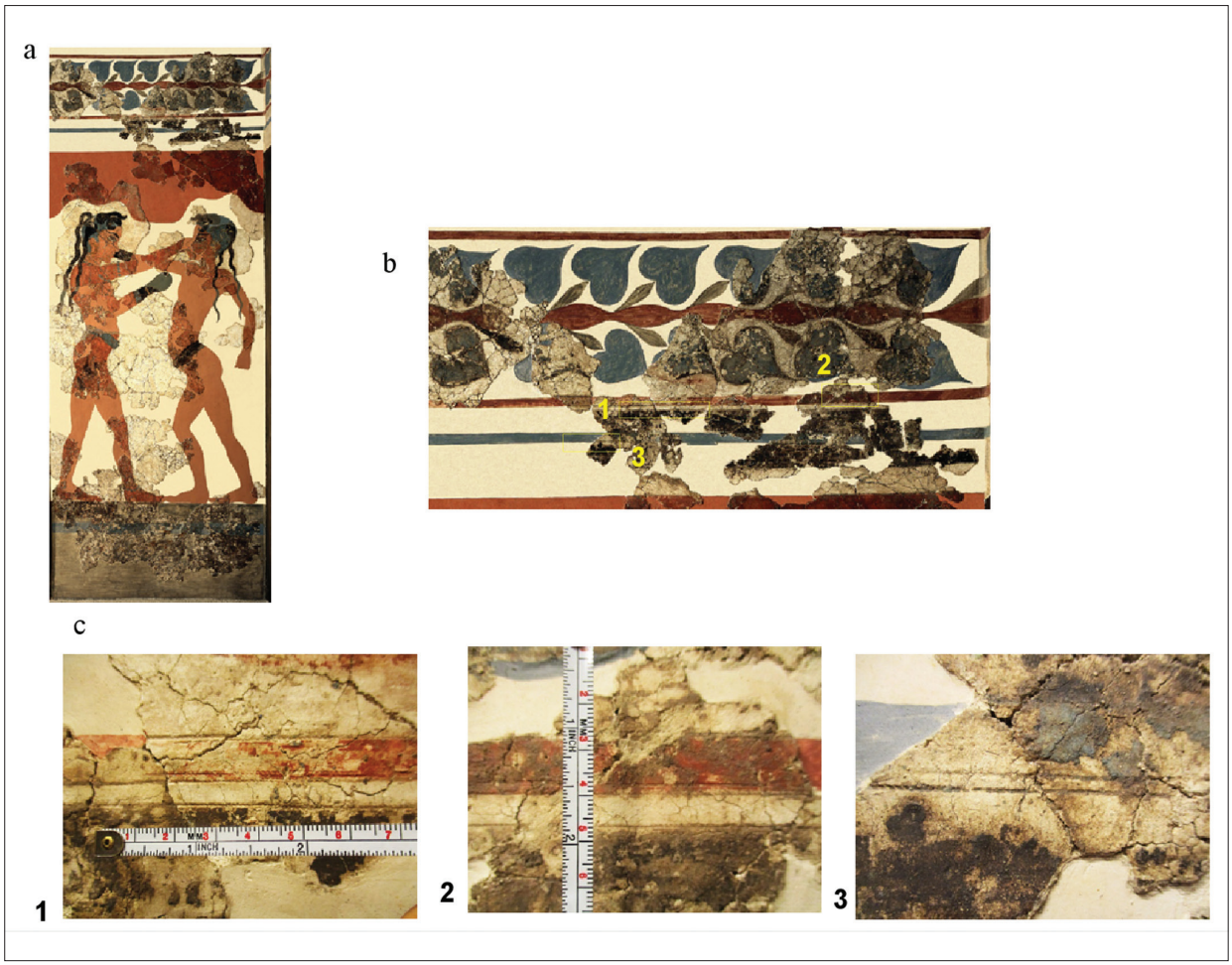

Fig. 1. a. 'Boxing Boys', 'Building Beta', Room 1, South Wall (height: 2.75 m, width: 0.94 m.; after Doumas 1992: Fig. 79); b. The foliate band with an indication of the points of observation of the imprints (1–3); c. Points 1–3 in a close-up (courtesy of the Akrotiri Excavation Archives).

In the case of the 'Boxing Boys', the imprints were measured at three points on the upper part of the composition, which is essentially a foliate band enclosed within thin coloured stripes: point 1 is on the upper limit of the dark stripe, point 2 on the lower limit of the red stripe, and point 3 just below the blue stripe (Fig. 1). At points 1 and 3, the width of the imprint was 1.5 mm, but at point 2 it was twice as much, *i.e.* 3 mm. In all three cases, the negative of the string had a z-twist direction, therefore the original was either s-spun or S-plied. However, it was not possible to discern macroscopically whether this is the primary twist or a plied string. Yet, the number of twists appeared homogeneous and rather consistent at all three points, as we measured 6 to 7 twists per cm.

In the composition of the 'Antelopes', three points on the upper part were observed and measured as well. They also belonged to the horizontal string imprints defining the drawing of thin colour stripes: point 1 is on the lower limit of the upper red stripe, point 2 is below the lower red stripe, point 3 is a little to the right from point 2 (Fig. 2). At point 1, the width of the imprint was 2 mm. At points 2 and 3 it measured 1.5 mm. In all three cases, the negative of the string had a z-twist direction, so the original was either s-spun or S-plied. Again, it was not possible to conclude, if this was the primary spin or a plied string. In this composition as well, the string had 6 to 7 twists per cm.

As a general conclusion, it could be observed that the strings used by the painters were meticulously spun. The consistency of the number of twists per cm suggests that their manufacture was mechanised, that is, that they were produced with the implementation of a spindle equipped with a whorl. The thickness of the original products may have ranged from 1.5 to 3 mm. Two basic questions could not be answered through macroscopic observation: first, whether the z direction of the twist corresponds to primary spinning or not; and second, the nature of the fibres used.

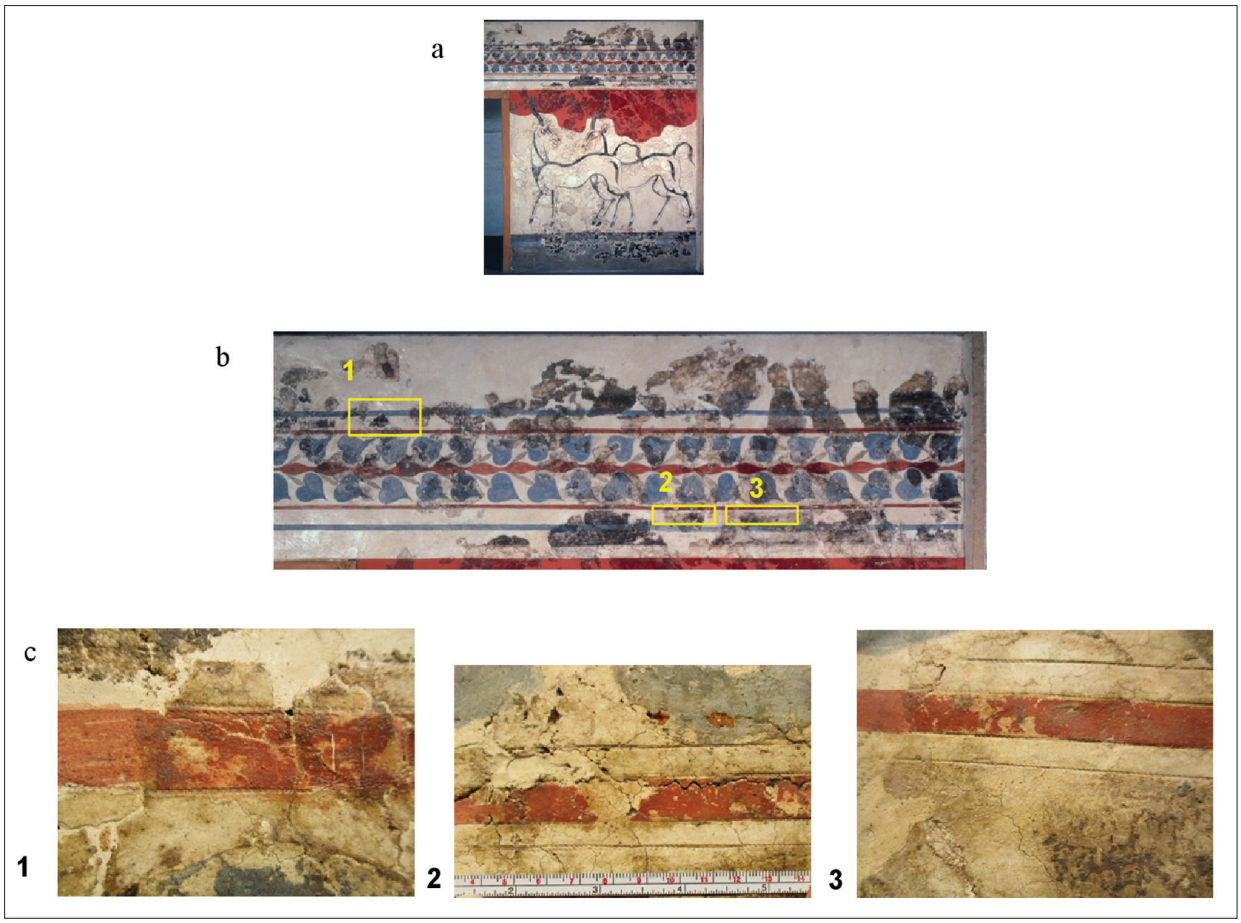

Fig. 2. a. 'Antelopes', 'Building Beta', Room 1, West Wall (height: 2.75 m, width: 2 m; after Doumas 1992: Fig. 83); b. The foliate band with indication of the observed imprints; c. Points 1–3 in a close-up (courtesy of the Akrotiri Excavation Archives).

e) Clay sealing imprints

The clay sealings

A unique testimony regarding strings at the site of Akrotiri on Thera is provided indirectly by string impressions on clay nodules. The testimony in question survives on the back of small-sized clay sealings recovered at the site of Akrotiri (Doumas 2000). These particular sealings belong to a type known as 'flat-based' sealings (Fig. 3) because one of their sides, the one usually referred to as their back side, is relatively flat, since it was pressed against a (relatively) flat object when the clay was still moist (Hallager 1996: 135–158). On the basis of the characteristic imprint, the object they were pressed against was definitely made of leather (Pini 1983; Weingarten 1983). Although initially it was suggested that the leather had been wrapped around some small-sized packets (hence the term devised by Pini, *Päckchenplomben*), the surviving impressions demonstrate beyond doubt that the leather was only folded over multiple times (Fig. 4). These small folded pieces of leather are assumed to have functioned much like parchment, serving some sort of administrative recording purposes and playing some yet unspecified role in exchange transactions (Karnava 2008). It also seems that the string was wrapped around the leather at the same time as layers of clay were stacked one after the other on top of the leather and also kept together by the wrapping string (Karnava 2018: 102–104). The string had been wrapped around the leather and the clay multiple times in order to keep them folded together, as well as to make sure that the clay would stay in place after it became dry. The last stage of the procedure was to stamp the clay with one, two, or even three different seals. It is believed that the stamped clay and the folded leather underneath were dispatched to localities outside their actual place of manufacture. What remains today, after the leather was obviously removed from the clay sealing or decomposed, is a small lump of dry, unfired clay bearing the impression of a leather piece wrapped in string on one side, and the impressions of one or more administrative seals on the other(s).

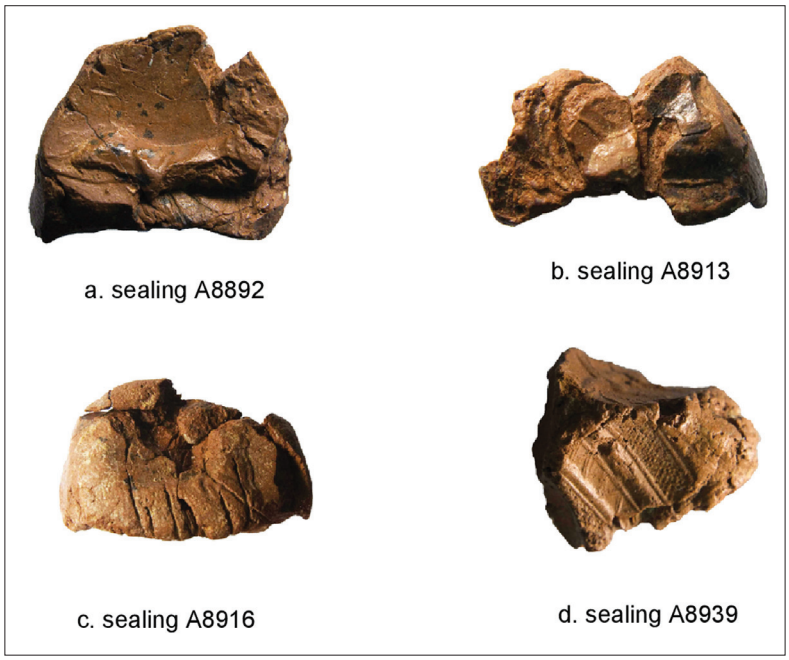

Fig. 3. a–d. Clay sealings nos A8892, A8913, A8916, and A8939 found at Akrotiri on Thera (courtesy of the Akrotiri Excavations Archives).

These sealings represent a specific stage in the history of the southern Aegean and most notably a specific stage in Minoan history. This sort of sealing has been found in a number of archaeological sites on the island of Crete, in deposits that date to the so-called Minoan Neopalatial period, roughly dating to between 1700 and 1450 BC. The evidence from Akrotiri does not represent local technology, that is to say that the clay sealings were imported to Akrotiri ready-made, *i.e.* it is certain that they had been prepared in some locality (or localities) on Crete but were then sent off to Thera (Karnava 2008: 378). Therefore, the strings preserved as imprints on the sealing clay originated on Crete.

The imprints

For this study, the string imprints were examined on high resolution photographs as well as on the casts

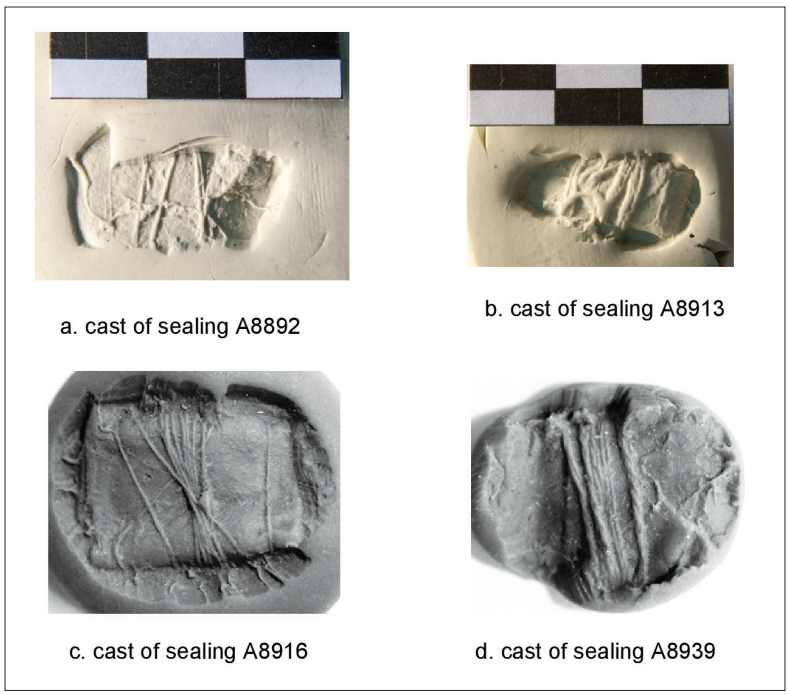

Fig. 4. a–d. Casts of the folded leather and thread imprints under clay sealings nos A8892, A8913, A8916, and A8939 found at Akrotiri on Thera (courtesy of the Akrotiri Excavations Archives).

of four sealings (Fig. 4). The cases discussed here represent a very small percentage of the total number of string imprints from the Akrotiri sealings. The imprints on clay were negatives as in the case of the Theran wall paintings, but their casts recreated the original twist direction.

In general, observation of the details was very challenging. It was easier to determine the direction of the spin or to measure the width of the imprint than to calculate the number of twists per cm. The casts of sealings nos A8892 and A8913 (Fig: 4.a–b) have imprints which are 0.4 to 0.5 mm and 0.6 mm wide, respectively. Extremely low relief, s direction slants were observed, which suggests that these strings were s-spun. It was not possible to observe on the casts if this was a primary or a secondary spin. The cast of another sealing, no. A8916 (Fig. 4.c), showed a clear contour of a folded piece of leather which was 1.9 × 1.3 cm. A very thin thread was wrapped tightly around it. The width of its imprint is 0.3 mm. Again, a very low relief s sloping configuration suggests an s-twist direction. Lastly, sealing no. A8939 (Fig. 4.d) bears one of the best-preserved and widest string imprints. It is 1 mm wide with an s-twist direction and has 5 twists per cm.

Given the examples above, it can be suggested that the Cretan administrative authorities made use of very fine strings, best classified as threads,[7] in order to wrap the folded leather pieces tightly. Although it is impossible to confirm whether these s-spun threads were single or plied from even finer ones, in any case their manufacture required considerable skill and care, as well as tools with rather small and light spindle whorls, at least for the finest products. Just as in the case of the wall paintings, also for the clay sealings it was not possible to detect evidence leading to identification of the fibres used.

f) Tools and products: correlating imprints and spindle whorls

The examination of thread and string imprints and the evaluation of the technical features of the original products provide a possibility to enrich our knowledge on fibre technology and to complement the data gained through textile tool analysis. It must be pointed out that this correlation is based on the assumption that the imprint's width corresponds to the original product's thickness.

It is highly probable that the strings whose imprints are preserved on the Theran wall paintings were produced at Akrotiri. In this case it is interesting to review the spindle whorl data from the site and to discuss which types of the tools found at Akrotiri could have been used to manufacture such strings. Late Cycladic deposits at Akrotiri yielded so far a total of 41 objects which were identified and studied as spindle whorls (Vakirtzi 2015). One of the analyses undertaken was a metrical classification of these tools according to their size class in order to infer the types of spun artefacts produced locally. This kind of analysis stems from the principle that the size of a spindle whorl, *i.e.* its weight and diameter, directly affects the thickness and the quality of the desired end product (Andersson Strand 2015: 47–48).

Metrical classification was applied to 30 out of the 41 whorls, *i.e.* those which were intact or almost intact and thus preserved all or almost all of their mass. They were classified according to their diameters and weights, which are considered the most important functional parameters, each affecting the speed of rotation of the spindle and the tension provided to the fibres accordingly (Barber 1991: 43–53). The results of the analysis demonstrated that a range of different fibre qualities were spun at Akrotiri into various types of products (Fig. 5). The manufacture of very fine and tight threads is indicated by six spindle whorls weighing between 2.9 and 10 g, with diameters between 1.6 and 2.5 cm. At the other end of the range are five spindle whorls weighing between 25 and 35 g, with diameters between 3.1 and 4.5 cm, which were used to make significantly coarser products. Between these extremes belongs the majority of Late Cycladic spindle whorls, with weight values between 10 and 25 g and diameters measuring between 2.5 and 5 cm. These twenty spindle whorls represent the main 'production line' of the Akrotiri Late Cycladic spinning

[7] According to one classification system, the criterion of distinction among different types of spun products is their diameter. Thus, following that classification and the related terminology, any spun product with a diameter of up to 2 mm is classified as a thread, those measuring between 2 and 8 mm in diameter would be called cords, while a product with a diameter of more than 8 mm would be called a rope (Andersson Strand 2015: 48, with further reference to Rast-Eicher 1997: 305–313). However, it must be born in mind that the classification so far has remained largely subjective and arbitrary in the archaeological textiles literature. Thus, it is suggested here that a robust classification system of spun products necessitates a survey and comparison of a large body of data and employment of more than just metrical criteria to distinguish among their different categories. Here, the term 'string' is used to refer to spun products whose function was unrelated to textile production, *i.e.* for preparation of wall paintings, which also seem to have been thicker than the majority of the identified and studied prehistoric threads (Andersson Strand, Nosch 2015: Appendix A). However, the clay sealing imprints may be considered as those of threads mainly on the grounds of their finesse, even though these threads had an alternative use beyond textile-making.

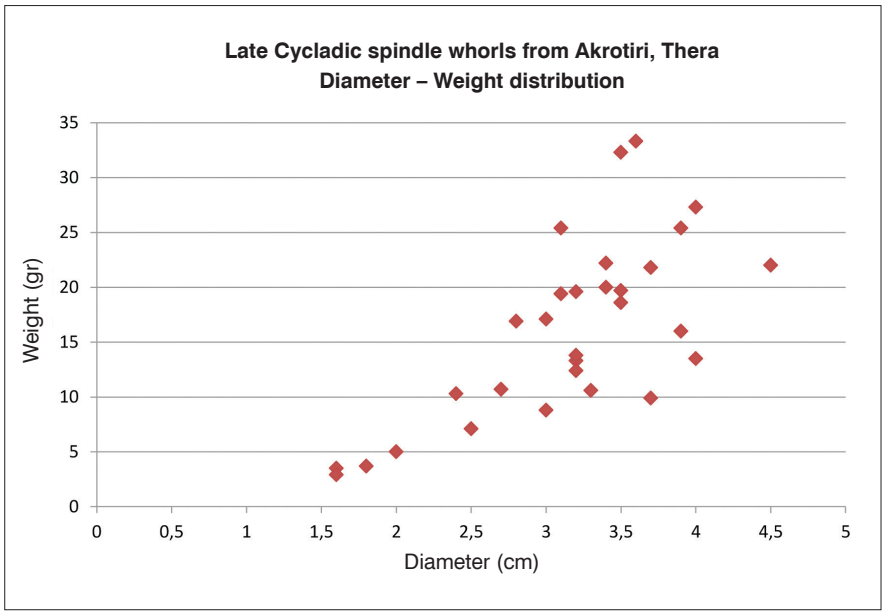

Fig. 5. Scatterplot of the diameter and weight values of spindle whorls from Late Cycladic Akrotiri.

'industry' as indicated by the tools discovered and examined so far.

But what types of products would have been produced with them? A perspective on the end products may be gained by experiments conducted by the CTR at the University of Copenhagen. Experimental spinning was conducted with replicas of prehistoric spindle whorls. Two replicas weighing respectively 8 and 18 g were used to spin wool fibres (Olofsson *et al.* 2015: 77). Woollen z-spun threads were produced with the use of these two different spindle whorls (Möller-Wiering 2015: 104). Spinning with an 8 g spindle whorl produced threads with a mean diameter of 0.3759 mm, while the use of an 18 g specimen resulted in threads with a mean diameter of 0.4582 mm (Möller-Wiering 2015: 107, Fig. 4.2.10). Spinning flax fibres with the same 8 g spindle whorl yielded slightly thinner threads with a mean diameter of 0.299 mm (Möller-Wiering 2015: 110).

The results of these experiments allow, by analogy, for a general correlation between the Theran wall painting imprints and the Akrotiri Late Cycladic spindle whorls. Given the width of their imprints, it may be hypothesised that the strings used by the painters had been spun with spindle whorls heavier than 18 g if the raw material was animal fibre and in particular wool. If the strings were made of flax, they might have required slightly heavier spindle whorls. The Akrotiri assemblage includes such heavy tools, but further experimentation is necessary to narrow down the spindle whorl size which can produce strings similar to those impressed on the wall paintings.

With regard to the clay sealing imprints, it is clear that these correspond to thread produced elsewhere, since the sealings themselves are considered to have been imported to Akrotiri, as indicated by the macroscopic clay examination and characterisation. The exact locality of their production cannot be confirmed at the moment, but a Cretan origin has been suggested (as mentioned previously). Although prehistoric spindle whorls were found in several locations on Crete, it is generally accepted that they have been comparatively rare finds on this island (Militello 2007: 41; Burke 2010: 50). This observation has triggered several hypotheses about alternative thread production techniques which perhaps did not require the use of the spindle whorl (Tzachili 1997: 128). However, the clay sealing imprints with visible fibre twists suggest the use of spindles equipped with very light spindle whorls *versus*, for example, splicing. Assuming that the threads wrapped around the leather pieces, to which the clay sealings were attached, were spun on Crete, a survey of Cretan spindle whorls from localities compatible with the clay fabric of the sealings would potentially enable testing further hypotheses on the manufacture localities of those threads, and to revisit the current views on Cretan spinning practices. Again, on the basis of the CTR experiments, one could postulate the use of spindle whorls weighing between 8 and 20 g for the manufacture of threads with diameters ranging from 0.3 to 0.5 mm, while slightly heavier spindle whorls were supposedly used for the thicker threads which created an imprint 1 mm thick.

What is interesting is the fact that all of the threads wrapped around the examined sealings had the s direction, suggesting a consistent technical choice to twist in the counter-clockwise direction. If this is the primary twist, then this choice brings these presumably Cretan

Imprint material	Identification	Measured Feature	Width	Spin direction	Structure	Twist density
Plaster	Boxing Boys 1	Imprint	1.5 mm	z (negative)	Single ?	6 twists / cm
Plaster	Boxing Boys 2	Imprint	3 mm	z (negative)	Single ?	7 twists / cm
Plaster	Boxing Boys 3	Imprint	1.5 mm	z (negative)	Single ?	7 twists / cm
Plaster	Antelopes 1	Imprint	2 mm	z (negative)	Single ?	6 twists / cm
Plaster	Antelopes 2	Imprint	1.5 mm	z (negative)	Single ?	6-7 twists / cm
Plaster	Antelopes 3	Imprint	1.5 mm	z (negative)	Single ?	6 twists / cm
Clay	A 8892	Cast of imprint	0.4-0.5 mm	s (positive)	Single ?	Non discernable
Clay	A 8913	Cast of imprint	0.6 mm	s (positive)	Single ?	Non discernable
Clay	A 8916	Cast of imprint	0.3 mm	s (positive)	Single ?	Non discernable
Clay	A 8939	Cast of imprint	1 mm	s (positive)	Single ?	5 twists / cm

Fig. 6. Technical features of spun products observed on the imprints and/or their casts.

threads closer to Egyptian spinning techniques (Barber 1991: 65). In this aspect, a comparison with the strings impressed on the Theran wall paintings becomes crucial. Unfortunately, it was not possible to confirm whether the wall painting imprints preserve the features of single-spun or plied strings. Accurate techniques of observation of the Theran string impressions, perhaps in the microscopic scale, would greatly enhance our understanding of their manufacturing technique and would render this comparison possible. If the fresco strings were proved to be S-plied, then the primary spin would be in the z direction, as is the case of the actual strings recovered at Akrotiri (Moulhérat, Spantidaki 2006). On the contrary, if they proved to be s-spun, then the hypothesis of diverse techniques of spinning at the same locality would be corroborated.

g) Concluding remarks

Akrotiri on Thera is one of the rare archaeological sites in the Aegean with exceptional preservation conditions. Due to its thick volcanic deposits which buried and sealed the site following the 'Minoan' explosion of the Santorini volcano in the 17th or 16th century BC, in some instances organic material has been found in relatively good condition. Among several organic finds, actual strings and ropes have been found as well (Michailidis, Angelidis 2006). Important as they may be, original strings and ropes are not recorded at most Aegean prehistoric sites, but with a combined methodology integrating tool analysis, imprints analysis, and original thread, string, or rope analysis it may be possible to disentangle the prehistory of the Aegean fibre crafts. Especially the thread and string imprints analysis will prove a source of crucial comparative data, since these relics survive frequently in archaeological contexts.

In particular, the collection of metrological and technical data deriving from imprints (Fig. 6) can be useful for a series of experimental tests to correlate tools and products on the basis of methodologies developed by the CTR in Copenhagen. The examples of imprints presented in this paper show how this particular field of research allows for testing previous experimental work in order to gain a clearer picture of the applied technology. The discussed observations enable a first level of comparison between what was in all probability local Theran fibre products on the one hand, and Cretan threads on the other. This suggests a preliminary conclusion that the spindle technology was applied in both localities for production of high quality fibre products to be used beyond textile production. So, the imprints suggest the use of the spindle whorls and the sharing of a common basic technological tradition in the two neighbouring islands during the Neopalatial period, at least in the light of the sample presented. Not all aspects of this technology are discernible by the use of this method, at least not during this early stage. To address crucial questions, such as the dominant twist direction and angle, microscopic analytical methods and a larger imprint sample would be necessary.

Aegean Bronze Age textile production was undoubtedly an industry which absorbed most of the processed wool and flax, and much of the fibre craftsmanship was organised around this central axis of weaving cloth. However, fibre crafts addressed a much wider range of everyday needs in Bronze Age communities. Strings and

ropes were essential for traditional applications such as binding and tying materials together. The sealing imprints discussed in this paper are only a single manifestation of such practices and other examples may also be mentioned. The cast of a bed from Akrotiri demonstrates how strings were used for its manufacture, while strings were also used to make the grid upon which the 'mattress' of the bed was to be laid (Gerontas 2004). A most ingenious use of strings, however, is demonstrated by the case of the wall painting imprints. The linear horizontal boundaries created by the string impressions may be regarded as an early form of a *canon*, a ruler to measure, arrange, and organise space. It is certain that this was a widely diffused artisanal technique in the Aegean Bronze Age since string impression was also used a few centuries later in the decoration of the floor of the Megaron at Mycenaean Pylos (Egan 2015). While the measuring function of the strings is not as straightforward as their organising function in the case of the wall paintings, an Akrotirian clay Middle Cycladic loom weight provides an opportunity to consider the former function: a thick string was pressed on the clay before this textile tool was fired, exactly in the middle of its surface and along its vertical axis. The accurate position of the string imprint with regard to the shape of the loom weight's surface indicates its intentional contact with the clay. It is possible that the string was attached to the still unfired loom weight in order to 'measure' its dimensions and transfer them on other pieces of clay in a process of mass manufacture of identical loom weights (Vakirtzi forthcoming b).

Fibre crafts, and in particular the laborious task of producing threads and strings, were entangled with many different aspects of technical and artisanal activities in the Aegean Bronze Age. A careful comparative examination of imprints has a potential to provide insights not only about fibre technology but also aspects of material and non-material culture which may be otherwise archaeologically undetected. In the case of strings and ropes, this paper highlights the way that their imprints may be integrated into research methodologies as a crucial category of archaeological evidence, suitable for the investigation of interregional transfer of technological know-how, as well as for exploration of cognitive achievements, such as the organisation of space in Bronze Age art.

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To Dye or Not to Dye: Bioarchaeological Studies of Hala Sultan Tekke Site, Cyprus

Abstract

Dated to the Late Bronze Age (Late Cypriot II: 1450–1200 BC and Late Cypriot III: 1200–1050 BC), the site of Hala Sultan Tekke brought to light interesting evidence of textile production and possible fabric dyeing. Finds of loom weights and spindle whorls together with remains of dyer's croton (*Chrozophora tinctoria*), field gromwell (*Buglossoides arvensis* syn. *Lithospermum arvense*), and shells of *murex* allow opening a discussion over the methods and reasons for undertaking the time and cost-consuming procedure of dye production. The present article, through an examination of finds and an analysis of plant macrofossils and molluscs, tests a hypothesis of textile dyeing at the Late Cypriot city of Dromolaxia Vizatzia.

Streszczenie

Farbować czy nie farbować. Badania bioarcheologiczne na stanowisku Hala Sultan Tekke, Cypr

Podczas badań archeologicznych prowadzonych na terenie miasta Dromolaxia Vizatzia datowanego na okres późnej epoki brązu (okres późnocypryjski II: 1450–1200 p.n.e. oraz późnocypryjski III: 1200–1050 p.n.e.) odkryto liczne ciężarki do krosna oraz przęśliki. Znaleziska sugerują, że jednym z ważniejszych elementów gospodarki stanowiska Hala Sultan Tekke było wytwarzanie tkanin. Natomiast odkrycie skupiska pokruszonych muszli ślimaków morskich z rodziny rozkolcowatych (*Muricidae*) oraz identyfikacja, podczas przeprowadzonych analiz archeobotanicznych, nasion należącej do rodziny wilczomleczowatych *Chrozophora tinctoria* oraz nawrotu polnego (*Buglossoides arvensis* syn. *Lithospermum arvense*) pozwala na podjęcie dyskusji na temat metod oraz powodów, dla których podejmowano czaso- oraz kosztochłonny proces produkcji barwników do tkanin. Poprzez analizę artefaktów i badania makroskopowe szczątków roślinnych oraz mięczaków artykuł podejmie próbę weryfikacji hipotezy na temat farbowania tkanin w Dromolaxia Vizatzia w późnej epoce brązu.

Keywords: Bronze Age, Cyprus, textile production, archaeobotany

Introduction

The archaeological site of Hala Sultan Tekke (HST) is located in the south-eastern part of Cyprus, *c.* 7 km from Larnaca (Fig. 1). The investigations have been undertaken within the Late Cypriot town of Dromolaxia Vizatzia. Due to the large area potentially taken by the settlement, the archaeological research was divided into smaller sections (Fig. 2). The exploration started in the 1970s in the so-called Area 8 and was continued intermittently for almost four decades (Fischer 2012a: 73). Over time, a series of houses arranged around a central courtyard were uncovered. Some of the buildings were constructed of large, finely-cut stones ('ashlar blocks'). Several of the houses had sophisticated features, such as carefully-paved rooms with their own wells interpreted as 'bathrooms'. In between the buildings, a street *c.* 4 m wide, which appeared to continue on the same alignment further to the south, was detected (Åström *et al.* 1977; 1983; Åström 1989). In addition to the regular excavations, trial trenches were dug to the north of Area 8 (currently City Quarter 1, CQ1) in the 1970s and at the end of the 1990s. The finds shed new light on the

Fig. 1. Map of Cyprus and the East Mediterranean with localisation of Hala Sultan Tekke.

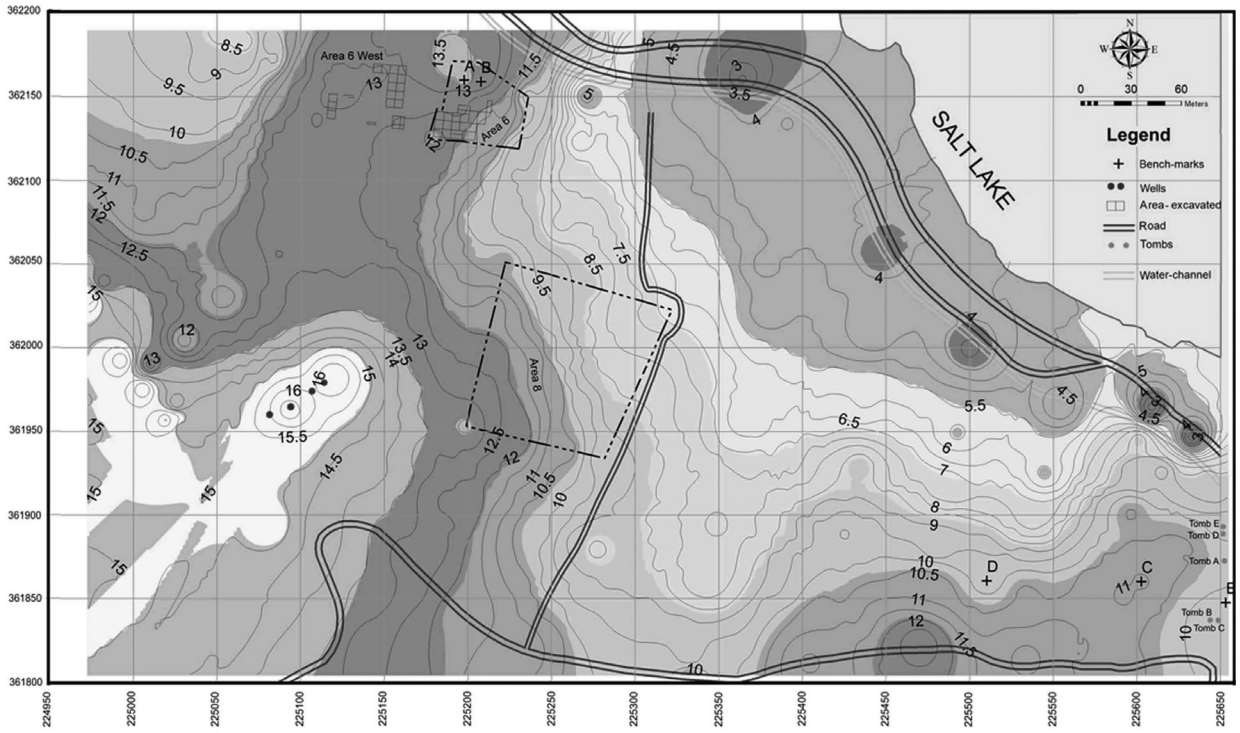

Fig. 2. Plan of Hala Sultan Tekke with localisation of the areas or city quarters researched until 2017 (drawing by M. Al-Bataineh).

occupation of the settlement dated to the first half of the Late Cypriot period (*c.* 1350 BC) (Åström 2001: 57–61). In 2010, a project titled '*New Swedish Cyprus Expedition*' was launched. The exploration started in CQ1, which is one of the three town quarters discovered and partly exposed. The others, CQ2 and CQ3, lie to the west of CQ1. Each of them was most likely inhabited by people of various professions. Based on the pottery, the life-span of this Late Bronze Age town lasted roughly from 1300 BC to 1150 BC. Around the mid-12th century BC, the town was destroyed and abandoned, never to be occupied again (Fischer 2011; 2012a).

The hitherto conducted excavations allowed determining the localisation of various settlement parts, workshops for various productions, and a possible cemetery. Additionally, three stages of site occupation have been

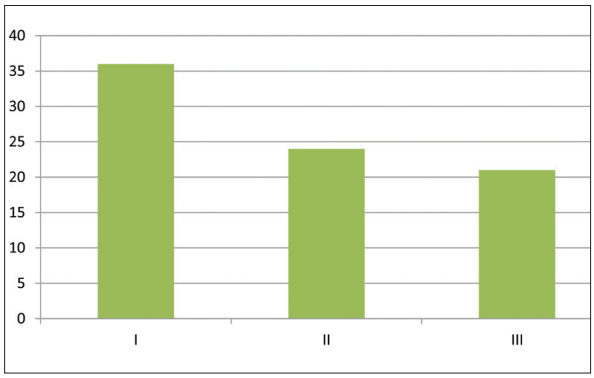

Fig. 3. Number of loom weights per strata (based on Svensson 2011; Fischer 2011; 2012b; Fischer, Bürge 2013; 2015; 2016; Miltiadous Johansson 2014).

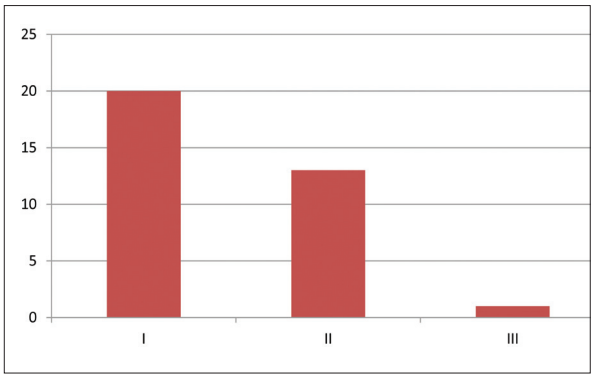

Fig. 4. Number of spindle whorls per strata (based on Svensson 2011; Fischer 2011; 2012b; Fischer, Bürge 2013; 2015; 2016; Miltiadous Johansson 2014).

recognised, which can be differentiated by a change in the colour of the soil and a shift in the construction technique of stone structures. Both Stratum 1 and 2 are dated to the 12th century BC. Unfortunately, precise dating of all the strata is not possible due to calibration plateau that occurs from roughly 1225–1130 BC. Additionally, there were artefacts that include jewellery, tools and weapons of bronze, and objects of stone and bone. The locally-produced pottery was of high quality and so were the imports mainly from the Mycenaean cultural area. The finds of copper slag, furnace walls, fragments of at least five *tuyères*, and pieces of raw copper along with moulds point to production of metal objects (Fischer, Bürge 2015; 2016).

Uncovered structures, together with artefacts and other materials, indicate that in the 13th century BC Dromolaxia Vizatzia was a developing town going through a period of intensification of industrial and commercial activities. The growth was possible due to the location of the town on the shore of the Mediterranean Sea. The surrounding area has been referred to as the 'fertile crescent of Cyprus' on account of its productive agricultural land and density of its population (Åström 1965: 119, note 19).

Undoubtedly, one of the most important components of the Late Bronze Age economy was textile production, the importance of which is reflected by numerous finds, including spindle whorls and loom weights. Throughout six years of research,[1] a total number of 81 loom weights and 34 spindle whorls were uncovered in three strata of occupation (Figs 3, 4). The question of usage of particular textile production tools was discussed at several occasions (*e.g.* Svensson 2011; Miltiadous, Johansson 2014 with further references), therefore it will not be addressed in the present paper.

Apart from the artefacts, bioarchaeological data including molluscs and plant macroremains potentially indicating dye or pigment production in the town were uncovered both at the site and in the analysed soil samples. More than 25 kg of *murex* shells were discovered in the area to the south of R40 (trench 16B) (Fischer, Bürge 2016). The preliminary studies showed that the assemblage was dominated by *Hexaplex trunculus* (Reese forthcoming), however, since further studies are being conducted, a possibility of occurrence of other species can be assumed. The plant macroremains identified in the soil samples include finds of field gromwell (*Buglossoides arvensis* syn. *Lithospermum arvense*), dyer's croton (*Chrozophora tinctoria*), terebinth (*Pistacia* sp.), olive (*Olea europeae*), and grape (*Vitis vinifera*), which may be indirectly and directly associated with textile and dye or pigment production.

The aim of the article is to verify the possibility the aforementioned bioarchaeological relics were used in the production of dyes for fabrics. Archaeobotanical and archaeomalacological data will be checked against experimental and ethnographical studies in order to examine the possible methods of use of the investigated resources.

Material and methods

In total, 126 soil samples were collected during three seasons of archaeobotanical research, when 802 litres of

[1] The article presents data available in 2015. Since then both the archaeological and archaeobotanical researches have evolved.

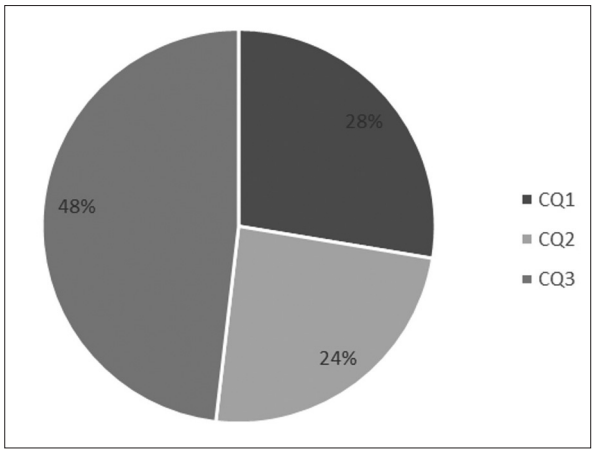

Fig. 5. Percentage share of economic plant remains per city quarters CQ1, CQ2, and CQ3 at Hala Sultan Tekke.

soil were floated with the manual bucket flotation system. Each soil sample was dispersed in water and then gently stirred to release the botanical remains. The watery solution from the upper part of the bucket was then poured through a set of sieves (0.5 mm and 0.25 mm mesh size). The next step was to pour fresh water onto the soil remains at the bottom of the bucket, and then the operation was repeated until no soil was left. Sieves retained both the heavy and the light residues after silts and other particles smaller than 0.25 mm were rinsed through. Residues were dried and the heavy elements were separated from the light elements. They were then sorted using a low-power stereo microscope at 6.3–40× magnification. The macroscopic plant remains and pieces of charcoal were picked from differently-sized residues. Plant macrofossils were identified on the basis of their morphological characteristics, whereas charcoal was determined on the basis of anatomical characteristics. Charcoal was identified under a metallographic microscope at 50–1000× magnification. All plant macrofossil and charcoal identifications were checked against the botanical literature (Cappers *et al.* 2006; Jacomet 2006; Neef *et al.* 2012; Crivellaro, Schweingruber 2013) and compared with a modern reference collection of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences, and the Bioarchaeological Department of the Silesian Museum. The nomenclature follows Mirek *et al.* (2002), Cappers *et al.* (2006), and Crivellaro, Schweingruber (2013).

Results

The main focus of the following paper was put on the results of dyes and pigments production. Nevertheless, general archaeobotanical results are also presented.[2] The first archaeobotanical analyses were undertaken in the 1970s (Åberg 1976; Hjelmqvist 1976; 1979). Both plant macrofossils (incl. charcoal) and impressions on pottery sherds and clay were researched. The studies concluded that olive, grape, and common fig (*Ficus carica*) belonged to the most common remains identified at the site. Meanwhile, the majority of the crops was represented by barley (*Hordeum vulgare*) (Hjelmqvist 1979). In the case of charcoal – terebinth, Cyprus pine (*Pinus brutia*), and olive tree were the most prevalent (Åberg 1976; Schoch 2001). The new archaeological project at HST enabled new sampling and analysis of plant macrofossils. Thus far, roughly 700 seeds and fruits of 29 different species were studied. The assemblages from the town quarters seem to be of quite unified composition. Economic plants, such as cereals, grapes, olives, almonds (*Prunus dulcis*), colocynth (*Citrullus colocynthis*), common figs, and others were present in each part of the settlement (Fig. 5). It seems that olives and grapes were the most common economic plants found at the site. They were scattered around the settlement in relatively high quantities. Herbs, weeds, and grains were most abundant in CQ3. The accumulation of macroremains of the economic plants in one of the contexts of this city quarter, along with a significant amount of ash (Fischer, Bürge 2016: 45) and animal bones, might indicate a dedicated space for food preparation or storage. CQ2 yielded finds of field gromwell, while in CQ3 – besides olives and grapes – fragments of almonds, common figs, and dyer's croton were found. The analysis of charcoal revealed a genus of terebinth and a species of the Cyprus pine.

Discussion

Dyeing of textiles might have been inspired by body-painting used for embellishment as well as for conferring magical powers or sexual appeal, which might have been at some point transferred onto clothing. The earliest dyes or colouring substances were undoubtedly discovered by accident through staining by parts of plants (Koren 1993: 16). Choice of colours and plants strongly depended on the locally-available vegetation; the more exotic, the more valuable they became. Their value might have

[2] This publication discusses plant macroremains that might have been used in the process of dye or pigment preparation. Therefore, the matters of other, not related species and their quantiles, distribution, and interpretation were omitted. For further information, *cf.* Kofel forthcoming.

depended on symbolic meanings related to religion, status, sex, age, and/or wealth (Sarpaki 2001: 202; Koren 2005: 198). Together with textiles that themselves acted as visible symbols of power and wealth, dyes could transmit information about the rank of specific persons, places, and environments (Gleba 2011: 5), and thus help differentiate their users from others (Sarpaki 2001: 203).

Dyes and pigments

Finds of broken molluscs shells or macrofossils of plants do not directly indicate textile dyeing at a given site (Koren 2013: 63). They might be remains of consumption or production of pigment or other colourant. At the same time, finding crushed *murex* shells at an archaeological site does not necessarily indicate that the snails served as food (Koren 2013: 63), but more likely illustrates production of a pigment (Koren 2013: 64) or, if additionally brought to a soluble form, a dye (Koren 2013: 63). For that reason, chemical studies of textile production tools could help verifying whether the yarns were dyed, and if so whether they were dyed with molluscs and/or plant dyes. This could be achieved by tracing remains of dye on, *e.g.*, loom weights in the course of a chromatographic analysis.

Before moving on to the discussion regarding dyeing, a short consideration of differences between a dye and a pigment is required. The simplest differentiation would be as follows: a pigment is a substance that is essentially insoluble in water, whereas a dye is water-soluble (Koren 2013: 62). In this vein, a pigment is a dry colour that may also be transferred into fibres but needs to be immersed in a water solution, or rubbed or pounded into the material. A binder, such as milk, bone marrow, or other sticky substance (*e.g.* tree resin), is required to fix the pigment to the textile. Consequently, a dye is a liquid containing colouring matter meant to impart a particular hue to, in this case, fibre (Koren 1993: 18). At the same time, dyeing of textiles involves a chemical reaction which creates a bond between the dye and the fibre (Koren 1993: 18). The true dyeing includes a penetration of dye molecules into the interior of the textile and forming of strong physico-chemical, non-washable bonds with the fibres. However, if oxidised, dye might become a solid pigment merged to the walls of the vat (Koren 2013: 62).

Dyes can be grouped and divided in various ways. The most general division is based on the properties of dyes in the dyeing process and might be described as substantive (direct) and adjective (mordant dyes). The first, unlike the second, can be fastened to a fibre without an intermediary or stabilising agent (Koren 1993: 26) and is represented by saffron and turmeric (Koren 1993: 27). The second group consists of mordant and vat dyes. Mordant dyes need mordant to fasten the dye to the fibre. The most common colours obtained are red, shades of purple, and yellow, which may be acquired from madder and other rubiaceous plants, insects, flavonoid dyes, gallotannins, and dyewoods (Ellis 2003: 157). Mordant dyeing involves using mediator substances, such as salts of aluminium, iron (Ellis 2003: 156), tin, or tannins obtainable from sumac leaves or oak gall 'nuts' (Koren 1993: 26). Those substances both fix the dye to the fibre and may influence the tones of the colour (Ugulu *et al.* 2009: 411).

Vat dyes undergo two chemical processes before being fixed to the fibre (Koren 1993: 27). Reduction occurs by fermentation in an alkaline solution (Ellis 2003: 156) that in Antiquity was produced by adding decomposed or stale urine, vegetable ashes, or lime water (Koren 1993: 27). To attain the final form of a blue or purple insoluble dye, wet fibres need to be exposed to the air (Koren 1993: 27; Ellis 2003: 156).

Dye preparation

Experimental and ethnographical studies showed that preparation of the colourant out of *Muricidae* shells is a time-consuming and rather unpleasant procedure (Verhecken 1994: 33). The snails can be found close to the sea, among rocky shores overgrown with seaweeds. They have to be collected alive and preserved this way until the procedure begins because the dye is formed just after the snail dies (Koren 2013: 46). After the shell is cracked, only the meaty part including the gland with the pigment is placed in a vat. Snail meat is a necessary nutrient for the reductive bacteria also present in the snail (Koren 2013: 48). Nonetheless, it bears emphasising that detecting whether the archaeomalacological material was used for dye preparation is indeed difficult and therefore broadly discussed (*e.g.* Carannante 2010), while the shells are sometimes suggested to have had an ornamental purpose (*e.g.* used as pendants).

The process of dye production involves reduction and oxidation. During the former, the dye vat has to be covered so that the atmospheric air and sunlight do not affect the solution (Koren 2013: 44). A slab of stone or wood, which would be opened only for short periods to stir the content, was used as a lid (Koren 2013: 51). During the whole process, the mixture had to be kept at moderately hot temperature but not boiled (Koren 2013: 52).Vats were probably placed in a pit with smouldering wood pieces placed around in order to maintain relatively constant warm to hot temperatures (Koren 2013: 53). Oxidation was conducted by exposing the ready liquid to sunlight. Then, the pigment, free from the strong stench of decomposing mollusc tissue, was formed (Verhecken 1994: 34). The final colour was dependent on the original colour of the raw pigment and it might have varied from reddish-purple to bluish-purple (violet) (Koren 2013: 44). The textile was then soaked in the dye bath. If required, the textile or yarns might have been then

re-inserted into the dye bath in order to obtain a richer and darker hue (Koren 2013: 61).

Most of the archaeological dyeing installations have been found close to shorelines. That is a strategic location for processing the collected sea snails from the nearby waters (Koren 2013: 58). Alkaline conditions are necessary to conduct dyeing (Verhecken 1994: 34), therefore seawater, which is naturally slightly alkaline, might have been used during the preparation of the dye bath. If required, more basic salt could have been added during the process (Koren 2013: 43). Other materials that could have been used in Antiquity to produce alkaline solutions are: stale urine, ashes of certain plants ('soda ash'), wood ash ('potash') (Koren 2013: 54), and lime with or without ash (Koren 2013: 55).

Plants as colourants

Producing colourants from plants seems less complicated. In the archaeobotanical material from HST, five taxa (dyer's croton, field gromwell, terebinth, grape, and olive) could be associated with textile and dye production.

Ethnographical studies indicate that dyes can be extracted from all parts of dyer's croton, which produces colours ranging from red to blue. Colours and shades are obtained through usage of mediator substances such as lime, salt, and ash that additionally combine colourants with fibres (Ugulu *et al.* 2009: 411). The dye acquired from *Chrozophora tinctoria* was, for example, used for colouring liqueurs, wine, pastries, linen, and Dutch cheeses. Its properties were supposedly known and used already in Antiquity (Uphof 1968: 128). Field gromwell occurs commonly in fields, fallows, and vineyards (Bojnanský, Fargašová 2007: 545). Roots of *Buglossoides arvensis* contain a purple dye commonly known as peasant's make-up (Ger. *Bauernschminke*) (Sauerhoff 2001: 116; Pustovoytov *et al.* 2004: 208). Such remains are commonly found in the archaeobotanical assemblages together with crops (Marinova 2003: 501; Cubero i Corpas *et al.* 2008: 88).

The genus *Pistacia* is estimated to have developed more than 80 million years ago (Parfitt, Badenes 1997) and is frequently noted in archaeobotanical material (*e.g.* Willcox *et al.* 2009). The wood was often used in carpentry, for construction, and as fuel, whereas its resin had medicinal applications (Potts 2012: 199). Moreover, galls and bark of *Pistacia* species are commonly known in Greece and the Mediterranean, where they are both used as a dye and a mordant (Sarpaki 2001: 213). Three species producing resin are common on Cyprus: *Pistacia atlantica*, *Pistacia lentiscus*, and *Pistacia terebinthus* (Crivellaro, Schweingruber 2013: 104–109). The last is claimed to be a prime source of resin in Antiquity (Nicholson, Shaw 2006: 435).

As mentioned before, the traces of olive and grape were the most common remains found at HST. Grapes and easily-storable dried raisins were used as a sugar-rich fruit and for wine fermentation (Zohary *et al.* 2012: 121). They might have also played a significant role in the dyeing procedure. During the fermentation process of wine-making, a salt of the tartaric acid (*potassium bitartate*) may be formed. This salt could be used in ancient dyeing as a mordant (Georgievics 2013: 161). On the other hand, the oil produced from olives, considered one of the most important fruits of the Old World, has been used in gastronomy, as lighting, fuel, and in cosmetics and medicines (Zohary *et al.* 2012: 116). Some authors (*e.g.* Christodoulou, Lyssiotis 2008: 10; Carannante 2010: 158) suggest that olive oil was used in the wool weaving process.

Dyeing at HST

In CQ3, an interesting structure, thought by the excavators (Fischer, Bürge 2016) to be probably related to textile dyeing, has been discovered. In Stratum 2, a 2.1 m × 2.7 m large basin built of a chalky, dense material was unearthed (Fischer, Bürge 2016: 44) (Fig. 6). The basin could have been used at certain stages of the process of textile, dye, or pigment production, such as *e.g.* wool cleaning. Grease and other elements, such as knots, plants, and excrements, needed to be removed. Unwashed wool is less durable than the processed fleece and dirty fibres produce a weaker thread. In addition, the dirt could hold viruses, bacteria, and smell of the sheep, which might be uncomfortable and dangerous to human health (Nobelen 2016: 20). Another process that the basin might have been used for is felting, during which hot water was applied to layers of animal hairs while they were repeatedly pressed. This caused the fibres to hook together and merge into a single piece of fabric (Fouchier 2009).

Alternatively, the basin could have been used to process flax into fibre. During the water retting, a dissolution of lignin and pectin binding the fibres with other plant tissues occurred (Kittel *et al.* 2014: 322).

Moreover, the excavators noticed pieces of a vat while excavating the basin. It might be suggested that the basin was used as a cleaning, retting, or felting container for wool or flax. Therefore, after the material was washed, it could be moved to nearby vats where dyes prepared from molluscs or plants were awaiting.

To conclude, no traces of flax fibre production have been detected at HST so far.[3] Hence, it may be suggested that wool was the main source used in textile production. Interestingly, among the natural fibres used in Antiquity, wool is thought to have been the easiest to dye, since it absorbed the colour faster than flax (Koren 1993: 18; Cybulska, Maik 2007: 186). Moreover, according to

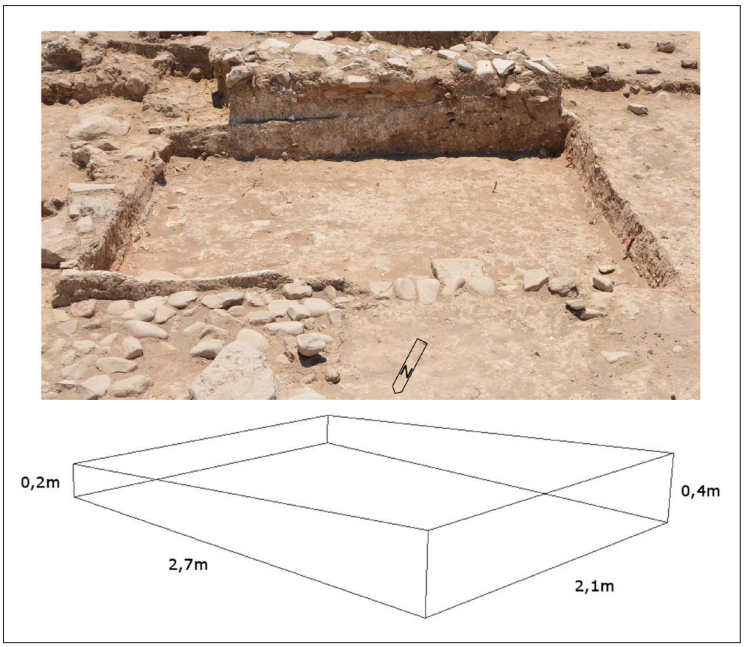

Fig. 6. Basin found in Stratum 2 (photograph by P.M. Fischer) and a sketch of its dimensions (drawing by K. Lubczyński).

Ugulu *et al.,* a low grade of reaction between wool and mordant substances would be a reason for the fibres to become of lighter colour (Ugulu *et al.* 2009: 411–412), which would allow to obtain more shades of a particular colour.

Conclusions

Although further archaeobotanical and malacological studies are required, some general conclusions can be presented based on the recent study:

1. The basin found in CQ3 during the archaeological excavations in 2015 might have been used as a cleaning, retting, or felting container for wool or flax.
2. *Murex* shells, along with dyer's croton and field gromwell, could have been used for pigment or dye production at HST.
3. Traces of terebinth charcoal were discovered at the site. Therefore, if textiles were dyed, it is possible that one of the methods for fixing dye to the fibres was to use terebinth resin.
4. Terebinth bark and galls could have been used both as a dye and a mordant.
5. Olive oil produced at HST could have been used during the wool weaving process.
6. Wool was probably the main resource used in textile production, since practically no evidence for flax has come to light up to date.
7. Dyeing could have increased the value of the textiles produced in Dromolaxia Vizatzia, so that they became luxury trade goods.
8. Application of a chromatographic analysis on, *e.g.,* loom weights could help verifying if dyeing of yarns would take place at the site.

[3] In the 2017 season, one seed of flax (*Linum usitatissimum*) was found in the context of Stratum 3. Nevertheless, one seed is definitely not an indication of fibre production.

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Technical Innovation in Processing of Flax Yarn Production in the Northwest of the Iberian Peninsula: The Spinning Bowl

Abstract

In space, the Castreña culture was located in the north-western part of the Iberian Peninsula, whereas in time it stretched from the Late Bronze Age to the beginning of the Roman period. This study focuses specifically on the invention and use of the spinning bowl in the Castreña culture. Theoretical and conceptual tools will enable tackling this item with a rigid research methodology and help answer the question of why the invention of the spinning bowl and the innovations in processing of flax yarn production occurred, and how they were transmitted to other areas in the forms of innovation or technical loan. To explain its presence within the limits of this geography and chronology, the use of *Linum usitatissimum* L. is discussed. This specific raw material is closely related to the entire innovation process on the one hand, and on the other opens an avenue for research into its function within the technical chain of the creation of linen thread or yarn.

Streszczenie

Misa przędzalnicza – innowacja techniczna w wytwarzaniu przędzy lnianej w północno-zachodniej części Półwyspu Iberyjskiego

Kultura Castreña rozwijała się w północno–zachodniej części Półwyspu Iberyjskiego od późnej epoki brązu po początki okresu rzymskiego. Autorka skupia się na kwestii wprowadzenia w kulturze Castreña specjalnych narzędzi wykorzystywanych przy wyrobie przędzy, tzw. mis przędzalniczych. Ich pojawienie się i użytkowanie analizowane jest w odniesieniu do występowania i wykorzystywania lnu na Półwyspie Iberyjskim. Ramy teoretyczne dla tych rozważań stanowią koncepcja innowacji i zapożyczeń technologicznych oraz sposób, w jaki innowacyjność (w tym przypadku dotycząca technologii przędzenia) manifestuje się w kulturze materialnej.

Keywords: invention, spinning techniques, spinning bowl, Iberian Peninsula

Theoretical and practical aspects of technological invention and technological loan

The first theories of invention and diffusion arose in the 19th century from various study areas. The interest in technological and cultural changes stems in principle from anthropological postulates that discuss cultural changes through an amalgam of perspectives.

The theoretical aspects that bear highlighting were addressed by such important theorists, to state only the most lasting examples, as: A. Comte regarding the theory of knowledge, H. Spencer – society, K. Marx – economy, L.H. Morgan – agency, and E.B. Tylor – religion (for an overview see O´Brien, Shennan 2010: 4–6; Godin 2013: 1–8).

It was not until the 20th century that two explanatory models, or theories of innovation, took centre stage. These have been known as the linear and the sequential models of innovation. Both attempt to explain how inventions emerge and explore the channels of their diffusion, rejection, or adoption. These models were created by V. Bush in 1945 in his *'Science: The Endless Frontier'* and were introduced to the field of innovation studies in the mid-1980s. He postulated that an innovation starts with basic research, followed by applied research and development, and is concluded with production and diffusion (Bush 1945; Godin 2013: 1, 12).

It also bears discussing the technological loan as a cultural transmission and a phenomenon of acculturation. According to B. Godin, acculturation is understood in a dual aspect, creative and destructive. It may synchronize and merge inventions of two cultures or completely disintegrate one of the cultures through internal or external conflict. Acculturation does not imply reception of a new culture and departure of one's own; acculturation is not a one-way process from one society to another. Rather, it is a source of change, diffusion, imitation, assimilation of new techniques, a loan or transfer of artisans, and a process of adoption and incorporation of new raw materials and tools adapted for a new environment (Eerkens, Lipo 2007: 239–242; Godin 2013: 12).

Reasons for the invention of the spinning bowl in the Iberian Peninsula

Invention is a vital part of the creation of a new material or non-material culture internalised within and adapted by a society or agency sector that creates it. Invention, as defined by Kristian Kristiansen, signifies an introduction of a new or original idea and is an innate ability of human agency (Kristiansen 2005: 113).

This definition of invention will be used as the operating concept to understand the evolution of material culture – in this case, the spinning bowl in the Castreña culture (Spain and Portugal) (Fig. 1). Our purpose is to lay a groundwork and create an explanatory model for the technological change in textile production in the period of protohistory through the use of a series of operational concepts such as invention, innovation, technological loan, and acculturation (*cf.* Ruiz 2017).

To this end, the study will focus on the technological chain (based on a general review of the technology used) and the operational-technical chain (based on a general review of the agents and their skills in the crafts being developed).

The examination of the technological and operative chains enables better understanding of the emergence and employment of the spinning bowl in the Iberian Peninsula, as well as the raw material, *Linum usitatissimum* L.*,* and the techniques used in spinning and splicing. The knowledge of the technological chains and the artisan agents will help us to understand the process of invention and innovation.

The first step is an analysis of the term 'artefact', understood as both a tool and technique. Artefacts should not be studied in an empirical way. Instead, researchers should go a step further and see a textile tool in operation in conjunction with the artisan. In other words, to pursue a valid archaeological study one must contextualize. For this, a theoretical framework developed by anthropologists, ethnographers, and archaeologists will be used (O´Brian, Shennan 2010: 11–12; Ruiz 2017). The relationship between material culture and the materiality of the cultural fabric of the agency has to be properly recognised, that is to say, comprehensive understanding of the relationships between the tools, textile products, and craftsmen who produced them should be sought. The present paper focuses on the lifecycle of an artefact, namely the spinning bowl, following A. Appadurai (Appadurai 1986) according to whom an artefact is created through a series of steps forming a sort of *curriculum vitae*.

The invention of the spinning bowl seems to have occurred in the southern Levant during the Chalcolithic period. From there, it was transmitted through a process of innovation, continuing northwards, to the region of the Balkans, and to the south, towards Egypt. The spinning bowl has been documented in the eastern Mediterranean from the Chalcolithic period to the Iron Age (Ruiz 2018).

The motivation for the introduction of a new spinning system appears to have been related to cultivation of flax and new processing techniques for other fibres that developed during the Neolithic period, including various techniques used for making yarn. The spinning bowl occurs again as an invention at the other end of the Mediterranean Sea, in the Iberian Peninsula, probably to answer the demand for a linen thread of a certain quality. Thus, the spinning bowl is found exclusively within the Castreña culture a few millennia after its invention in the eastern Mediterranean. Another possible impetus for this invention was the introduction and increased cultivation of *Linum usitatissimum* L. in the Iberian Peninsula and adoption of new aesthetic concepts and clothing in this culture. These new aesthetics and clothing were, in turn, driven by the impact of trade in Semitic fabrics and accessories such as *fibulae* (Ruiz 2018).

Indeed, the overarching factor in the invention of the spinning bowl in the Iberian Peninsula may well be that of business motivation itself; it behoves us to understand trade with Canaanite and Cypriot merchants on the routes towards the Atlantic – from the Hesperides to the columns of Hercules – as an aspect of social agency that acquires all novelties through trade and coexistence with other cultures. When items were traded among Canaanite and Cypriot merchants – in this case textiles, garments, and ornaments to fasten them – this apparently generated an inventive and innovative initiative among *habitus ingenius* (Ruiz-Gálvez 2013). Trade can be an intense transmitter of cultural information, explaining developments in material culture found in the archaeological record and, specific to our review, technological inventions. The consumer of such material culture re-contextualises it and becomes a promoter of the new inventions. This, in turn, leads to creation of another unique material culture (Antoniadou 2005: 66–67).

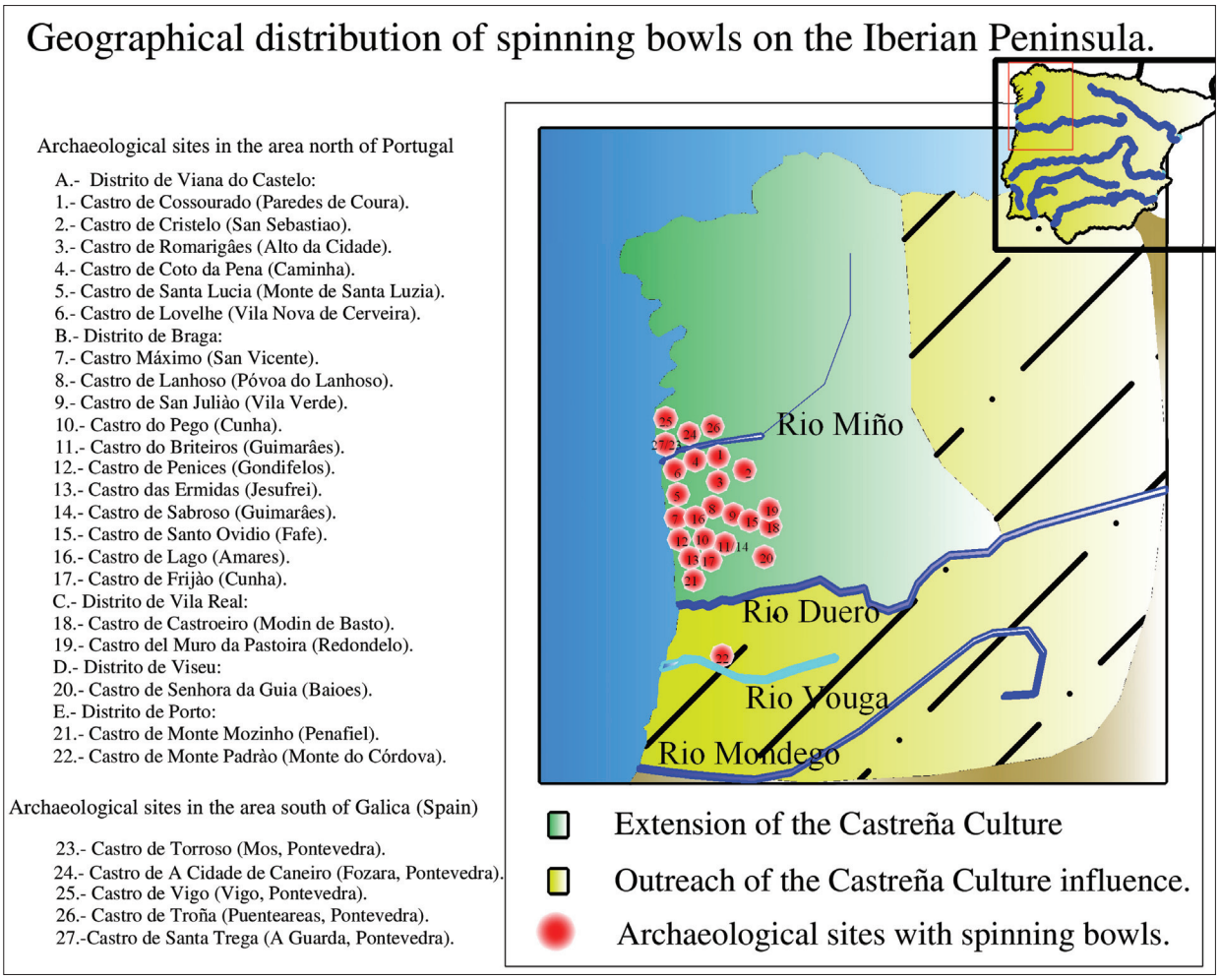

Fig. 1. Castreña culture and the distribution of the spinning bowl on the Atlantic shore of the Iberian Peninsula (drawing by the author).

The curious thing about the spinning bowl is that in the Iberian Peninsula its invention did not pass through cultural boundaries to other surrounding areas as an innovation (as for example to the Tartessian cultural area or the Phoenician coastal settlements). Rather, it remained deeply rooted as a strong tradition of spinning for one thousand years within a very specific area of the Castreña culture located between northern Portugal and southern Galicia (Spain) (Fig. 1) (Ruiz 2018).

The development of spinning technology in the northwest of the Iberian Peninsula during the Late Bronze and Iron Ages

The spinning bowl: a tool for spinning

The spinning bowl is a vessel made of ceramic or stone (ceramic types being the most common), of a shape that can be classified within the ceramic typology as a shaped bowl with a handmade or wheel-thrown body and a handmade, internal handle or handles (Fig. 4).

Despite the variations in body shape, the feature that is common to all these vessels is the presence of internal handles that vary in number from one to four. They may be arranged in the centre of the bottom or elsewhere on the inside, with the handle or handles extending vertically to just below the rim of the bowl (Fig. 4). These internal handles, which are a defining feature of these objects, usually have a number of grooves worn on the inside of the loop. This tool was used in the process of textile production, specifically in the production of linen yarn (Ruiz 2018).

Spinning techniques related to the spinning bowl

There are four spinning techniques used in conjunction with the spinning bowl, such as splicing, spinning with a hooked stick, spinning with grasped and sup ported spindle, and suspended spindle (Crowfoot 1931:

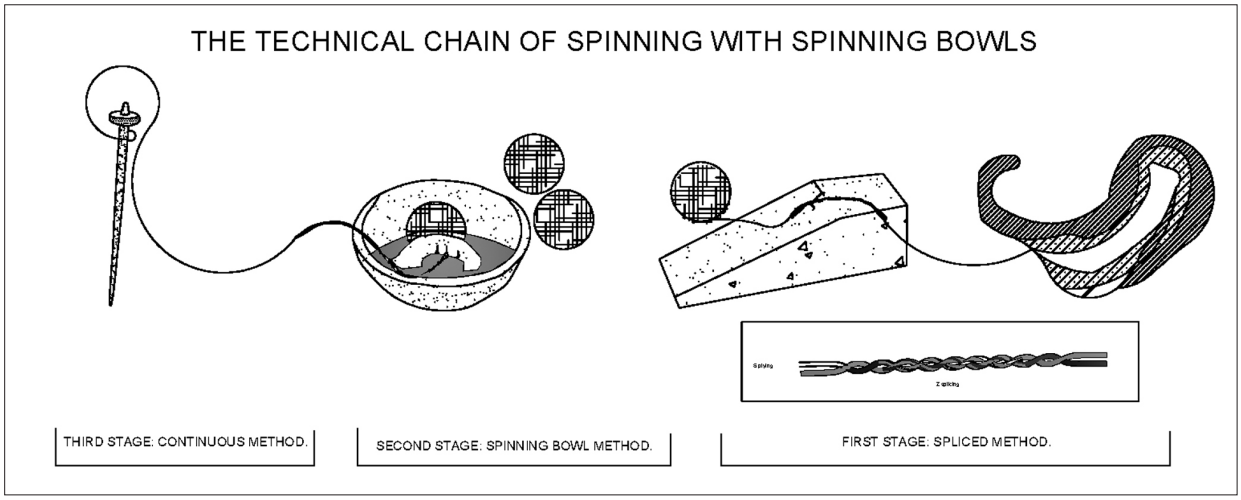

Fig. 2. Operational sequences of spinning with a spinning bowl (drawing by the author).

7–31; Barber 1991: 39, 41–50; Ruiz 2018). These techniques of creating thread are clearly confirmed in Egypt through wall paintings and models from the necropolises. They were used to achieve a linen thread of high quality (Kemp, Vogelsang-Eastwood 2001).

The present study aims at exploring the process of making a high quality linen thread by a skilled artisan. Fine properties of the yarn were possibly achieved thanks to the spinning bowl (Fig. 2). The grooves of the internal handles and the process of moistening the flax seem to be crucial, as these two techniques result in linen thread of high quality (flexibility and strength). We do not discard religious and symbolic beliefs connected to spinning that give the fabric qualities of not only extrinsic but also intrinsic character. From the above it can be concluded that this tool was essential for creation of a thread of high quality and certain characteristics that are present in textile remains from Egypt (Cooke *et al.* 1991; Hearle *et al.* 1998; Granger-Taylor 1998: 104; Ruiz 2018).

Spinning systems employed within the Castreña culture during protohistory: textile fragments of Tartessian and Semitic origin in Iberia, *fibulae*, and spinning tools in the Castreña culture

The extreme acidity of the soil in the region occupied by the Castreña culture makes it impossible to collect and study samples of textiles from this area (Santos 1984: 55; Matos 2006: 305, 319, 545). It also hinders survival of textile tools made of perishable materials, even those made of clay. Yet, the archaeological record offers us a series of materials directly or indirectly associated with textiles, such as *fibulae*, clothes pins, buttons, and Castreña iconography. The research is also aided by examining preserved textile remains of the same age but from other cultural contexts in Iberia.

An attempt was also made at identifying the social and symbolic changes, and the value of the new fashion that emerged between the Late Bronze Age and the Early Iron Age (Fig. 3).

Textile fragments of Tartessian and Semitic origin in Iberia

To understand spinning in the Iberian Peninsula better, it is necessary to describe some textile fragments coming from the cultural environment of the Castreña culture, *e.g.* the Tartessian and Phoenician necropolises. The Phoenician colonies and small settlements in Iberia were composed of Canaanite and Cypriot people who settled on the Iberian coast. The Tartessos or Tartessian culture corresponds to the autochthonous culture with a large population and pronounced cultural hybridity. It begins in the Late Bronze Age (the 9th century BC) and extends geographically to the south of Portugal and the current region of Andalusia (Spain) (Collado 2017: 22–24).

The Phoenician and Tartessian textiles preserved in tombs help visualise textile traditions in the region:

1. Semitic tombs located in Cadiz, ancient Gadir. One contained several textile fragments inside a woman's anthropomorphic sarcophagus dated to approximately the 5th century BC (Alfaro Giner 1983).

The analysis of these textile pieces shows that the deceased was buried with an outfit composed of several overlapping tunics (three or four). These tunics were made of fine s-spun linen threads in a 1/1 tabby. This spinning direction is significant, since until the arrival of the Semitic people in the Iberian Peninsula z-spun threads dominated. Dr Carmen Alfaro Giner points to the possibility that this clothing, designed and manufactured for the person for the afterlife, may have come from outside the Iberian Peninsula, given the

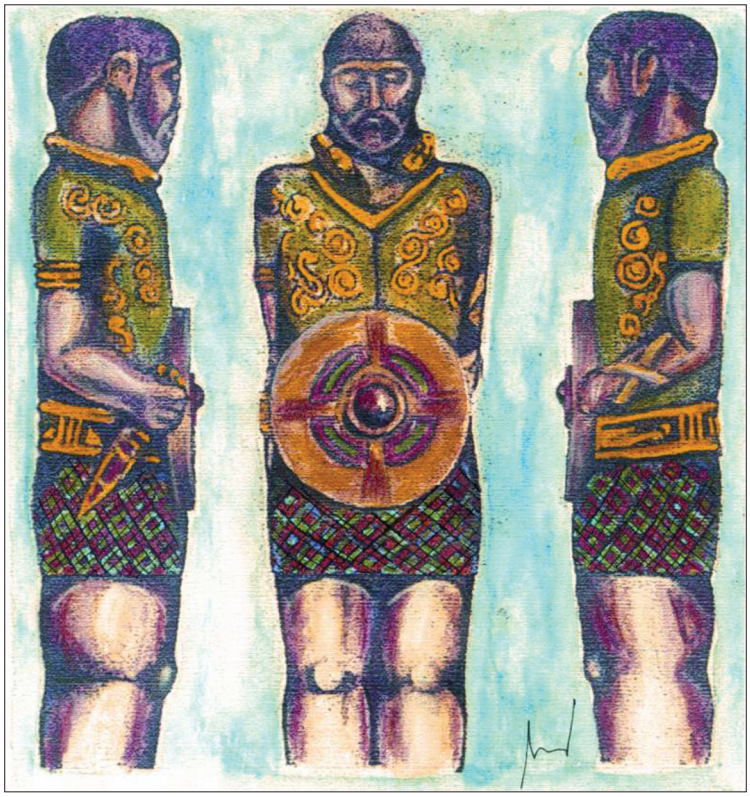

Fig. 3. Reconstruction of the clothing of a Castro warrior (Rey o 'Princeps' galaico de Lezenho, parroquia de Campos, en la Gallaecia meridional. Estatua del siglo III a.C) (by André Pena Graña).

quality of the s-spun threads. This is, however, not to totally discard the theory that these textiles might have been of local production (Alfaro Giner 1983: 281–289).

2. Tartessian tombs with textile remains, particularly those located in Seville Angorilla (Alcalá del Rio, Seville). Various carbonised textile remains have been found and dated to the 7th century BC. They comprise pleated fabrics and tapestries (Alfaro Giner 2007).

The textile remains were found by G. Bonsor in the Tartessian necropolis of Alcantarilla (Carmona, Seville). The textiles have been dated by other relics found with them, such as buttons and pieces of ivory, to approximately the 7th century BC (Alfaro Giner, Tébar Megías 2007).

The study carried out by Alfaro Giner describes two types of Tartessian textiles. The first were made of z-spun threads in a 1/1 tabby and were most likely pleated. This clearly demonstrates that the pleated vestments documented in the Phoenician iconography were introduced into the Tartessian culture. There are also representations of the pleated garments on the ivory objects form these tombs, such as combs and decorated wooden boxes for ointments and personal items (Alfaro Giner, Tébar Megías 2007: 65–66).

The other type of Tartessian fabrics demonstrates a different technique which imitates tapestries. They were made of 2S-plied z-spun yarn in a 1/1 tabby. The fabrics were made of flax, but, since they were studied under difficult conditions, it could not be conclusively excluded that animal fibres, such as wool, were also used for their production (Alfaro Giner, Tébar Megías 2007: 65–68).

These fabrics, probably of Tartessian manufacture, show how this culture adopted the technique of making fabrics that imitate tapestries and pleating, which was widely used in the Eastern Mediterranean, as well as in the Semitic and Egyptian environments. In addition, with z-spun threads (in contrast to the local tradition of making s semi-spun threads), it also exemplifies how new techniques partly integrated the traditional technology and how innovations were introduced and adopted (Alfaro Giner, Tébar Megías 2007: 69).

There is another textile fragment from the Tartessian necropolis of Angorilla (Alcalá del Rio, Seville), also studied by Alfaro Giner and dated to between the 7th and 6th century BC. The textile is in a mineralised state. Studies conducted with the SEM reveal that it is a 1/1 tabby made of s-spun linen threads of an extreme fineness (0.2–0.3 mm diameter in weft, 0.3–0.4 mm diameter in warp) and a density of 14 threads per centimetre (Alfaro Giner 2007: 1–5).

It is to be assumed that the fabrics used in the Castreña culture might have been similar to the described ones, since both cultures maintained intense commercial contacts with the Phoenicians, with whom not only goods were exchanged but also ideas, techniques, knowledge, and the artisans themselves (Naveiro 1991: 23–115; González 2011: 171–172).

Fibulae

Valuable information about textiles comes also from the *fibulae* (La Salete 1999), especially when they are analysed in a socio-economic context, delving deeply into typology, chronology, and its introduction into the Castreña culture. *Fibulae* in this period might have had a symbolic meaning, beside their purely utilitarian function and possible other uses, *e.g.* as an object of exchange or for some medical or hygienic purposes. As suggested by Maria La Salete (1999), evidence for the *fibulae* in the Iberian Peninsula is definitely an indicator of supra-regional trade between the Atlantic and Mediterranean regions and Central Europe, especially from 1250 BC to the 8th century BC. Moreover, it should be noted that the prevalence of *fibulae* in the Iberian Peninsula would have been accompanied by new styles of clothing. Initially, the *fibulae* were transmitted through trade from the Central and Eastern Mediterranean and were later manufactured locally in the Castreña culture.

Spindle whorls in the Castreña culture

Spindle whorls provide the most useful evidence of spinning techniques in protohistory. The study of these items in the Castreña culture indicates that in the areas where the use of the spinning bowl was attested, ceramic spindle whorls made *ex professo* were also found. In contrast with these fine spindle whorls, their counterparts from other areas were made of pierced pot-sherds (Rodríguez 2014: 402). Within the class of whorls made from reused ceramic, fragments of containers, plates, and other elements of domestic ware are worth noting. These pieces had undergone special treatment, *e.g.* rounding out the shape or perforation of the centre, thereby achieving optimal dimensions, shape, and weight to perform their new function. Neither the reason nor the social and technical implications are known in regard to this pan-Mediterranean tradition of recycling ceramic fragments of containers and domestic tableware as spindle whorls (Naveiro 1991: 113–114; Rodríguez 2014).

It is also noteworthy that the spindle whorls found in the same contexts as spinning bowls were made of fine clays distinct from those used in other areas. The whorls from *castros* (settlements in the Castreña culture), *e.g.* in Castro de Vigo, where spinning bowls were found as well, were also carefully manufactured.

The cultivation of flax (*Linum usitatissimum* L.) in the north-west of the Iberian Peninsula in the Late Bronze Age and the Iron Age

At present, no flax remains are known from the north-western region of the Iberian Peninsula dated to the period of the Late Bronze Age and the Iron Age. Thus, it is still unknown what type or variety of flax was used, if any. Neither is it clear what fibres were potentially used to manufacture yarns during this time and in this region.

However, the historian Pliny, who collected information on the territory of the Zoelae (Celtic tribe of Gallaecia) in the northern part of the Iberian Peninsula, left a written account that mentions flax in the area of the Roman Gallaecia, *i.e.* modern-day Galicia. Specifically, Pliny highlights the fame of the linen fabrics from this region (Pliny, NH, XIX, 10) (Naveiro 1991: 76; Alfaro Giner 1997: 22–24). There is also a mention by Strabo, who conveys information about the Lusitanos and, specifically, the inhabitants of the area along the river Douro (in northern Portugal and southern Galicia). He describes their warriors who wore shirts made of flax and also mentions the taxes collected in linen fabrics (Strabo III, 3, 5). Further evidence comes from stone sculptures that depict Iron Age male clothing. These sculptures and other archaeological findings in Galicia and northern Portugal (Arias 1984: 23–24) reveal that the people wore wool and linen clothing, following a new fashion that mixed Celtic attires with an Oriental or Mediterranean touch. Thus, they achieved an individual style, termed 'Atlantic', as indicated by the uniqueness of some geometric patterns that can be observed in the sculptures (Ruiz-Gálvez 2013) (Fig. 3). For their daily wear, the men usually wore black clothes with small cloaks; the women, light-coloured clothes with long capes. As in the surrounding cultures, clothing, social functions, rites, and festivities were inherently linked and harmonised. It is also known that both male and female warriors wore light clothing and a harness or breastplate made of linen. The king and local leaders used also knitted chainmail and helmets, *fibulae*, amulets (and glass beads), and ornamental belts of Phoenician, Celtic, and Tartessian origin (Naveiro 1991: 163; González 2011: 171–172).

Pollen diagrams from the regions of southern Galicia in Spain and northern Portugal indicate that flax was not a cultivated crop in that region in the period from 3500/3000 to 1500 BC. The absence of flax in the area is indicated not only by the lack of pollen but also by the lack of seeds and remains of other plant material from this time. We only found evidence of domesticated flax in the diagrams of pollen studies from Casim de Conimbriga (northern Portugal), a habitat within our study area (Ramil, Aira 1996: 278–279).

For the Castreña culture, pollen studies have also been undertaken at various archaeological sites of the Late Bronze Age. Surprisingly, there is no documentation in the databases of pollen extracted from *Linum usitatissimum* L., although this area possessed an extremely humid and temperate-to-cool climate during this period (González 2006–2007: 80–81).

There is evidence showing that throughout the entire Castreña culture, in the northernmost part of the studied region, Castro de Camoca (Asturias, Spain), plants of the genus *Linum* were cultivated during the 1st millennium BC, but this is far from the archaeologically-traceable distribution area of the spinning bowls. A series of pollen analyses made for this area and covering the Iron Age demonstrates that flax has been cultivated at this site from that age until the present (Barroso *et al.* 2008: 179, 183).

Analysis of the contexts of discovery of the spinning bowls in the Iberian Peninsula

The spinning bowl in the domestic context: household production

The Castreña housing architecture is very unique within the Iberian Peninsula, as it is a mixture of two cultures, the Celtic and the indigenous (Rey 1990–1991). This resulted in the emergence of fortified settlements. Inside such residential complexes there were individualised and independent domestic areas (Fig. 5). The Castreña housing consisted of four areas: the housing area itself, a separate area differentiated and compartmentalised at the entrance, another building adjoining it used for manufacturing activities and storage, and a patio.

The interior of a typical household within the entire area of the Castreña culture contains clear and repeated evidence of several types of activities, such as metallurgy, textiles, processing of agricultural products, pottery-making, goldsmithing, woodworking, *etc.* (Rey 1999: 174). These activities in the domestic space correspond to a general maintenance area (fireplace and kitchen) and a space for craft activities, such as textile production for domestic purposes or exchange, as evidenced by the presence of spinning bowls and whorls (Ayán 2001: 47).

The spinning bowl in the artisanal context: the first specialised production in Castreña workshops

Two spinning bowls were found within two large elongated structures, possibly workshops, at the site of Castro de Cossourado in Portugal, dated to between the 5th and 2nd century BC. The multifunctional buildings where these spinning bowls were found comprise a part of an artisanal area used for storage and processing of raw materials. The site consists of several buildings in close proximity to each other and at some distance from other houses within this fortified settlement (Matos 2006).

The spinning bowl in the religious context

The spinning bowl was also found in a ritual pit in Castro de Frijao. In the pit, there were deposited artefacts witnessing a religious symposium (*e.g.* a European-type bronze cauldron, tableware, and other items used in rituals) (Fontes 2013).

The spinning bowl inside this ritual pit could be connected to other sacred areas in temples, sanctuaries, or places of worship where textile tools were found. Whorls, needles, and loom weights were possibly given to the divinity as offerings or were used in rituals (Vílchez 2015).

The spinning bowl in the Roman thermae in the Roman period

There is a spinning bowl in the atrium or entrance area of a Roman public bath in Castro de Monte Padrão (Brito 2010). The location of the spinning bowl in the archaeological context suggests it may be contextualised as a part of the construction. That is to say, it might have been reused as construction material in one of the building phases. It is also possible that the portico entrance was designed for some manufacturing activities, one of which could have been spinning (Coelho 1995: 522).

Conclusions

The spinning bowl as an invention in the Castreña culture did not cross that culture's borders. We only locate this tool in other areas of the Eastern Mediterranean. There is a gap in its distribution in the Central and a part of the Western Mediterranean, as well as in Central and Western Europe.

The possibility that the spinning bowl in the Castreña culture was an innovation that was transferred through contact with Canaanite people living in Iberia should be discarded, since this tool has not been documented in Phoenician colonial contexts.

Other communities of the Iberian Peninsula did not adopt this tool as an innovation or technological loan from the Castreña area. The reason for this may be two-fold. On the one hand, older methods of spinning and fibre processing might have been maintained for symbolic or religious reasons. On the other hand, certain specialised commercial trade goods, such as fabrics with certain characteristics, made of unique raw materials, such as flax, and manufactured with specific techniques and tools, such as spinning bowls, might have been produced for exclusive markets or for craft groups that did not openly share their secrets. This may explain why the invention of the spinning bowl did not progress outside the restricted area in the Iberian Peninsula, despite being used there for more than a thousand years. The geographically and culturally restricted use of the spinning

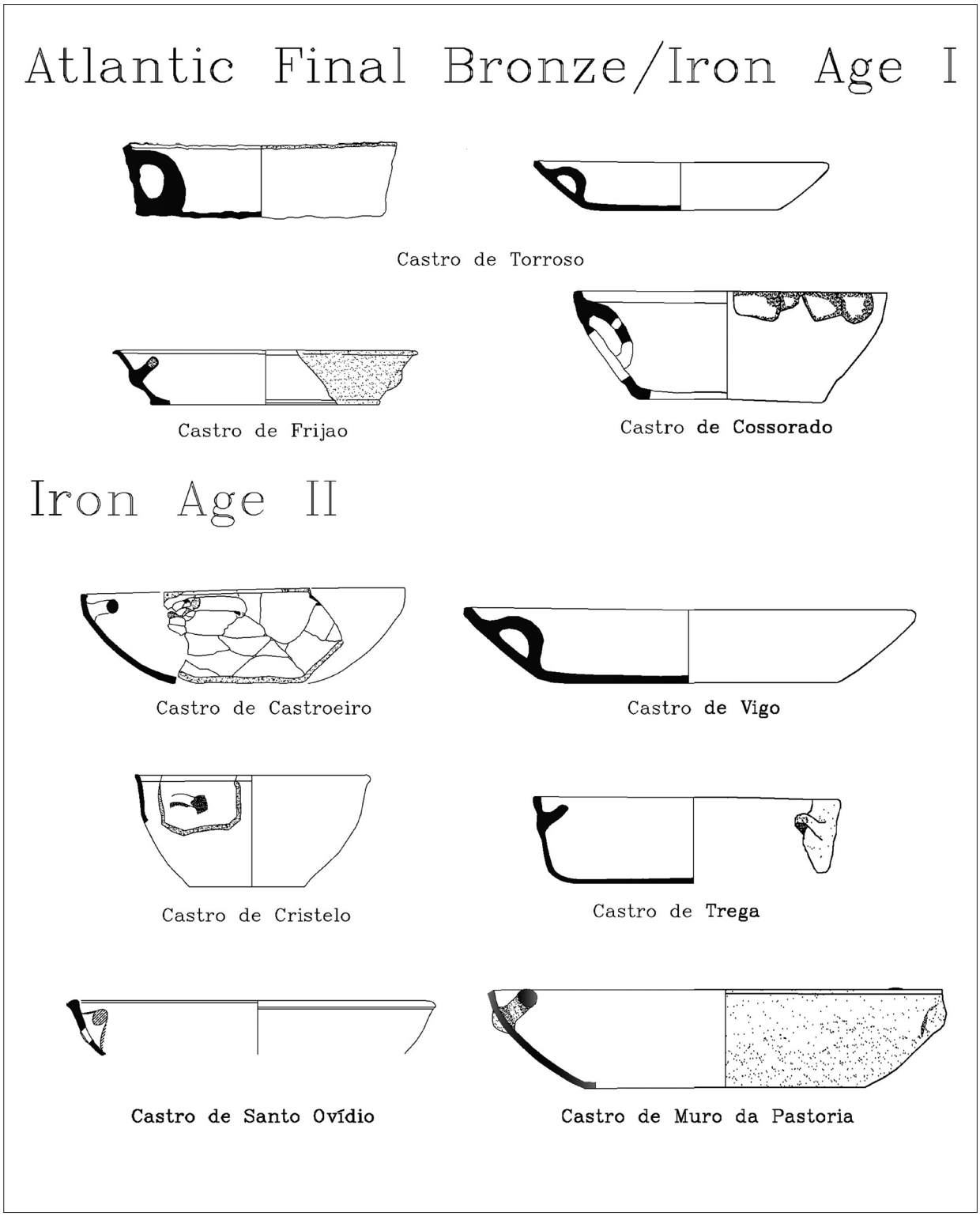

Fig. 4. Typology of the spinning bowls in the Iberian Peninsula (drawing by the author).

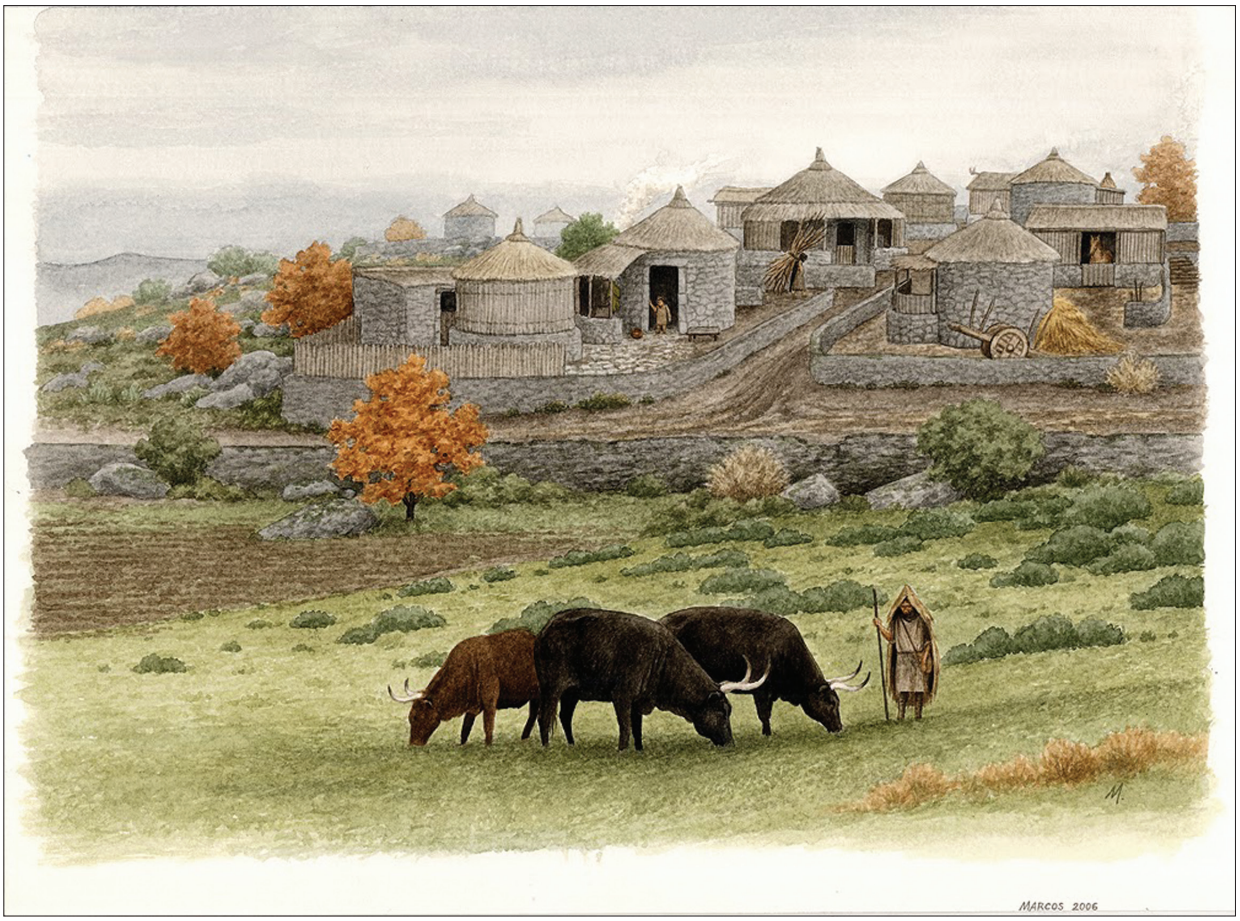

Fig. 5. Reconstruction of a Castreña habitat (watercolour by Marcos Oliveira Silva).

bowls may be associated with the use of fine spindle whorls made by professionals.

It may be suggested that the invention of the spinning bowl emerged in association with flax processing. Both the spinning bowl as a new tool for making thread and *Linum usitatissimum* L. as a new type of a cultivated textile plant gave birth to a new technological chain that expanded towards southern Galicia and northern Portugal. However, pollen analyses from this area indicate that *Linum usitatissimum* L. was absent in the Late Bronze Age and the Iron Age, *i.e.* during a large part of the time-span of the Castreña culture. Indeed, evidence of this crop has only been found in two fortified settlements. This suggests a possibility that a more diversified and specialised chain of production might have been involved and flax might have been imported as a raw material.

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Textile-impressed Pottery Revisited: Its Usefulness for Studying Bronze Age Textile Craft in Estonia

Abstract

Although textile craft is a socially complex and economically significant phenomenon, little is known about textile techniques in the Bronze Age of the eastern shore of the Baltic Sea, including Estonia. No textile or cloth remains dated to the Bronze Age, *i.e.* between 1800 and 500 BC in the Estonian context, have been found so far. Only indirect evidence such as possible textile tools and impressions on pottery can be used in the study of textile-making. The aim of the present study is to review the available evidence regarding Bronze Age pottery with patterns commonly described as made with textiles, and to systematise it. As a result, it is suggested that the evidence based on these impressions is even more limited than thought so far. Few finds clearly indicate the use of textiles. Regular patterns consisting of variously-shaped concavities on the vessels' walls may have been made also with other items, for example by rolling fir cones over the surface of a freshly-modelled pot.

Streszczenie

Odciski tekstyliów na ceramice zrewidowane. O przydatności odcisków w studiach nad rzemiosłem włókienniczym w Estonii w epoce brązu

Chociaż produkcja włókiennicza miała istotne znaczenie społeczne i ekonomiczne, niewiele wiadomo o samych technikach włókienniczych w epoce brązu na wschodnim wybrzeżu Morza Bałtyckiego, między innymi w Estonii. Do naszych czasów nie przetrwały żadne wyroby włókiennicze z Estonii datowane na epokę brązu, czyli na okres 1800–500 p.n.e. W badaniach nad włókiennictwem mogą być zatem wykorzystane jedynie źródła pośrednie, takie jak pozostałości narzędzi włókienniczych i odciski wyrobów tekstylnych na ceramice. Celem artykułu jest przegląd oraz usystematyzowanie informacji dotyczących ceramiki z epoki brązu odciskanej wzorami określanymi powszechnie jako odciski tekstyliów. Wyniki analizy pokazują, że odciski tekstylne na ceramice występują rzadziej niż sugerowano do tej pory i tylko nieliczne wzory powstały z użyciem wyrobów włókienniczych. Regularne, powtarzające się wzory utworzone przez różnego rodzaju wgłębienia na powierzchni naczyń, mogły powstawać z użyciem bardzo różnych materiałów, na przykład poprzez toczenie szyszek jodły po ściankach świeżo wymodelowanego naczynia.

Keywords: textile impressions on ceramics, textile ceramics, Bronze Age, textile technology, East Baltic

1. Introduction

No textile remains dated to the Bronze Age (1800–500 BC) have been found so far in Estonia, and textile tools of the period are also rare in archaeological collections. Most numerous finds that could be related to textile-making are bone needles (Lang 2007: 139). No other tools (*e.g.* spindle whorls) dated undoubtedly to the Bronze Age have been found (Vedru 1999: 109; Lang 2007: 137). So far, it has been claimed that the imprints on the ceramic vessels are the main evidence for textile production in the Neolithic and Bronze Age in present-day Estonia. The starting point for the study was to collect more information about textile techniques.

Therefore, the main emphasis was put on a more in-depth analysis of the textile impressions on vessels in order to acquire information about textile types used. In the course of the study, the focus shifted as it became clear that the regular patterns labelled as textile impressions were in fact not always made this way. Moreover, 'textile ceramics' as a phenomenon is not uniform and various different pattern groups can be distinguished. Were the imprints really made with textiles, *i.e.* products of fibrous raw material? How to distinguish between different patterns? How much can we still detect on the basis of these imprints about the textiles used?

The custom of finishing the surface of a pot with textile impressions has been a widespread phenomenon both in time and space (*e.g.* Drooker 2000; Özdemir 2007; Alipour *et al.* 2011; Mazăre 2011; Doumani, Frachetti 2012; Schaefer in this volume). Regular patterns resembling textile impressions were also common on Neolithic and Bronze Age pottery in the vast area of the north-eastern European forest zone (*e.g.* Lavento 2001: 20–43; Lang 2007: 128). Since the end of the Neolithic (*c.* 2700 cal BC), various pottery types have been thought to be related to this surface finishing tradition also in Estonia (Kriiska *et al.* 2005: 5; Lang 2007: 126–136). As the so-called textile impressions were used on various ceramic types and together with other treatments (striating, smoothing, and cord impressions), I define this custom as one of the possible finishing treatments of ceramics and do not use the term 'textile ceramics' (Lang 2007: 126). The custom disappeared in northern and western Estonia during the middle of the Pre-Roman Iron Age but prevailed in south-eastern Estonia until the advent of the Migration Period approximately in 500 AD (Lang 2007: 126).

Researchers have paid little attention to the textile impressions as a possible source of knowledge about textile technology in Estonia. However, it has been a focus of two previous studies by Silvia Laul and Jüri Peets (Laul 1966; Kriiska *et al.* 2005: 18–25, respectively). Both assume that the textiles used to make these impressions were made primarily from plant fibres and the main technique was plain weave, often with repp character. Also *nålebinding* technique was mentioned (Kriiska *et al.* 2015: 24). For the present study, especially enlightening were the experiments that had been carried out on the basis of similar potsherds found in Latvia and the Volga-Oka region (D'yakovo culture) (Dumpe 2006; Lopatina 2015, respectively).

2. Finds

For the present study 170 sherds with impressions were analysed; 12 of them were too vague to allow for a further study and were left out (Tab. 1). As the Bronze Age was in focus, the study was based on the sherds from three settlements dated to the period: Asva (Fig. 1.1), Ridala (Fig. 1.2), and Iru (Fig. 1.3). The majority of the analysed finds come from Asva; a selection from other sites allows for a comparison and pointing out general trends. The finds are roughly dated to the beginning of the 1st millennium BC, *i.e.* the Late Bronze Age in the Estonian context (Sperling 2014: 219). According to Valter Lang, the sites listed above belong to a group called 'enclosed settlements' (or 'fortified settlements'), because all these sites were separated from the rest of the landscape by natural or modest man-made fortifications (Lang 2007: 55). It has been suggested that the inhabitants of the sites occupied themselves with, among other activities, importing, reprocessing, and distributing metal (Lang 2007: 71).

'Textile impressions' occur on coarse ware, mainly pots, modest in terms of quality and meant for storage and food preparation (Lang 2007: 126; Sperling 2014: 217). The vessels were presumably modelled, as previously, by using the coiling technique (Kriiska *et al.* 2005; Lang 2007: 126; Sperling 2014: 199–205). 'Textile-impressed' ware was not very common; for example, less than 5% of the whole ceramic assemblages in Asva and Ridala were finished in this technique (Sperling 2014: 216). The 'textile impressions' were used together with other finishing methods, such as smoothing or striating (Lang 2007: 126). Mainly the exterior surfaces were covered with impressions, but occasionally bottom parts with a textile pattern occurred as well. Imprints would sometimes cover the entire walls of the pots, although more often they would reach as far up as the carina or the neck. The upper parts of the pots were frequently decorated with a row of circular pits or an impression of a cord.

3. Methodology

One of the main aims was to detect how and with what tools the patterns were made, and, therefore, the methodological focus was on a close study of selected samples. After a preliminary study and description of the patterns and their components, 158 sherds were divided into six typological groups (Tab. 1). After that, 32 samples were chosen for making casts and thorough microscopic studies (Tab. 2). Casts were made with the help of a modelling clay 'Sculpey Original' that was easy to use, so that the casts were detailed enough to enable an in-depth study. Moreover, after firing the casts, it was possible to preserve them for further research. However, a serious negative side-effect was contamination of the original sherds and, occasionally, oily stains on the surface.

A stereomicroscope (Nikon SMZ 1000) with up to 80× magnification was used. The main aim of the

Tab. 1. Distribution and types of impressions. Type 1 – tabby textile; type 2 – putative cord patterns; type 3 – round, oval, or rhomboid pits; type 4 – wavy diagonal rows; type 5 – sharp notches; type 6 – wedge-shaped grooves.

Site	No. of sherds	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Asva	136	3% (4)	16% (22)	36% (49)	32% (44)	11% (15)	2% (2)
Ridala	10	0	0	100% (10)	0	0	0
Iru	12	8.3% (1)	0	75% (9)	8.3% (1)	0	8.3% (1)
Total	158	3% (5)	14% (22)	43% (68)	28% (45)	10% (15)	2% (3)

Fig. 1. Location of the settlement sites mentioned in the text: 1 – Asva, 2 – Ridala, 3 – Iru (drawing by R. Rammo).

microscopy of the original finds was to describe particular elements of the regular patterns – shape and bottom of the concavities – to find traces of fibrous structures left by the presumed use of yarn. Another task was to detect two different yarn systems indicating possible weaving or braiding. Secondly, the casts were studied as well, and the results were examined side by side with the original finds. It is important to compare positive casts with original negative impressions to exclude possible errors caused, for example, by two different finishing treatments following each other. For example, the surface was sometimes striated after making the 'textile pattern' causing false impression of two alternating yarn systems on the cast.

4. Identified impression types

The phenomenon referred to by other researchers under a broad term 'textile impressions' actually incorporates various types of patterns on pottery. A common trait in describing them all is a certain regularity: systematically placed, small concavities of various shapes, such as narrow and steep slots or round, oval, and rhomboid pits. In the course of the present analyses, it became clear that it is rather hard to relate these patterns to particular textile structures. While comparing with examples showing clear and easily-identifiable textile impressions known from other cultures (*e.g.* Alipour *et al.* 2011; Mazăre 2011; Doumani, Frachetti 2012), doubts arose whether textiles

Tab. 2. The catalogue of finds chosen for making casts and microscopic study.
AI – Tallinn University, Archaeological Research Collection

Site	Cat. no.	Width 1 (mm)	Width 2 (mm)	Thickness (mm)	Type in the text
Asva	AI 3307: 172	48	40	11	2
Asva	AI 3307: 221	33	26	11	2
Asva	AI 3307: 318	61	38	12	2
Asva	AI 3307: 319	61	56	14	3
Asva	AI 3307: 319	40	35	10	2
Iru	AI 3428: 493	82	65	9	6
Iru	AI 3428: 630	30	26	8	3
Iru	AI 3428: 829	48	33	8	3
Iru	AI 3428: 1199	107	93	15	1
Iru	AI 3428: 1223	63	44	10	3
Iru	AI 3428: 1223	30	26	9	5
Iru	AI 3428: 1272	68	56	10	4
Asva	AI 3658: 328	44	36	10	3
Asva	AI 3658: 461	75	75	9	4
Asva	AI 3658: 561	60	51	14	3
Asva	AI 3658: 661	38	37	9	2
Asva	AI 3658: 670	44	33	11	3
Asva	AI 3799: 262	53	50	8	4
Asva	AI 3799: 378	40	35	12	3
Asva	AI 4012: 300	28	27	9	5
Asva	AI 4012: 317	33	27	8	4
Asva	AI 4012: 325	36	26	7	6
Asva	AI 4012: 347	47	45	10	4
Asva	AI 4012: 350	45	30	8	3
Asva	AI 4012: 356	65	52	8	5
Ridala	AI 4261: 20	42	35	10	3
Asva	AI 4366: 105	34	32	6	3
Asva	AI 4366: 312	92	67	13	3
Asva	AI 4366: 527	125	104	10	4
Asva	AI 4366: 557	144	120	20	1
Asva	AI 4366: 1512	79	65	13	3
Asva	AI 4366: 1789	70	62	12	3

were used to make these patterns. Not all patterns were made with textiles – actually only a few imprints were undoubtedly produced this way.

It seems that in the case of the Estonian samples, the pattern itself was not of a great importance because often the surfaces covered with impressions were carelessly smoothed or striated afterwards; occasionally, the imprints have even been entirely removed (*e.g.* Sperling 2014: 221). The main aim was probably to achieve a particular finishing of the pots' walls. It has been suggested that complex imprinting helped to weld clay surface together and to reduce irregularities (*e.g.* Holmes 1901: 400–401). The fact that the bottoms and the walls have been treated in different ways (see below) indirectly supports the functional purpose of the finishing against its purely aesthetic meaning.

A microscopic examination of the traces on the vessels' walls did not unambiguously prove that impressions were made by simply pressing a piece of textile against still pliable clay. Judging from the overall scratches on the surfaces, repetitions of the structures, and the runs of different pattern patches that occasionally change directions, it seems that the patterns resulted rather from rolling an item resembling a roulette over the surfaces of the modelled pots. This assumption has been confirmed by experiments made by various researchers (*e.g.* Dumpe 2006; Lopatina 2015).

4.1. Tabby textiles (type 1)

Only one of the analysed impressions was definitely made with a woven fabric. The sample has clearly two basic sets of threads – warp and weft – and it represents a textile woven in the tabby weave (Fig. 2). Four more finds (AI 3428: 1199; AI 3658: 250, 718f; AI 3994: 601) bear traces that could have been made with a tabby textile, but the imprints are not clear enough to allow for a final conclusion. It is noteworthy that all imprints indicating tabbies are preserved on the bottoms of the vessels. Therefore, it is plausible that during the shaping process the bases of the pots were placed on surfaces covered with woven cloths or plaited mats. The weave of the first and the clearest of the said impressions seems to be well balanced with a count of approximately six threads per cm in both systems. The twist direction is z in the former and s in the latter system. The estimated thread diameter ranges between 1.0 and 1.4 mm. The other four textile imprints indicate a similar textile type: *c.* 3–5 threads per cm and a yarn diameter of between 0.7 and 1.8 mm. It seems that most common was the z-spun yarn in the first and s-spun yarn in the second system. However, it is rather difficult to prove that only single yarns were used; the yarns could have been also plied. Tabby textile fragments with similar technical characteristics have been found, for example, in contemporaneous sites in Scandinavia (*e.g.* Franzén *et al.* 2012: 353; Mannering *et al.* 2012: 97).

4.2. Putative cord patterns (type 2)

Another type of impressions (14%), which was found only on the outer surfaces of the vessels' walls, consists of relatively narrow furrows that often have remarkably steep walls and sharp ends (Fig. 3). The furrows are in rows that are often clearly separated from each other. The ends of the furrows are more or less overlapping. The bottoms of the furrows sometimes bear a pattern of diagonal lines indicating the possible twist direction of a spun thread, although sometimes it is missing and instead the bottom is even or covered with mottled relief. The casts made from those sherds show rows which may at least partly belong to loosely

Fig. 2. Tabby imprint on the bottom of a coarse-grained vessel from Asva (AI 4366: 557) (photo by J. Ratas). The microscopic photographs of the imprint and the cast (8×) (photos by R. Rammo).

Fig. 3. Imprint of a pattern consisting of narrow furrows, possibly made with double-twisted cords (Asva, AI 3307: 172) or eaten fir cone carinas (photo by J. Ratas). The microscopic photographs of the imprint and the cast (8×) (photos by R. Rammo).

twisted two-ply cords. Baiba Dumpe (2006) has suggested on the basis of similar Latvian finds that the cord was wound around a stick and rolled over the surface of a pot. Another explanation for making these patterns is offered by Olga Lopatina (2005), whose experiments showed that fir cones, chewed by rodents or squirrels so that only carinas without seeds and scales are left, rolled over the clay can produce very similar traces.

4.3. Regular pattern of round, oval, or rhomboid cavities (type 3)

The most common pattern (43%) on the vessels' walls were close-set diagonal rows of round, oval, or slightly rhomboid shallow pits (Fig. 4). The diameter of these concavities was *c.* 2–4 mm. Another common trait was that the pits were deeper and steeper on one side and, therefore, sometimes the pit was more similar to a crescent. Usually, the pattern was very regular and concavities were placed densely. Nevertheless, sometimes the pits were organised in diagonal rows slightly apart from each other. No traces of a second yarn system (*e.g.* warp or weft) indicating twined or woven textile have been recorded.

The bottoms of these pits were mostly very smooth and without a fibrous pattern characteristic for spun yarns. Obviously, it is not a question of preservation, such as abrasion or wearing off. At least in one case, on the same sherd as pits, a single fine groove ran around the rim, and judging from the well-preserved diagonal lines on its bottom it had been clearly made with a single s-spun yarn.

At the present stage of research, no final conclusions can be made regarding the tools used to make such patterns. The most widespread interpretation is that the finishing treatment involved using a textile item either in the

Fig. 4. Imprint consisting of oval pits with even bottoms (Asva, AI 4366: 1789) (photo by J. Ratas). The microscopic photographs of the imprint and the cast (8×) (photos by R. Rammo).

twining technique or tabby weave of a repp character, in which one system is dominant and covers the other entirely (*e.g.* Laul 1966; Kriiska *et al.* 2005: 9–11). The second possibility could be rolling the cord over the pot surface (Dumpe 2006). Lastly, the possibility that similar impressions were not made with textiles but with some kind of stamps has also been suggested (*e.g.* Carpelan 1970).

Considering the possibility that these imprints were made with textile items, the smooth bottoms of the pits need explanation. It is possible that the raw material was not a fibrous spun thread but rather something wide and smooth. Therefore, also interpretations other than textiles should be considered in further studies and experiments. Once again, fir cones can be mentioned as a possible solution, only this time whole and fresh specimens. However, fir cones' scales admittedly bear a characteristic pattern which is not visible on the studied items.

4.4. Other types of impressions on the vessels' walls

Out of 45 cases (28%; type 4), a single element of the wavy diagonal row had an arched shape which to some extent resembled traces made by fingernails. Another characteristic of these elements were double grooves (Fig. 5; see also Lopatina 2015: 166). Similar imprints on sherds have been interpreted as left by a textile made with the *nålebinding* technique (Kriiska *et al.* 2005: 20, Fig. 20; Sperling 2014: 218, Fig. 87). Lopatina convincingly showed that a very similar pattern could be produced with fir cones, whose scales and seeds had been partly removed (Lopatina 2015: Fig. 2; *cf.* Kriiska *et al.* 2005: Fig. 12).

Fifteen sherds were covered with a fine net of notches and grooves (type 5; Fig. 6). A common trait were two parallel furrows that ended with a crossing notch. It is possible that these imprints were made with so far unidentified textile items because the grooves and notches can be interpreted as two different textile systems. However, probably it is possible to produce this kind of pattern also with items not made of textiles (*cf.* Lopatina 2015). Three specimens of 158 sherds (type 6; AI 3428: 493; AI 4012: 299, 325) had regular patterns of sparsely placed wedge-shaped grooves with steep walls and even bottoms that most likely had nothing to do with textiles.

5. Conclusions

The results of this preliminary study show that, contrary to a common scholarly assumption, only few impressions can undoubtedly be considered as made with textiles. Thus, the studied impressions on clay do not reveal much about textile techniques used in the Bronze Age. However, some conclusions can be pointed out. The few imprints actually made with tabby textiles, cords, and yarn are still almost the only and crucial evidence of cloth-making in the Bronze Age settlement sites of the region. The textile imprints do not allow for ascertaining what kinds of raw materials were used in textile production. Mostly, it has been suggested that these textiles were made of plant fibres such as tree bast or nettle, although wool cannot be totally excluded either (Kriiska *et al.* 2005: 24). It is clear that both s- and z-spun yarns were known, and plied cords were obviously produced as well. As the spindle whorls were not common until the Iron Age in Estonia, it is impossible to deduce how the yarns and cords were made. Obviously, it is possible to spin with a whorl of a perishable material or use a simple stick instead. Nevertheless, the relatively finely

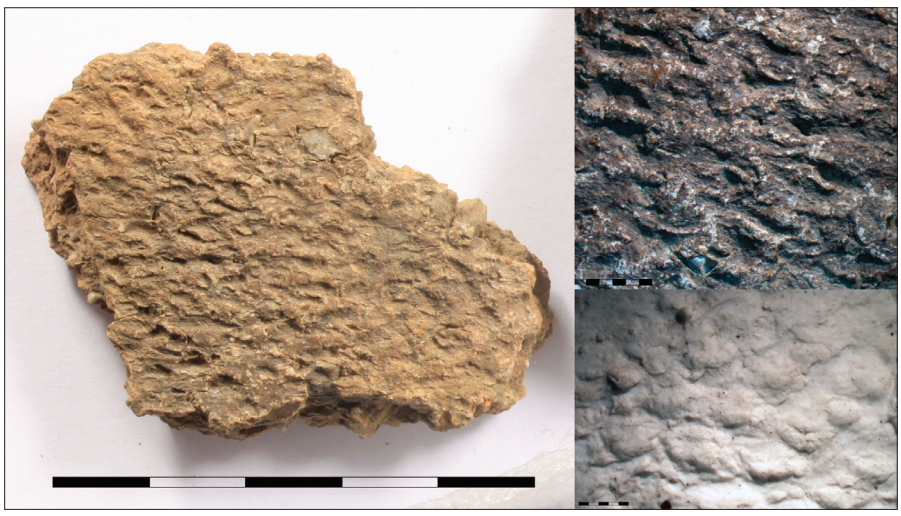

Fig. 5. Imprint of type 4 (Iru, 3428: 1272) (photo by J. Ratas). The microscopic photographs of the imprint and the cast (8×) (photos by R. Rammo).

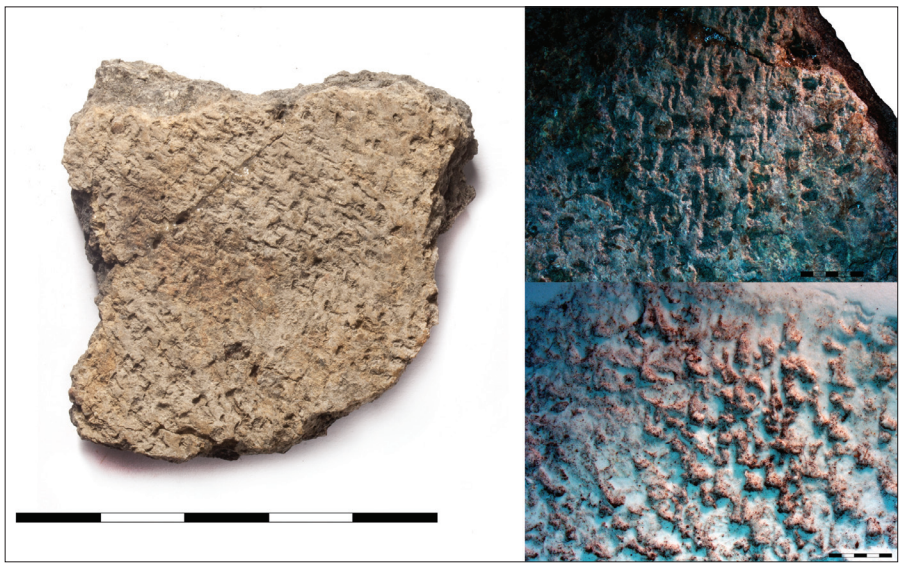

Fig. 6. Imprint of type 5 (Asva, AI 4012: 356) (photo by J. Ratas). The mircroscopic photographs of the imprint and the cast (8×) (photos by R. Rammo).

balanced tabby proves that looms and weaving were known, although considering the knowledge about textile production in the neighbouring areas, for example in Scandinavia (*e.g.* Franzén *et al.* 2012: 353; Mannering *et al.* 2012: 97), there was no reason to doubt it even earlier. Numerous bone needles may indicate that various netting and twining techniques were used as well, but such textiles were not used in ceramic production.

It seems that the aim of making the impressed patterns was mainly functional. Distinct impressions on the bottoms and the walls indicate different steps in pottery production. A tabby cloth or mat was used for covering the surface on which the vessel's bottom was formed, probably to prevent the clay from sticking. The finishing of the surfaces of vessels' walls with concavities might have been used to make clay more durable. Nevertheless, if one assumed that imitating textile structures with other tools was indeed the intention of ancient potters, a symbolic meaning of these imitations cannot be excluded either.

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A Comb or a Loom? An Attempt at Interpretation of the Szemud Urn Image

Abstract

Combs belong to characteristic motifs appearing on face urns from the Pomeranian culture. They are usually presented in the simplest way – in the form of several vertical lines coming from one horizontal line situated mostly in the central part of the urn. Archaeologists studying the Pomeranian culture accept an interpretation that all images comprised of vertical lines are combs (Dzięgielewski 2007: 183). The article presents another way of interpreting the engraving from the Szemud urn which has been assumed to depict a comb. As it has been discussed, both the image itself (extremely long comb teeth) and the structural position of the image (directly under a face image) are not typical. The author suggests that it is rather a depiction of a vertical warp-weighted loom, as evidenced by other images known from Europe (*e.g.* Sopron, Bologna) dated to the Late Bronze Age and Early Iron Age.

Streszczenie

Grzebień czy krosno? Próba interpretacji przedstawienia na urnie z Szemudu

Grzebienie należą do jednych z najbardziej charakterystycznych motywów pojawiających się na urnach twarzowych kultury pomorskiej. Zazwyczaj są przedstawiane w najprostszy sposób – w postaci kilku lub kilkunastu pionowych linii odchodzących od jednej linii poziomej. Najczęściej znajdują się w środkowej części urny. Archeolodzy badający kulturę pomorską przyjmują tę interpretację, w związku z czym wszystkie ryty na urnach złożone z pionowych linii uważane są za grzebienie. W artykule zaproponowano inną możliwą interpretację przedstawienia na urnie z Szemudu, które wcześniej rozpatrywane było jako grzebień. W innych publikacjach zauważono, że zarówno samo przedstawienie (wyjątkowo długie zęby grzebienia), jak i jego położenie (bezpośrednio pod wyobrażeniem twarzy) są nietypowe. Autorka sugeruje, że jest to przedstawienie pionowego krosna ciężarkowego. Przekonanie to poparte jest innymi przedstawieniami pionowych krosien, zidentyfikowanych na różnych zabytkach archeologicznych znanych z Europy (np. Sopron, Bolonia), datowanych na późną epokę brązu i wczesną epokę żelaza.

Keywords: Face urns, vertical loom, Pomeranian culture, Early Iron Age

Introduction

The Szemud hamlet is situated 14 km south from Wejherowo, on the Gościęcino River (Dobrogowski 1949: 299). Archaeological explorations were performed there nearly 80 years ago (between 1936 and 1938) and were supervised by Z. Zakrzewski. Two burial grounds from the Pomeranian culture with a total of 21 cist graves containing face urns were excavated then. They were both single and family graves, with the oldest burials dating to Hallstatt C (*c.* 650 BC) and the majority – to Hallstatt D (*c.* 450 BC) (Dąbrowski 2009: 17). The latest burials were dated to the early La Tène period (Dobrogowski 1949: 314). The present paper

discusses one of the urns excavated in the Cemetery II, which is currently kept in the District Museum in Toruń, with a signature no. A/1505. The urn was reconstructed some years ago (empty spaces were filled with plaster). In the author's opinion, the engraving made on the urn (under the schematically sketched face) can be an image of a vertical warp-weighted loom. Since the author has specialised for some years in the textile manufacture of communities of the Late Bronze Age and Early Iron Age on the Polish territory (she is also skilled at weaving and spinning), it was evident for her, judging from the appearance of the urn picture, that this image showed a vertical warp-weighted loom. Such interpretation becomes even more convincing when the picture is compared with other images of vertical looms coming from the south of Poland (Grömer 2016: 110). Although these images occur rarely, they are similar and each of them contains the most characteristic elements of the vertical looms. To understand the archaeological object's context and images placed on them, it is necessary first to present some information concerning the Pomeranian culture and the phenomenon of the face urns.

Current state of research on face urns

The Pomeranian culture (also called the Face Urn culture or the East Pomeranian culture) developed within the territory of present-day Poland between the 7th and 3rd century BC, originating from the Lusatian culture, in the area of the Vistula and the Parsęta rivers basin, and expanding further to the south. This culture is characterised by burials in urns with face images on them. The urns were placed in cist graves (hence its another alternative name – the 'Cist-graves culture'). Pictures engraved on urns represent not only faces themselves but also hunting scenes, chariots and riders, animals (rare motifs of deer, horses, cows, and birds), weaponry (spears and shields), as well as clothing accessories, such as pins, clasps, belts, necklaces, and combs. Aleksander Kwapiński (2005: 307–314) tried to systematise all the images and also indicated that particular types of images were placed in defined urn sectors, *e.g.* necklaces, breastplates, and pins were usually placed on a vessel's neck or its base, while figurative scenes appear only in the upper urn part (Kwapiński 2005: 315).

Distribution of the face urns around such a vast area – Germany, Denmark, Poland, Sweden, Norway, and Italy – indicates intensive interactions between populations inhabiting the lands listed above. Figurative images appear on urns dated to the Hal C-La Tène A (650–400 BC), according to the Central-European chronology (Kniesel 2016: 393). The majority of the face urns (*c.* 3000) were excavated in Poland, in the cemeteries of the Pomeranian culture (Kniesel 2016: 406). Urns from Poland have more complex faces with clearly outlined elements, like mouth, chin, ears, or eyes. Jutta Kniesel (2016: 404) remarked that face urns occur in territories rich in natural resources, such as salt and amber. Moreover, objects imported from the south have been registered in Central and Northern Europe, which leads to a conclusion that they witness existence of regional centres, which contacted with one another over long distances (Kniesel 2016: 405), and trade routes, which served not only for transporting luxurious commodities and raw material but also some particular ideas.

The Face Urn culture has been fascinating archaeologists for decades. Face images and compositions consisting of various pictures engraved on them were subjects of particular interest to researchers *(e.g.* Łuka 1978; Kowalska 1998; Kwapiński 1993; 1998; 2003). Much attention was paid to the problem of the symbolism of the faces. First, they were interpreted as images of persons buried in particular urns, which cannot be true since there are numerous cases where several individuals had been buried in one urn (Kowalska 1998: 41). A face may rather be a symbolic human model (Kowalska 1998: 42). The question of interpretation of iconography of the urns is still open.

Generally, the majority of publications concerning the Pomeranian culture concentrate on collecting and typologically ordering all the groups of images. Therefore, there are works registering representations of weapons (Fogel 1980), shields (Bukowski 1971), chariots (Kwapiński 1993), animals (Sylwestrowicz 1979), earrings (Andrzejowska 1981), clasps (Gedl 1993), necklaces and breastplates (Kamińska 1992), and combs (Dzięgielewski 2007). There were also attempts at correlating particular images (breastplates, shields, or pins) with archaeological gender indicators (such as *e.g.* earrings) and anthropologically defined gender of the buried individuals (Malinowski 1966). However, these studies have not brought any definite answers. The burial rite of the Pomeranian culture itself was a subject of interest as well (*e.g.* Malinowski 1966; Kowalska 1998; 2003; 2005; Woźny 2000). Pomeranian urns were also a subject of philosophical debates on how archaeologists perceive symbols and objects (*e.g.* M. Kwapiński 2000a; 2000b; Woźny 2001).

The urn from Szemud

The present contribution discusses the urn from Grave I, Cemetery II. It was a single grave containing one pear-shaped urn with polished walls in brownish/orange colour (Fig. 1.A). A roughly-sketched face (on side A) consisting of ears and a nose was depicted on it. Each of the ears had three holes with bronze rings. The grooves situated under the sketched face were components

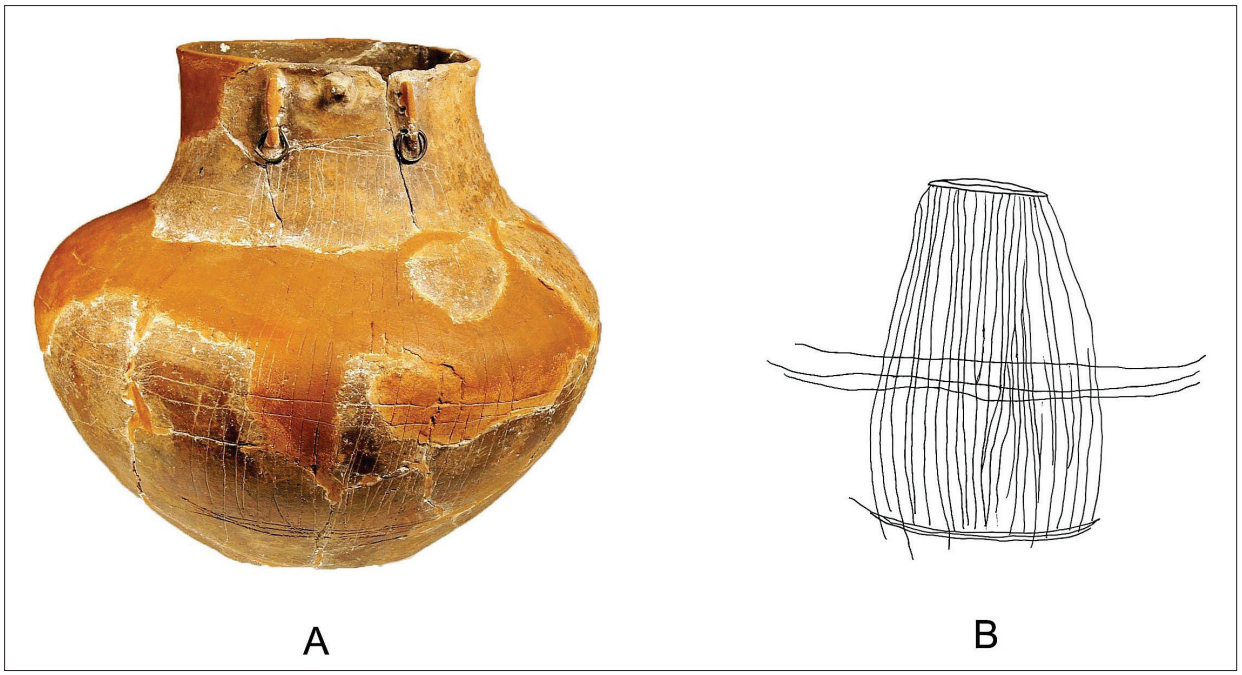

Fig. 1. A – reconstructed urn from the District Museum in Toruń (photo by M. Przymorska-Sztuczka); B – engraving on the urn (drawing by M. Przymorska-Sztuczka).

of a single image. There were between 21 and 24 lines engraved vertically. At each end, they were framed by three horizontal lines. In the middle, three longer vertical lines were carved around the urn. The whole image was trapezoidal in shape (Fig. 1.B). Three vertical lines situated on side B were separate engravings not belonging to the described image. The urn contained bones of an adult individual arranged in the anatomical order. The skull area contained a find of a triangular iron pendant. The urn was preserved in fragments and only its drawing reconstruction has been published so far (Kwapiński 1999) (Fig. 2.B). The first photograph of the urn after its conservation and reconstruction is published in the present article (Fig. 1.A).

In the literature, the imagery of the Szemud urn is described as four separate elements. The first one, situated under the schematically sketched face (side A), is described as a comb – "ryt złożony z 3 kresek poziomych i odchodzących od nich 20-21 kresek pionowych o niespotykanej, w przypadku wizerunków grzebieni, długości; ryt umiejscowiony na szyi urny twarzowej w miejscu ust (umiejscowienie rytu jest także nietypowe)"[1] (Dzięgielewski 2007: 203). On the belly of the vessel, there are three grooves running around, which were interpreted by M. Kwapiński as a breastplate (1999: 177). However, the images of breastplates and necklaces are usually located higher, in the upper part of vessels' necks. Below the image, on the urn's neck in the bottom part, there is the last image – a rectangular figure filled with vertical lines (Dobrogowski 1949: 306; Kwapiński 1999: 177). On the opposite side (B) from these images, there are three short vertical grooves (Kwapiński 1999: 177).

The description of the urn and the drawing from Dobrogowski's article (Fig. 2.A) differ significantly from the descriptions quoted in the later publications (Dobrogowski 1949; Kwapiński 1999; Dzięgielewski 2007). Dobrogowski does not mention any lines surrounding the entire urn, although they are clearly marked. Moreover, the older drawing presents the image only in the upper urn section, while in the later publications (Fig. 2.B) it occupies practically all the vessel's height (Kwapiński 1999: 177). Drawing reconstruction of the urn from Szemud in Dobrogowski's article is too schematic and figures are inappropriately located.

What may be the reasons for these differences in presenting the same object? Facing so many doubts and various descriptions, the author decided to examine the problematic item by herself. On the reconstructed

[1] In author's translation: "the engraving consists of three horizontal lines and 20–21 vertical lines coming out of them, with lengths unusual for comb images; the engraving is situated on the urn's neck, in the place of a mouth (the location is also unusual)".

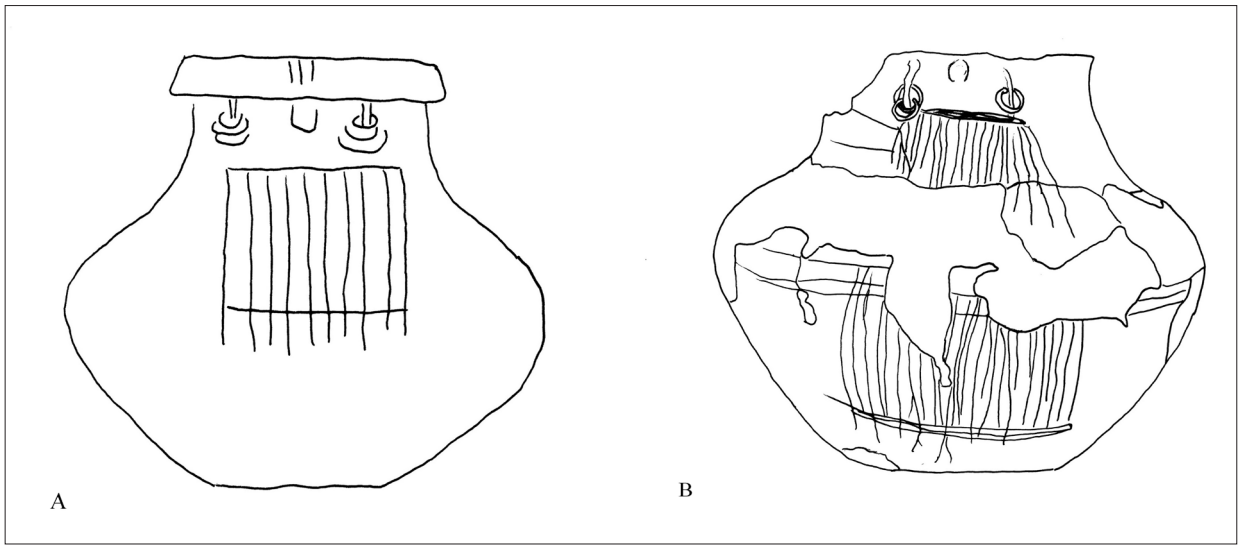

Fig. 2. A – urn from Szemud after Dobrogowski (1949: Fig. 13.2); B – after Kwapiński (1999: Tab. CLXXXVI).

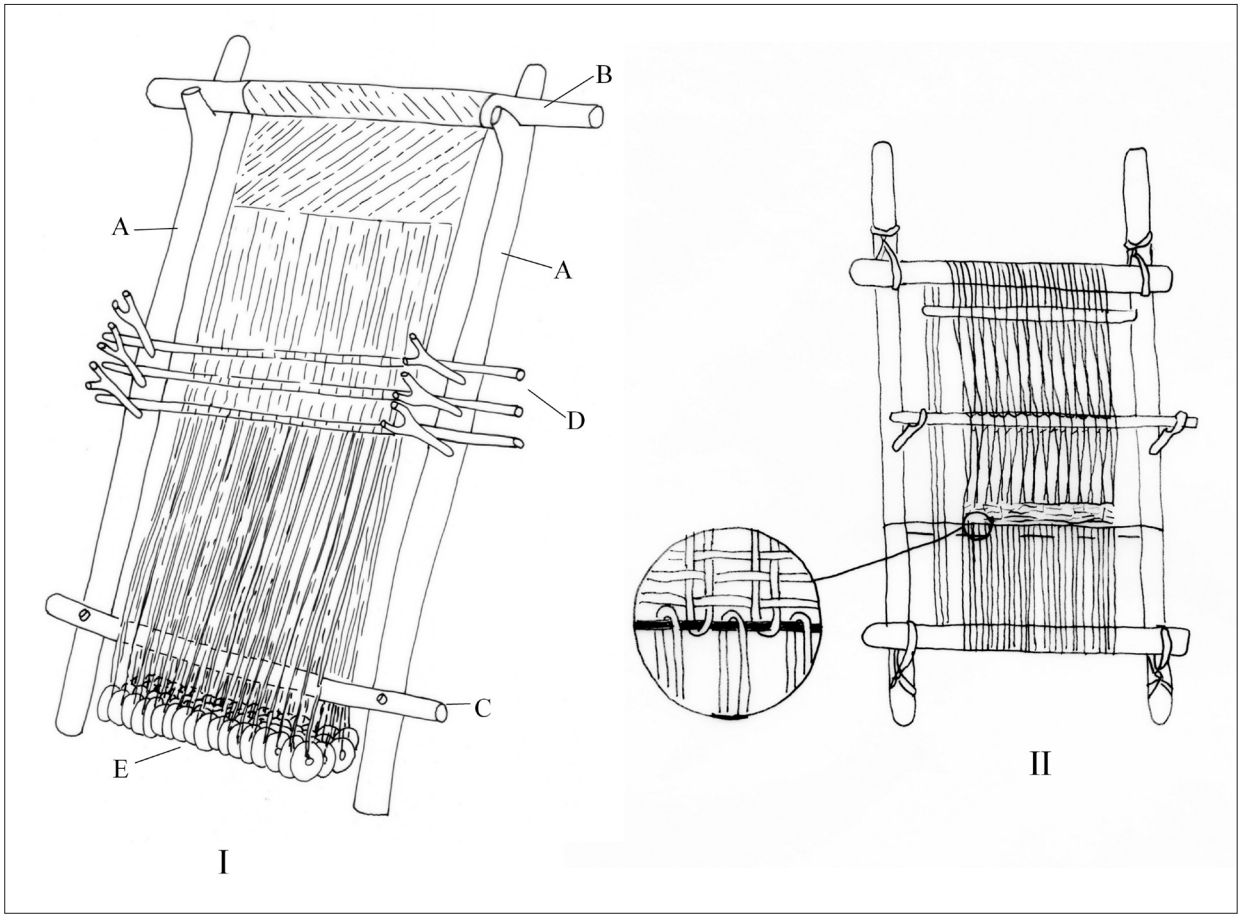

Fig. 3. I – scheme of the vertical warp-weighted loom (drawing by A. Jeppsson, Centre for Textile Research, University of Copenhagen, https://commons.wikimedia.org/wiki/File:Warp-weighted_loom_twill.jpg, accessed 1.12.2017); II – scheme of the two-beam vertical loom (after Grömer 2016: Fig. 79).

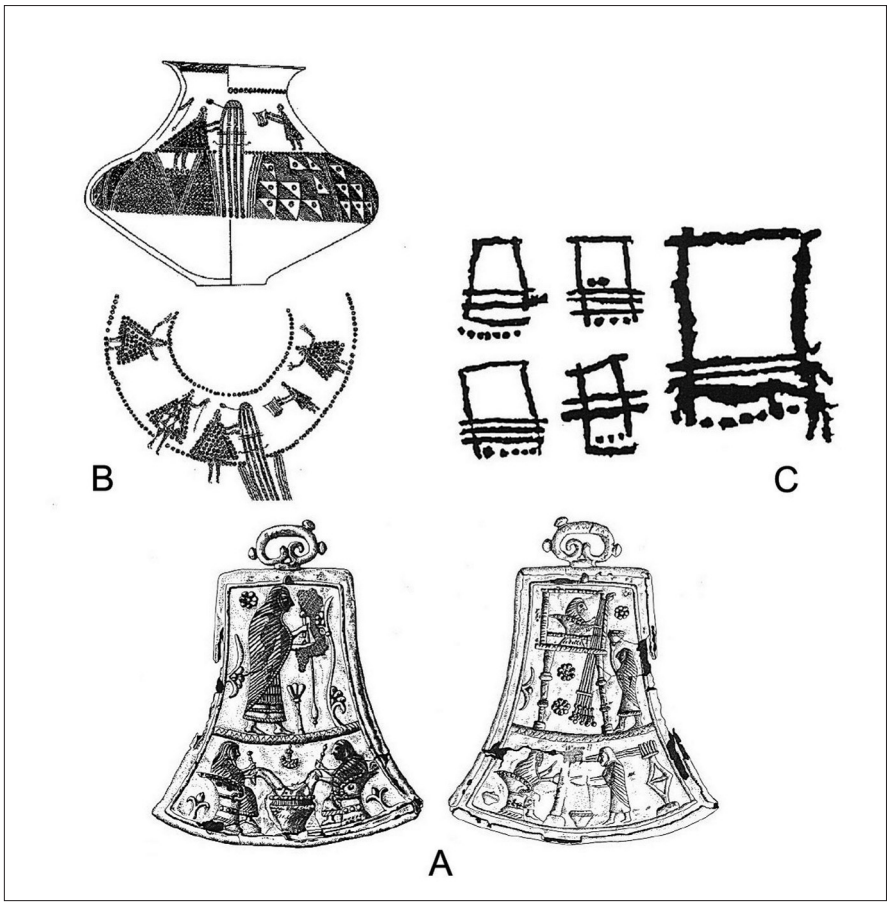

Fig. 4. Loom images on historical objects: A – tintinnabulum from Bologna (after M. Gleba 2012: Fig. 9.16); B – vase from Sopron (after Chmielewski 2011: Fig. 111); C – engravings from Val Camonica (after Bazzanella 2012: Fig. 8.15).

object, the supposed comb and the rectangular figure situated under it were connected into a single whole. As it was mentioned in the Introduction, the author postulates a new interpretation of the image as a vertical warp-weighted loom.

To see the similarity of the discussed image with a real vertical loom one must learn the loom construction first. Generally, there are two types of vertical looms – the warp-weighted (Fig. 3.I) and two-beam (Fig. 3.II) vertical looms. Both have similar construction – they are equipped with a frame consisting of two vertical beams, two horizontal beams, and heddles. They differ in the manner of setting up and stretching the warp threads. In the two-beam loom, warp threads can be spanned between the upper and the bottom beam. Next, they run around the bar marking the warp's end, turn back, and run upwards to the top beam (Barber 1991: 115; Grömer 2016: 139). The warp-weighted loom is made of a frame consisting of two vertical posts (Fig. 3.A), which keep a horizontal beam up (Fig. 3.B), to which warp threads are fixed. The warp threads are tensioned by loom weights (Fig. 3.E). At the loom bottom, there is also a shed bar separating the warp threads (Fig. 3.C). This type of loom is often placed leaning against a wall at some angle (although it is not a rule), which creates a natural shed through which weft thread is passed. To make another shed, warp threads at the back of the separating beam must be pulled forward, before those which are not moved. To do it, the heddles knotted to the back layer of the warp are required. By pulling them forward, the back threads are drawn before the front threads and another shed is opened for the weft (Broudy 1979: 25).

To make a more complicated weave, such as twill weave which was more popular than the tabby in the Halstatt period in Central Europe (Grömer 2016: 129), additional heddles are required. Their number depends on a type of the vertical loom and a type of the twill weave which one wants to produce. To obtain 2/2 and 3/1 twill weave on the warp-weighted loom, one must divide the warp threads into four rows and use three heddles (Fig. 3.D). While working on the two beam loom, one uses four heddles (Barber 1991: 187). Consecutive heddles with rows of warps fixed to them are pulled front and back in pairs in a proper order (Chmielewski 2011: 209).

Knowing the vertical loom's construction, we are able to interpret its particular elements in the image from the Szemud urn discussed above. Starting from the top part: horizontal lines situated below the face may stand

for the upper loom beam with the fixed warp threads represented by vertical lines running down the urn's height. Lines placed on the bottom part may depict a beam separating the warp and the loom base. Three lines surrounding the entire urn located in the middle of the image can be interpreted as three heddles (this part of the image raises the author's greatest doubts because the grooves are engraved around the entire urn). If one accepts this point of view (or if this interpretation may be considered acceptable), the engraving can be interpreted as the earliest image of the vertical loom in Poland but also as a loom setup for making twill weaves.

Several depictions of the warp-weighted loom and other activities related to textile production, such as spinning, can be found in Greek vase painting (Barber 1991: 92). There are also a few depictions of textile implements on archaeological objects from Southern and Central Europe (Fig. 4). These are images from a tintinnabulum from Bologna (Fig. 4.A) and the throne from Verucchio in Italy, as well as from the vase from the burial mound (Tumulus 27) from Sopron in Hungary (Fig. 4.B), dated to between 800 and 500 BC (Grömer 2016: 108–110). Seven warp-weighted looms carved into a rock in Val Camonica Valley in Italy are absolutely unique finds (Fig. 4.C). Unfortunately, their dating is insecure and ranges from 1400 BC (Bazzanella 2012: 211) to 800–500 BC (Grömer 2016: 110). All of these images demonstrate elements that are most characteristic for vertical looms, such as the vertical and horizontal beams, heddles, warp threads, and weights (Grömer 2016: 110).

The assumed vertical loom shown on the Szemud urn suits a vast chronology of images listed above (the grave with the urn is dated to the Hallstatt D, *i.e.* approximately 650–450 BC). Despite the apparent lack of loom weights (maybe this is the warp alone just prepared for weaving?) the author is convinced that the image depicts a warp-weighted loom. Using this type of loom in the Late Bronze Age and Early Iron Age is evidenced by numerous finds of loom weights from Poland, *e.g.* from Biskupin (Balcer 1961), Bnin (Szamałek *et al.* 1979), Słupca (Malinowski 1958), or Gazdowice-Kwiatoniów (Macewicz, Wuszkan 1991).

Conclusions

Images from urns of the Pomeranian culture have already been a subject of numerous publications, just as many of their aspects, such as symbolism, rituals, categories, *etc.* The aim of this article was not to create another typology of motifs but rather to suggest a possible different interpretation of the urns' iconography. The engraving from the Szemud urn from Grave I has already been interpreted as a comb image. Despite some doubts concerning its unusual location and excessive teeth length (Kwapiński 1998: 167; Dzięgielewski 2007: 203), nobody has suggested a new interpretation of this image up until now. However, the author suggests a new, different interpretation of the object. According to her analysis, this may be the first image of the warp-weighted loom preserved in Poland. This calls for a new, different interpretation of the object and draws attention to the need for a careful review of the existing iconographic interpretations.

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The Hallstatt Textiles from the Bi-ritual Cemetery in Świbie

Abstract

Textile production during the Hallstatt period was an integral part of everyday life of societies living in Poland. However, discoveries of fabrics are very rare. Textile remains from this period survived primarily in the skeletal bi-ritual graves in the Silesia voivodship. Among preserved fragments of organic finds, remains of clothes and elements of accessories can be distinguished. The best-preserved and well-studied textile remains come from the cemetery in Świbie, Gliwice district. The locality was accidentally discovered in 1930s, but regular excavations started there thirty years later. As a result of the archaeological works, 576 cremation urns and skeletal graves were explored providing a rich set of materials. Grave goods were local products, as well as imports from Southern and Western Europe. Sixty three graves contained remains of textiles. The majority of the surviving fabrics adhered to metal outfits. In addition, research encountered woven tape remains, braided ribbons, threads, and strings.

The material acquired from the cemetery in Świbie is the largest textile collection from the Hallstatt period discovered in Poland. It waited in a museum warehouse until the year 2015 when the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in Łódź initiated further studies. Despite the fact that most fragments were small and mineralised, all the undertaken analyses led to a better understanding of textile production in the Hallstatt period in Poland with its innovative and traditional elements.

Streszczenie

Tekstylia halsztackie z cmentarzyska birytualnego w Świbiu

Cmentarzysko w Świbiu, w powiecie gliwickim (wcześniej Schwieben, Kr. Gleiwitz) odkryte zostało przypadkowo w latach 30-tych XX wieku. Regularne badania podjęte zostały 30 lat później przez pracowników Muzeum w Gliwicach. W efekcie przeprowadzonych prac archeologicznych przebadano 576 grobów ciałopalnych i szkieletowych, które dostarczyły bogatego zbioru materiałów. Wśród darów grobowych znajdowały się wyroby o charakterze lokalnym powiązane z osadnictwem kultury łużyckiej, jak również importy z regionów południowo- i zachodnioeuropejskich łączone z kręgiem kultury halsztackiej. W świetle najnowszych badań cmentarzysk w Domasławiu i Kietrzu wydaje się, iż nekropolię w Świbiu wiązać należy z ludnością halsztackiego kręgu kulturowego, z jej północno-wschodnim odłamem.

Na pozyskany na cmentarzysku materiał archeologiczny składały się liczne wyroby włókiennicze, które poddano analizom surowcowym i technologicznym. Materiały odkryte zostały w 63 grobach szkieletowych, w liczbie 180 fragmentów. Składały się na nie fragmenty tkanin, nici, sznurków oraz plecionych wstążek. W większości przypadków zachowały się one w postaci niewielkich fragmentów, w sąsiedztwie brązowych i żelaznych darów grobowych, na kościach zmarłych oraz w okolicy drewnianych elementów konstrukcji grobowych.

W zbiorze dominowały fragmenty tkanin (100 sztuk), w większości utkanych z surowca roślinnego. Przeważał splot płócienny, o przędzy pojedynczej, przeważnie skręconej w prawo. Wyroby charakteryzujące się takimi parametrami należą do typowych produktów średniej

jakości, które znajdują liczne analogie na innych stanowiskach z obszaru Polski datowanych na wczesną epokę żelaza.

Drugą co do wielkości kategorię zabytków tworzyły fragmenty plecionych wstążek (38 sztuk) z surowca roślinnego. Przypuszczalnie pełniły one funkcję elementów łączących ze sobą ozdoby metalowe, tworząc wraz z nimi rodzaje naszyjników, gdyż znajdowano je w okolicach klatek piersiowych zmarłych. Odmienną funkcję można przypisać trzem spośród nich, które odnalezione zostały bezpośrednio na kościach czaszek. Stanowiły one wraz z brązowymi guziczkami elementy ozdobnych przepasek czołowych, w starszej literaturze zwanych diademami. Z tymi ozdobami łączyć należy także fragmenty nici (21 sztuk), które występowały w oczkach brązowych guziczków. Za ich pomocą przyszywano guziczki do podstawy diademu wykonanej z plecionej wstążki (w Świbiu), paska skóry (w Pawełkach, powiat Lublinice) czy tkaniny (w Łabędach-Przyszówce, powiat Gliwice).

Pozyskany na nekropolii w Świbiu materiał stanowi największy dotychczas odkryty i przebadany zbiór wyrobów włókienniczych datowanych na okres halsztacki z terenu Polski. Pomimo iż stanowisko można wiązać z halsztackim kręgiem kulturowym, to w świetle przeprowadzonych analiz tekstyliów nie stwierdzono zmian jakościowych w stosunku do materiałów odkrytych na stanowiskach ludności kultury łużyckiej.

Keywords: textiles, cemetery, Early Iron Age, Hallstatt period, Świbie, Silesia

Introduction

Textile production was an integral part of daily life of the societies inhabiting the territory of modern Poland in the Early Iron Age.[1] However, despite the universal use of textiles, they are extremely rarely found during archaeological excavations. Preserved until the present day only in the form of tiny fragments, they are permanently attached to construction elements of graves or to grave goods. Textiles discovered in bi-ritual cemeteries located in western Lesser Poland, south-eastern Greater Poland, central Silesia, and the central and northern parts of Lower Silesia were preserved in this very form (Fig. 2) (Dobrzańska-Szydłowska, Gedl 1962: 100–102, 121–122; Szczepanek *et al.* 2004: 415–458; Moskal-del Hoyo, Badal Garcia 2009: 243–252; Młodkowska-Przepiórkowska 2010: 141–166; Antosik, Słomska 2017: 89–96).

The richest and the most thoroughly studied bi-ritual cemetery is the one in Świbie, Gliwice district, which is dated to the Hallstatt period (650–450 BC) (Wojciechowska 1996: 513–523, with further references). During more than thirty years of archaeological exploration, a group of organic artefacts has been acquired that formed a set of textiles which accompanied the deceased in their final journey.

Traditionally, the cemetery has been linked to the settlement of the people of the Upper Silesia-Lesser Poland (*górnośląsko-małopolska*) group of the Lusatian culture, which occupied the territory of south-western Poland since the fifth period of the Bronze Age until the Hallstatt D (900–450 BC) period. It was distinguished on the basis of its funeral customs that involved both cremation and inhumation burials.

The outcome of the latest archaeological research inclines us to verify our views. It suggests that a part of Silesia and southern Greater Poland was inhabited in the beginnings of the Iron Age (650–550 BC) by the people of the Hallstatt culture, namely its north-eastern group (Gediga 2013: 383–399; 2014: 15–25, with further references). This conclusion is supported by numerous archaeological finds related to the Hallstatt circle that were discovered in Domasław, Wrocław district (Józefowska, Łaciak 2012: 463–482), Milejowice, Wrocław district (Kopiasz 2008: 211–228), and Kietrz, Głubczyce district (Gedl 2002: 75–116). It is preliminarily assumed that the cemetery in Świbie might have also belonged to the Hallstatt culture. This view, however, needs precise verification and further research.[2]

The site no. 16 in Świbie, Gliwice district,[3] was accidentally discovered in the 1930s. The first archaeological excavations there were conducted by the German archaeologist F. Pfützenreiter. It was then that cremation and inhumation graves were found (Pfützenreiter 1936). Regular exploration was only launched three decades later

[1] The text is based on the poster *Hallstatt Textiles from Poland: Analysis of Textile Finds from the Bi-Ritual Cemetery in Świbie,* presented at the session '*Tradition and Innovation in Textile Technology in Bronze Age Europe and the Mediterranean*', EAA Vilnius 2016.

[2] A monograph on the site is being prepared by the employees of the Archaeology Department of the Museum in Gliwice.

[3] German name of the village: Schwieben, Kr. Gleiwitz.

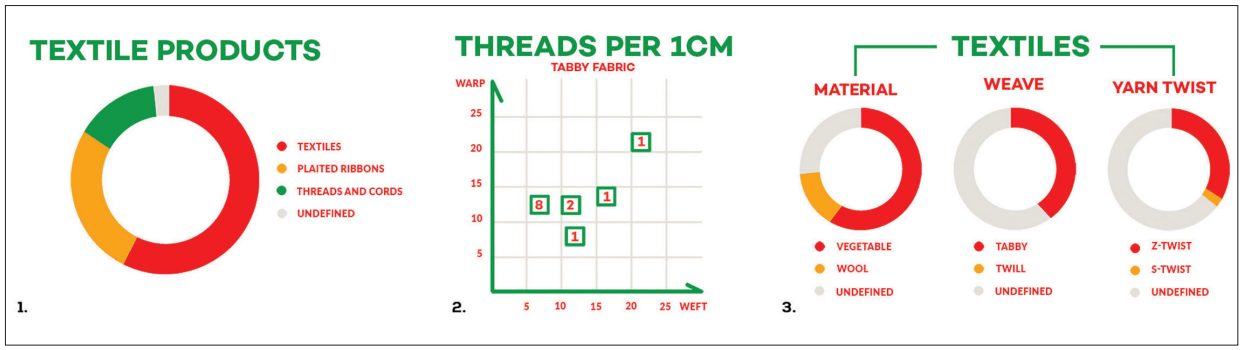

Fig. 1. Textiles from Świbie in statistical charts: 1. Share of particular types of textile products in the collection; 2. Densities of the fabrics, *i.e.* the number of threads in warp and weft per cm; 3. Share of individual types of raw materials, types of weaves, and yarn twists in a set (compiled by J. Słomska).

by employees of the Archaeological Department of the Museum in Gliwice.[4] As a result, as many as 576 cremation and inhumation graves were explored. The majority of the archaeological finds were situated in the richly-furnished inhumation graves that contained ceramic vessels and metal products, mostly decorative items, less often tools and weapons. The ceramic vessels were deposited above the heads of the deceased in the form of a set consisting of a pot, a bowl, and a cup. On skulls, there were headbands (or diadems) made of textile or leather straps, to which bronze buttons and temporal pendants were sewn as a decoration. Below, around the neck area, necklaces, glass bead collars, and earthen or bone pendants were found. Pins and *fibulae* were situated near the chests. They were made of bronze and iron, similarly to bracelets on the arms and greaves around the ankles. The grave goods also included rare tools, such as iron axes and spearheads, and bronze arrowheads (Michnik, Zdaniewicz 2014: 79–80). These artefacts were either local products or imported items from the Eastern Alps, Pannonia, and northern Italy (Stankiewicz-Węgrzykowa 1972: 49–60; Michnik, Zdaniewicz 2014: 29–31).

Textiles from Świbie

The grave finds also included remains of textiles that were discovered in 63 inhumation graves. They were preserved on remains of bones, wooden construction elements of the graves, and metal elements of clothing. Apart from woven fabrics, remains of woven bands, plaited ribbons and threads, and cords were found (Fig. 1). These finds form the largest discovered and studied set of Early Iron Age textiles from the territory of modern Poland (Fig. 2). It consists of a total of 180 textiles including threads and cords (Słomska, Antosik forthcoming).

The largest group of artefacts consists of 100 fragments of woven fabrics (Fig. 3.1–2, 4–5) that together constitute 57% of the entire set (graves nos 76, 81, 102, 125, 141, 143, 159, 164, 170, 228, 241, 257, 259, 283, 349, 354, 395, 400, 402, 403, 449, 554, 574, and 576). Most products were woven of threads made with vegetable fibre (65 fragments). Only 16 fragments were produced with wool yarn, and in the case of 19 artefacts, the material proved indeterminable (Antosik 2015; Słomska 2015).

Tabby is dominant among the woven fabrics as it was identified in 43 fragments. In 30 cases, identical z-twisted yarn in both systems was used. Only one textile contained s-twisted yarn made of two very low twisted plies that were rather loosely twisted together. Furthermore, in the case of six textiles, only z-twisted yarn for one system was all that could be determined (Antosik 2015; Słomska 2015).

The thread diameter was established for 26 fragments of woven fabrics. Most of them (15 fragments) were made with yarn whose diameter ranges between 0.8 and 1.0 mm. Nine fragments were woven with threads whose diameter oscillates around 1.0–1.2 mm (Antosik 2015; Słomska 2015). It should be emphasised that such parameters are typical for yarn of medium quality in the Iron Age in Poland (Maik 2012: 295–297; Antosik, Słomska 2014: 103–109).

The analyses also determined that the examined woven fabrics have thread counts of 6–16 threads per 1 cm. Most

[4] Since 1961, archaeological research was conducted by A. Stankiewicz-Węgrzykowa, and since 1967 by H. Wojciechowska. The two scholars continued the research as a team until 1992.

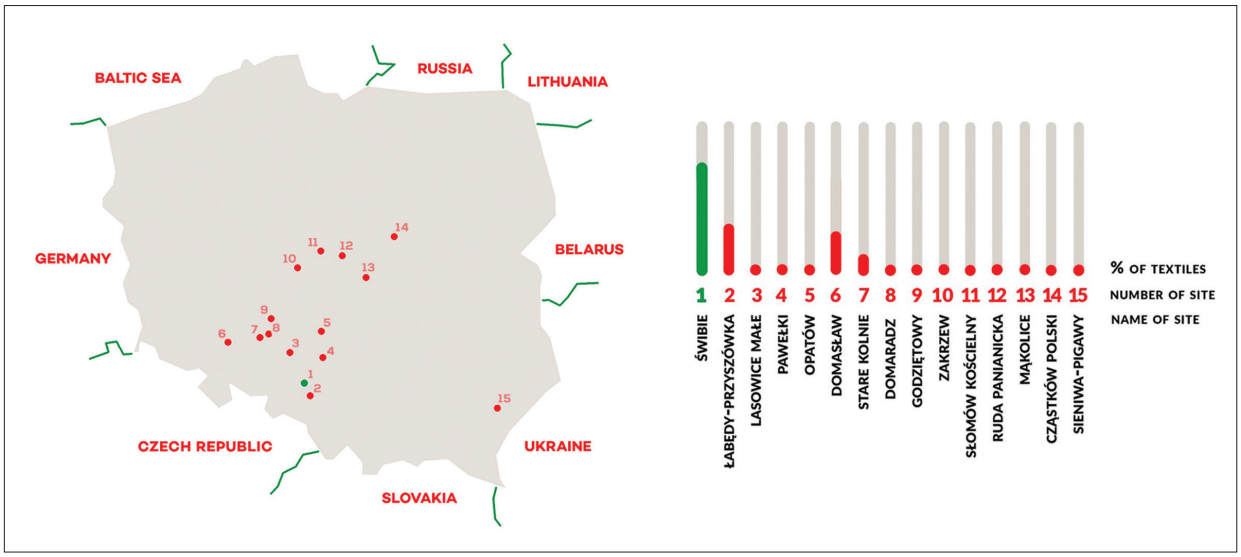

Fig. 2. Textiles from Świbie as compared to other textile finds from the Early Iron Age from Poland (compiled by J. Słomska).

Fig. 3. Examples of textile products discovered at the cemetery in Świbie (photo by J. Słomska): 1. Fragment of a woollen fabric from the grave no. 170 preserved on an iron bracelet; 2. Fragment of a woollen fabric from the grave no. 125; 3. Woven ribbons made of vegetable raw material; 4. Fragment of a woollen fabric from the grave no. 449 preserved on iron greaves; 5. Fragment of a vegetable fabric preserved on a bronze pin in the grave no. 474; 6–7. Woven plant ribbons preserved on bronze rings from the graves nos 125 and 412.

artefacts, however, have the thread counts of 6–10 threads per 1 cm in both systems (Antosik 2015; Słomska 2015).

Apart from the woven fabrics, also 21 fragments of threads or cords made of vegetable fibre were found in the graves. The artefacts from this category constitute 8% of the entire set (graves nos 14, 19, 73, 129, 283, 412, 449, and 480). In this set, products made of two-ply threads twisted together are dominant. Beside them are simple artefacts, too, like one-ply or untwisted products (Antosik 2015; Słomska 2015).

The group of plaited ribbons made of vegetable fibre is rather numerous. It consists of 38 artefacts (Fig. 3.3, 6–7) that make up 22% of all the textile products discovered in the cemetery (graves nos 14, 125, 128, 136, 141, 209, 221, 283, 344, 391, 412, and 418). They were produced in the form of plaited braids found around the skulls and chests of the deceased (Antosik 2015; Słomska 2015).

One interesting find from the cemetery is a fragment of a woollen sprang. It has been published, complete

with a photograph, in *Zarys Historii Włókiennictwa* [An Outline of the History of Textile Production], however, unaccompanied by a more detailed technological analysis (Łaszczewska 1966: 33, Fig. 10). Its location is presently unknown. The artefact is presumed to have been lost or destroyed.

Discussion

All the aforementioned types of textiles were preserved as fragments. The woven fabrics and ribbons were permanently attached to the surfaces of decorative metal items, and their dimensions usually did not exceed 8 cm^2. Only one sample of woven fabrics, the one from the grave no. 125 (Fig. 3.2), retained both flexibility and significant size (45 cm^2), which should be considered an unprecedented find for this period in the territory of modern Poland. While the evidence from the cemetery in Świbie mostly consists of tiny textile fragments, as a set it offers a huge source database for study and comparison. On its basis, we could state that people who used the cemetery in Świbie knew only how to produce fabrics in tabby weave. For that purpose, they used both vegetable and animal material. These woven fabrics were likely elements of clothing, shrouds, or headscarves, as suggested by numerous discoveries on external surfaces of decorative metal items, as well as the co-existence of two different woven fabrics on one artefact, on both of its sides (graves nos 395 and 449) (Słomska 2015).

As for the plaited braids, it is presumed that they joined various decorative metal items to form a necklace. It is the case for the bronze rings located near the chests of the individuals from the graves nos 125, 128, 283, and 318. These textile products are a unique discovery as they find no counterpart in other sites from the Hallstatt Period in Poland. The closest analogy is provided by the plaited braids from the salt mine in Hallstatt (Grömer *et al.* 2013; Grömer 2016: 72–73).

The situation regarding the threads is somewhat different, as they have been found in large numbers in many sites in this region. In the cemeteries in Łabędy-Przyszówka (Antosik, Słomska 2017: 89–96) and Lasowice Małe, Olesno district (Dobrzańska, Gedl 1962: 121–122), two-ply threads made with vegetable fibre were found. In Pawełki, Lubliniec district (Młodkowska-Przepiórowska 2010: 141–166), and Opatów, Kłobuck district (Szczepanek *et al.* 2007: 641), two-ply threads produced with animal gut were discovered. Independently from the employed material, threads have always been found inside the loops of bronze buttons sewn to headbands (or diadems). The same threads must have also been used for sewing other pieces of clothing.

Despite the theory that the cemetery in Świbie may have been related to the north-eastern circle of the Hallstatt culture, the discovered textiles display technological parameters analogical to the evidence known from the sites of the Lusatian culture. Unlike the case of the evidence from the site in Domasław, Wrocław district (Maik, Rybaczyk 2015: 83–94; 2016: 25–43), the set from Świbie contains less technological characteristics of the Hallstatt culture, such as twill or tablet weaves. The plaited braids may appear as an exception, yet they could hardly be considered examples of innovative textile technology. Consequently, on the basis of the afore-presented artefacts, it is concluded that the evidence from Świbie should be associated with the textile production of the Lusatian culture.

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Wool Textiles from the Roman Period at the Site of Grudna, Poland

Abstract

In October 2012, the Conservation Laboratory of the Institute of Archaeology at the NCU in Toruń received soil samples excavated from a kurgan in Grudna, Złotów commune, dated to the Roman period. No human remains were reported inside the grave chamber apart from some elements of grave goods: a glass bead, a clay spindle whorl, three iron nails, fragments of a bone pin, bronze and iron chest fittings, and a bronze vessel with a stamp of Pubius Cipius Polybius, who was active around the first half of the 1st century AD. In result of a cleaning treatment removing all soil impurities, tiny textile fragments were obtained, which were, interestingly, made of woollen fibres in sprang technique, while some of them imitated gauze (known in later periods) but were manufactured in a plain 1/1 weave. Technological analysis of the fibres revealed their high quality with average fibre thickness ranging from 8 to 18 μm. Insufficient material base for these textiles in Poland does not give a convincing answer to a basic question of whether it was an import or local production. Studies on the subject performed by European researchers, most notably J. Maik, indicate local or North European production. Hopefully, more light will be shed on this problem by further comparative studies.

Streszczenie

Tekstylia wełniane z okresu wpływów rzymskich na stanowisku Grudna, Polska

W październiku 2012 roku do Pracowni Konserwacji Zabytków Instytutu Archeologii UMK w Toruniu trafiły próbki gleby wydobyte z kurhanu w Grudnej, pow. Złotów, który datowany jest na okres wpływów rzymskich. We wnętrzu komory grobowej nie odnotowano szczątków ludzkich, ale odnaleziono paciorek szklany, gliniany przęślik, trzy żelazne gwoździe, brązowe i żelazne okucia od skrzynki, fragmenty szpili kościanej, a także brązowe naczynie sygnowane stemplem Publiusza Cypiusza Polibiusza, który działał mniej więcej w połowie I wieku n.e. Po wypreparowaniu z próbek zanieczyszczeń i ziaren gleby uzyskano niewielkich rozmiarów fragmenty tkanin. Były one niewykle interesujące, ponieważ okazało się, że są wykonane z włókien wełnianych w technice sprang, a druga ich część imitowała znaną w późniejszych wiekach tzw. gazę, tylko wykonaną w splocie płóciennym 1/1. Analiza technologiczna włókien wykazała bardzo dobrą ich jakość, średnia grubość włókien wynosiła od 8 do 18 μm. Jednak zbyt mała baza tego typu tkanin w Polsce nie daje możliwości odpowiedzenia na podstawowe pytanie: czy jest to import czy miejscowa wytwórczość? Badania wełnoznawcze europejskich badaczy, a przede wszystkim J. Maika, wskazują na produkt miejscowy lub z północnej Europy, co mamy nadzieję wyjaśni się w dalszych badaniach porównawczych.

Keywords: Poland, Roman period, kurgan, wool, sprang

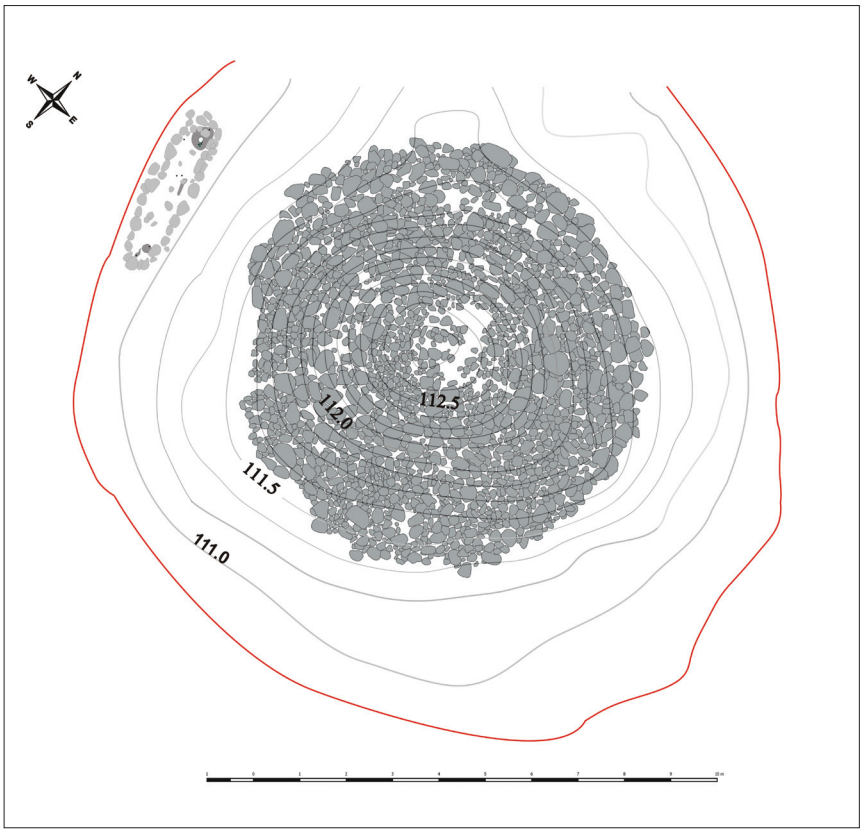

Fig. 1. Grudna, site 2, Złotów district. A layout of level II of kurgan 10 with marked location of the grave 1 and the range of the edge of the kurgan (after Kołoszuk 2015: Fig. 1).

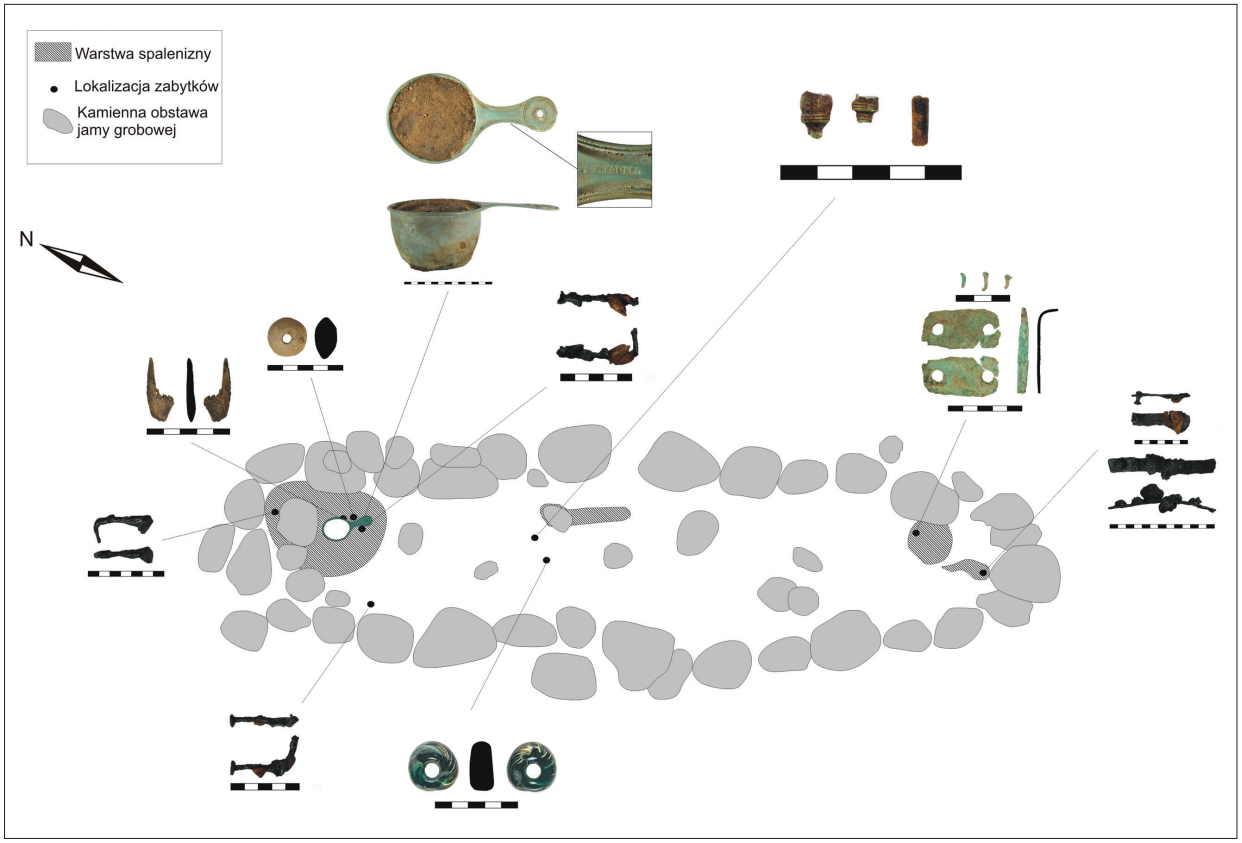

Fig. 2. Grudna, site 2, Złotów district. A layout of the grave 1 with marked location of the artefacts (after Kołoszuk 2015: Fig. 2).

Fig. 3. Textile relics with soil particles (photo by D. Grupa).

A grave exhumed in Grudna (Greater Poland voivodship, Pomerania province) delivered surprising finds. Exploration revealed relics of grave goods from almost 2000 years ago. Under a levelled earthen embankment, a stone structure of a kurgan centre on a burnt layer about 25 cm thick was registered (Kołoszuk 2015: 220). One and a half metre westwards from it, a rectangular object measuring 106 × 390 cm was excavated. In the course of exploration, it was interpreted as a burial pit (Fig. 1). Further work enabled reading clear signs of intentional dismantling of this compact stone construction, which was probably the original framework and a cover of the grave. No human remains were registered inside as they may have been removed for some reason. Apart from signs of this human interference, exhumation of human remains could also be confirmed by the fact that some of the grave goods were left in the 2 metres deep burial pit and included a glass bead, a clay spindle whorl, three iron nails, bronze and iron chest fittings, a fragment of a bone pin, and a bronze vessel (Fig. 2) (Kołoszuk 2015: 221–222). The finds also consisted of soil clods[1] which may have included textile relics.[2]

Separating the textile relics from the clods was a major challenge and although a tangled, twisted mass of fibres was visible, it was difficult to recognise the type of the textile (Fig. 3). Therefore, the soil was removed carefully by rinsing it out delicately and cleaning its excess with a needle. Due to this treatment, several small fragments belonging to different types of woollen textiles were found. One of the types was represented by fragments (four pieces) of what was presumably a part of a bonnet made in the sprang technique with a Z-twist thread (Fig. 4). All the said fragments were made in the sprang technique,[3] with braiding classified as interlinking according to the Collingwood's typology (Collingwood 1974: 31, Fig. 1a). These were followed by fragments classified as plaited strings (three pieces) and 1/1 weaves (two pieces).

One fragment with a preserved selvedge made of 3-plied threads had a twisted string of three threads with composition: S2z+S2z+S2z=Z (Fig. 5).

Another type seems to be a woven piece in open plain 1/1 weave with large distances between the threads (loose structure). During the analysis, traces of an additional thread(s) were sought, since they might have been woven into this textile. However, while being made of another fibre, *e.g.* flax, which could indicate a half-woollen textile made of various types of fibres, the additional threads did not survive. Unfortunately, no such traces were reported. Therefore, it should be stated that the textile was intentionally woven as an open structure, imitating

[1] Unfortunately, the location of the obtained soil samples remains unspecified, so it is difficult to establish whether they were found in one or three different places. This information would not be useful, however, because of earlier grave exhumation.

[2] In October 2012, the Conservation Laboratory of the Institute of Archaeology, the Nicolaus Copernicus University in Toruń, received soil samples excavated from an empty grave at Grudna. The cleaning treatment and separating soil clods and fiber fragments lasted 3 months.

[3] Sprang is a term describing textiles, as well as a textile technique, of making fabric by manipulating parallel threads of a warp that is fixed at both ends. The manipulation takes the form of interlinking, interlacing, or intertwining of adjacent threads or groups of threads (Collingwood 1974: 31). History of textiles made in the sprang technique spans over 3000 years (Collingwood 1974: 37–44). They are known, for instance, from a Bronze Age oak coffin burial in Denmark.

Fig. 4. Textile fragment in the sprang technique after cleaning from soil particles (photo by D. Grupa).

Fig. 5. Fragment of a woollen string (photo by D. Grupa).

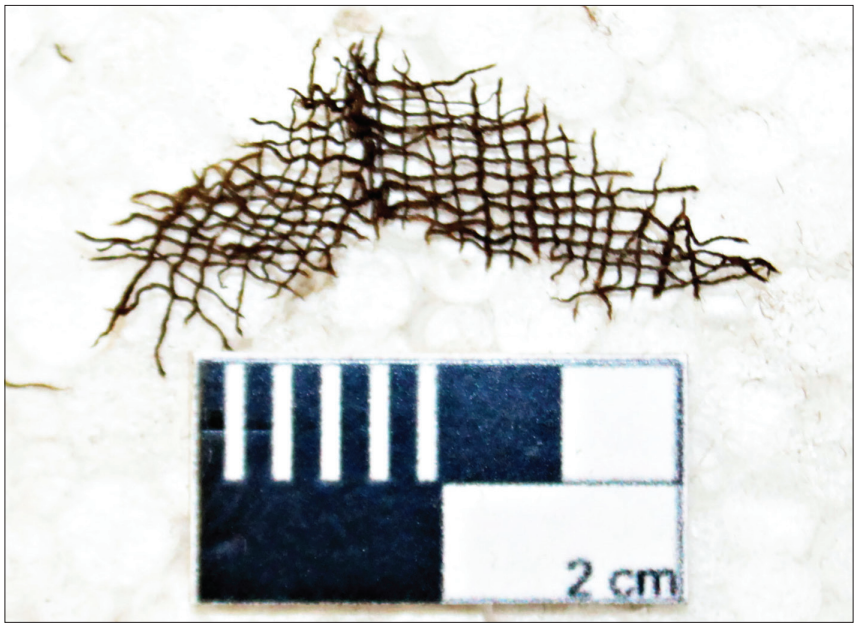

Fig. 6. Woollen net in 1/1 weave (photo by D. Grupa).

netting techniques with tiny loops (Fig. 6). This textile was made of z-spun from 0.10 mm to 0.20 mm thick, with a density of 11 threads per 14 threads per 1 cm.

An analysis of particular threads from the fragment of sprang identified animal fibres with small scales on their surfaces (Fig. 7). The size and shape of the scales could vary, depending on particular sheep breeds. It should also be noted that fleece of different breeds is characterised by different fibre diameter and absence of medulla fibres and barbs (Maik 2012: 66). Among 198 examined fibres, only six had a clearly-shaped, but not fully developed, medulla (Fig. 8). According to Antoinette Rast-Eicher's typology, they can be classified as interrupted structures (Rast-Eicher 2016: 11–12, Fig. 1). Average fibre diameter ranged from 8 to 18 μm (Fig. 9), which amounted to nearly 70% of the examined fibres. Such a large quantity of thin fibres indicates high quality of the yarn (the thickest fibre had 44 μm). Studying wool quality in the Wielbark culture, J. Maik pointed out that textiles of the period contained mainly wool deprived of medullae, and only single samples exhibited small percentage share of them (Maik 2012a: 71). That information is compatible with the results of the analyses of the wool from Grudna, where these fibres amounted to only 3.03% (Fig. 9).

Following the studies of A. Nahlik (1964: 64–78), M.L. Ryder (1982), P. Walton (1990; 1993), and J. Maik (2001), we can state that domestic sheep derives from a wild mouflon living in Europe and Western Asia. It is characterised by two general types of wool: fine and short fluffy hair (6–18 μm), and long, thick and stiff hair (100–200 μm). In case of the wool used in sprang, the wool was fluffy and of perfect quality (whether it is a result of fine fleece used in this case, high processing skills, or both is yet to be determined).

It is still unknown, whether the sheep were sheared once or twice a year[4] and the role of combing escapes precise evaluation, since clean yarn is free from impurities (grass, straw, burdock achenes and other plants, excrements, sand, and small stones collected in the fleece during sheep's life) (Grupa 2012: 72). Long thick hair could have been removed during cleaning, with the use of flexible tree branches (soft willow, hazel, birch, or yew) or iron combs which have been excavated at various European archaeological sites (Werner 1990: 608–611; Ilkjær 1998: 43–54; Gładysz, Kokowski 2002: 92). The discussed cloth element manufactured in the sprang technique must have been made of high quality wool[5] rarely found in archaeological material.[6]

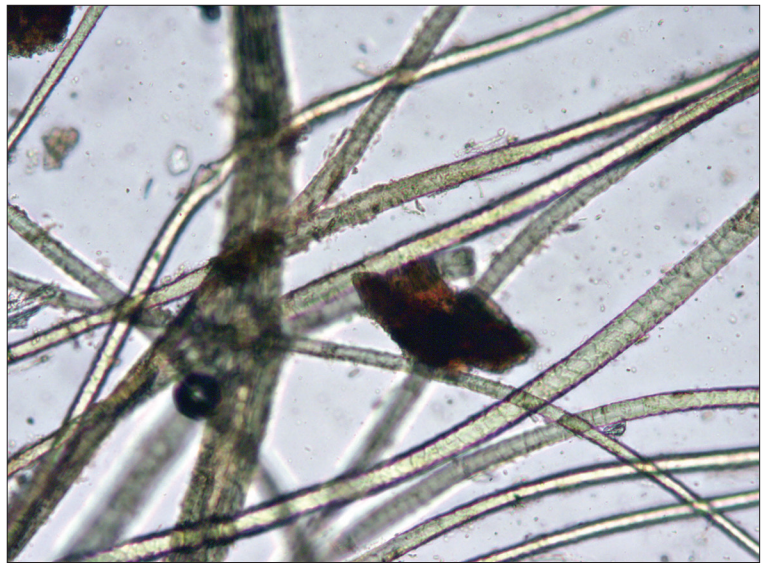

Fig. 7. Single fibres with visible flakes (photo by D. Grupa).

[4] During the Middle Ages, to obtain wool of higher quality, sheep were sheared only once a year (Maik 2012: 71).

[5] Sheep domestication took place in the Neolithic, which in the beginning of the Bronze Age produced sheep with thick coarse wool. Further breeding experiments resulted in breeding similar animals but with more delicate fleece. According to the researchers of the subject, similar evolution was observed in the sheep bred in Northern Europe, Middle East, and the Mediterranean. An analysis of the available material indicates that the wool quality was mainly a result of intentional breeding and, to a smaller extent, of the region and the quality of pastures (Maik 2001: 313).

[6] While studying materials coming from Pomerania of the Roman period, J. Maik examined 117 samples and assessed the average fiber thickness to be 18–25 μm, which was a base for interpreting the fleece as a product of local sheep bred in Europe during the Roman period (Maik 2001: 313).

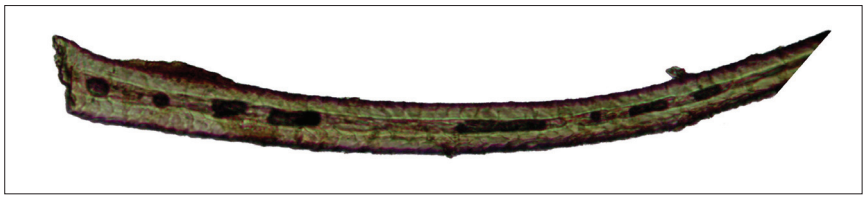

Fig. 8. Formation of the rod in fibres (photo by D. Grupa).

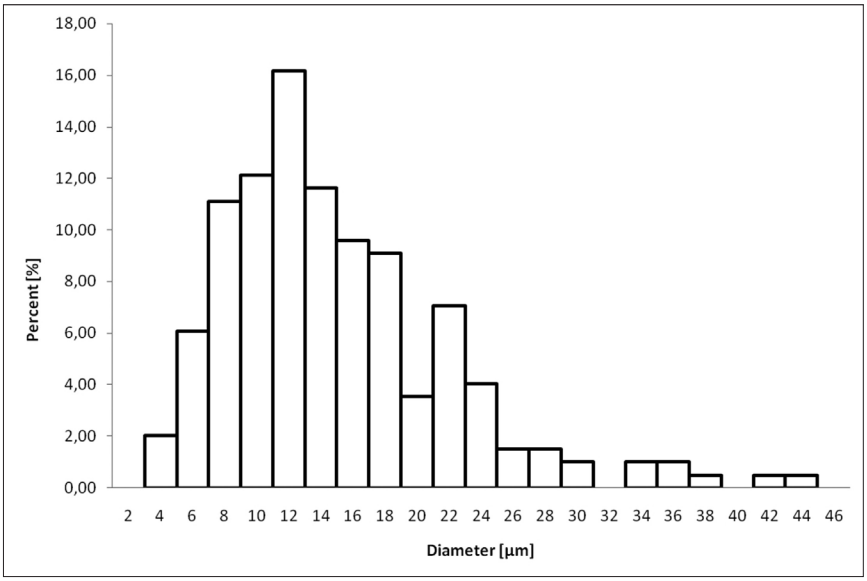

Fig. 9. Histogram of wool fibre thickness.

Over 15 years ago, Jerzy Maik presented a hypothesis regarding wool quality from the Roman period, suggesting that it was obtained as a result of crossbreeding between sheep imported from the Empire and local animals (Maik 2001: 314–315). As a result of the crossbreeding, two sheep groups were distinguished: the thin-fleeced and the thick-fleeced. The thick-fleeced sheep were of the Mediterranean origin, while the thin-fleeced variety came from the Middle East. First they came to Greece and next to Italy, where they were given various names: Taranto, Greek, or Attica sheep. In the next step, breeders tried to combine these crossbreeds with local animals to obtain the highest fleece quality. P. Walton and J. Maik's research results imply that the crossbreeds between the local and the Roman sheep were of a good quality (Walton 1993: 61–68; Maik 2001: 315–316). Following these conclusions, it can be assumed that the wool used in Grudna textiles was of local production or came from Northern Europe and thus belonged to the so-called *woolly Soay*, also known as the Roman sheep (Ryder 1982: 224–238; Maik 1986: 67–69; 2012: 68; Walton 1990: 144–158; 1993: 61–68). Of course, any new textile fragment to be excavated may confirm or contradict this hypothesis. To solve this problem, new comparative tests of the quality of wool are required as well as, even more so, new textile finds from Northern Europe and Poland.[7] Until the final verdict, this hypothesis should be treated very cautiously. The textile products from Grudna could have come from trade exchange and been brought there together with the bronze vessel presented above.

The next step was spinning the combed wool with a wooden spindle fitted with a clay or stone spindle whorl. In the case of Grudna, a clay one was supposedly used, since such a spindle whorl was found among the grave goods. Did the person buried in the grave know the spinning technique? It was possible according to the analyses of the Pomeranian wool performed by Maik (Maik 2001: 320; 2012: 71).

Was it a grave of a woman whose occupation involved spinning? The absence of a skeleton makes answering this question impossible. If it had been a woman, she must have belonged to the tribal elite, since the grave also contained a bronze dish with a stamp of Publius Cipius Polybius (Fig. 10), who was a Roman coppersmith

[7] Excavations in the nearby Lędyczek yielded textile fragments in the 2/2 weave along with imported goods dated to the phase B1/B2 of the Roman period (Biborski, Kaczanowski 2001: 70–88). Was the wool quality identical with the studied samples? It is uncertain – further comparative analyses would probably answer this question.

Fig. 10. A stamp of Publius Scipio Polybius from the bronze vessel (photo by D. Grupa).

manufacturing various vessels near Capua around the 1st century AD (Kołoszuk 2015: 222). At this stage of research, it is difficult to recognise whether female graves were often equipped with bronze vessels, but their presence proves that an intense network of trade and cultural exchange existed along the northern sea route and affected also the southern coast of the Baltic. Such exchange must have also influenced innovations in textile production (as evidenced by an excavated textile sprang fragment in loose plain weave).

Fragments of sprang textiles were also excavated in a grave from Lubowidz near Lębork (the Wielbark culture) (Maik 2007: 105–112), dated similarly to the Grudna burial. Analogous objects were also reported in Northern Africa and were made of flax threads, *e.g.* a mesh bonnet from the collection of the Museum of History of Art in Brussels (*Égyptiennes* 1997: 138). Another four examples of mesh head covers are held by the museum collection of Georges-Labit, two of which were made of coloured threads (Lorquin 1999: 80–83).

This brief outline of textiles made in sprang confirms popularity of the technique all over Europe, North Africa, and the New World in different periods. Variety of loop compositions and patterns required great manual skills and spatial imagination. This technique is very decorative, since even the basic manipulation would create an attractive ornamental form.

The fragments from Grudna were made the same way, *i.e.* interlinking, as in the case of bonnet pieces from Arden (Arden Mose) dated to the Early Iron Age (Hald 1980: 251, 258, Fig. 260). Are the finds from the kurgan elements of a headwear? It is possible. A woollen string running along one of the edges suggests that the very element was forming an oval shape of a face. However, due to the lack of a skeleton it is impossible to solve the riddle.

In Poland, the oldest fragment of sprang was excavated at the burial ground of the Lusatian culture in Świbie, Gliwice commune, dated to the Early Iron Age (650–400 BC). An analysis of the iconographical material shows that the mesh is combined with a metal ring which served as a belt clasp[8] (Łaszczewska 1966: 33–34; Maik 2012: 296) (a fragment of a woollen belt?). Three fragments made in the sprang technique are known to have been excavated in Pomerania before WWII. The textile from Grave 21 was made in the intertwining technique according to Collingwood (Collingwood 1974: 31, Fig. 1c). The yarn was classified as delicate (Maik 2012: 29). Unfortunately, the textiles were lost during WWII, hence comparative analyses are impossible.[9] Another example – a duke's grave located in Leśno, Chojnice commune, near Lędyczek, contained small fragments (size of up to 2 cm) of woollen textile made in the mesh technique (Maik 2012a: 40). The fragments were linked very tightly until their surface became completely compact.

The material discussed above provokes many questions which cannot be answered at this stage of research. The gender of the individual buried in the grave is unknown, just as whether the spindle whorl and sprang textile fragments are sufficient evidence to identify it as a female burial. It seems unlikely, since the sprang technique was used for male clothing as well,[10] and the spindle whorl is hardly a convincing proof. The majority of spindle

[8] Similar mesh was excavated in a tomb in Alicante, Spain, and it is dated to the 4th century BC (Alfaro Giner 2012: 340–342).

[9] The textiles from Grudna can also be defined as delicate wool fabrics.

[10] Permanent occurrence of that technique in history is evidenced by mesh belts worn by Polish nobles with zhupans and kontushes in the 17th and 18th centuries. During archaeological works in the Lublin cathedral, four mesh belts (probably crimson in colour) with edges plaited with silver or gold (Grupa 2005: 93) were excavated. All the textiles lost their colours while deposited in the graves. In the case of the Lublin belts, we can infer the colour to be close to crimson, because the artefacts were folded carefully at least 27 times into small overlapping plaits, thanks to which their central internal parts kept colour, which could thus be identified during conservation process and microscope analyses performed by the author. Another example of a mesh belt, produced with the same technique (Grupa *et al.* 2015: 62), was excavated in Gniew (the southern crypt of a local church).

whorls were found in different periods in female graves, but medieval and later iconographical images evidence that also men were engaged in spinning. A 16th-century woodcut from Sebastian Münster's "Cosmographia" titled "Peasants spinning flax and wool" presents a woman, a man, and a child against a background of a mountainous landscape. The woman is probably twisting yarn in S twist, because she is keeping a spindle in her left hand, a man – in Z twist (a spindle in his right hand), while the boy (probably the couple's son) is winding the yarn onto a reel[11] (Kühn 2001: 556, Fig. 179; Grupa 2012: 84, 86, Fig. 17).[12] Another problem – the head cover. Is it a hair net or a part of an upper bonnet? It is also unknown whether textile products manufactured in this technique and made of flax thread were reported from the territory of today's Poland. The wool quality is the most intriguing aspect of this find. Where did the sheep for such a fine product come from? Was textile manufacturing so highly-developed at the time in what is today's Poland? All these questions seem to remain unanswered at this stage of research. Hopefully, new finds will advance our knowledge on the subject.

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[11] It is difficult to define sex of individuals buried in different cemeteries and assume *a priori* that they were female burials.

[12] Some researchers think (unfortunately, these statements refer only to the Middle Ages and the modern times) that whole families were busy with spinning wool and flax (Semrau 1922: 63; Maik 1997: 44).

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