STUDIA EUROPAEA GNESNENSIA 16/2017
ISSN 2082-5951
DOI 10.14746/seg.2017.16.27

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TEXTILE PRODUCTION AND CONSUMPTION IN ROMAN PROVINCES AND IN FREE GERMANIA – A 21ST CENTURY PERSPECTIVE[1]

Abstract

The paper aims to present the state of research on Roman Period archaeological textiles and new, 21st century perspectives for further analyses. The textiles proves to be important from the viewpoint of provincial economy, trade and cultural exchange. That is why, a special emphasis is put on the textile types, which are called Roman imports.

Key words

archaeological textiles, Roman Provinces, Free Germania, analytical methods, Roman imports

[1] This article was written with financial support from Narodowe Centrum Nauki/National Science Centre, as part of grant no. 2015/19/B/HS3/00547.

Although Roman textiles have been known to European scholars for quite some time, the proper textile research have started not so long ago[2] and it is gaining on popularity among the scholars. The newest analysis introduce to what was originally humanities natural and technical sciences. This particular mixture of different disciplines gives not only to the textile researchers, but also to all Roman archaeologists and historians, new opportunities and new standpoints for their own survey. In this paper I would like to present especially those studies, which are important from the viewpoint of provincial economy, trade and cultural exchange. The textile production and consumption was not one of professor Alföldy's main interests, but the textile research can add to our knowledge about Roman provinces' economy and trade, something Professor would certainly consider important.

For some 50 years of archaeological textile research history there is much the researchers managed to achieve. There is a proper methodology of describing material finds (like the thread-count, spin direction of the fibres, the repeat etc.), a platform (like The North European Symposium for Textile Research) for exchanging the information about new discoveries and methods, journals (for example Archaeological Textile Newsletter) and institutions (Centre for Textile Research, Centre International d'Études des Textiles Anciens – to name just the two of the most active institutions in Europe). That is why I can start my paper with something I would like to call general truths, which were established during scientific research and which concern the textile production and consumption in Roman Provinces and in Free Germania:

– Textiles in general are very susceptible to branding, i.e. the creation of special types – brands – which differ with their quality, tradition, skills needed to weave them etc.[3]

– Roman textiles are of very high quality, not only those found in Roman provinces, but also the ones excavated in Free Germania[4].

[2] J.P. Wild, The Roman Textile Industry: Problems, but progress, [in:] C. Alfaro, J.P. Wild, B. Costa (eds.), Purpurae Vestes. Actas del I symposium internacional sobre textiles y tinte del mediterráneo en época Romana (Ibiza, 8 al 10 de noviembre 2002), Valencia 2004, p. 23, cf. J. Maik, Jak było na początku, czyli Adam Nahlik i badania tkanin wykopaliskowych, [in:] M. Głosek, J. Maik (eds.), Od pradziejów po współczesność. Archeologiczne wędrówki, Łódź 2007, p. 91-95.

[3] P. Horden, N. Purcell, The Corrupting Sea. A Study of Mediterranean History, Oxford 2000, p. 354.

[4] J. Maik, Kleidung und Kulturidentität in der Wielbark-Kultur – Untersuchunsperspektiven, Fasciculi Archaeologiae Historiae 23, 2010, p. 25.

– Wool, the raw material of the majority of the Roman period textiles, found on the territory of Free Germania, is of very high quality[5].

– Textile technology is comparable not only within the Roman Empire borders, but also outside them[6]. Textile tools are similar or same, irrespectively the region of Europe.

– Textile „industry" changes slowly, no economic or technological revolution is needed to increase production for exchange, likewise all forms of intensification can disappear as quickly as they appeared[7].

– Fulling was an important aspect of textile making in Roman Empire, but no traces of fulling are found on archaeological textiles deriving from Free Germania[8].

Those aspects one has to bear in mind while we turn to textile production and consumption in Roman provinces and Free Germania.

Clothes are one of the basic needs of men, that is why textile production is crucial for every society from the time weaving was invented[9]. Textile production in Roman period was very time-consuming activity, it required space, skills and experience. Sometimes it involved trade, especially when certain raw materials, like for example dyestuff, were needed[10]. Clothes are also an important part of cultural[11] and gender identity. As textile production was a domain of women, slaves or craftsmen, people rather omitted in ancient literary sources, textile archaeology can give us insight into those areas of everyday life, which are invisible for traditional history.

[5] Idem, Włókiennictwo kultury wielbarskiej, Łódź 2012, p. 113, 118-119; idem, Tkaniny z pomorskich cmentarzysk kultury wielbarskiej w świetle najnowszych badań, [in:] M. Fudziński, H. Panera, Nowe materiały i ich interpretacje. Stan dyskusji na temat kultury wielbarskiej, Gdańsk 2007, p. 103.

[6] Ibidem.

[7] P. Horden, N. Purcell, The Corrupting Sea, p. 352.

[8] The problem of fullers and fulling in Northern Roman Provinces deserves a separate study. Suffice it to say that fulling is not necessary, it is possibile to wear the clothes that have not been fulled, although fulling makes textile more comfortable to wear and could be the indicator of one's cultural attitudes towards clothing (M. Flohr, Consumption Not Production. Understanding the Fullonicae of Pompeii, [in:] C. Alfaro, J.P. Brun, R. Pierobon Benoit, Ph. Borgard (eds.), Pururae Vestes. III Symposium Internacional sobre Textiles y Tintes del Mediterráneo en el mundo antiguo, Naples 2011, p. 209). Fullonicae are found in the Northern Roman provinces – the question is who fulled clothes there?

[9] L. Bender Jørgensen, North European Textiles until AD 1000, Aarhus 1991, p. 11.

[10] T. Belanová Štolcova, K. Grömer, Loom-weights, Spindles and Textiles – Textile Production in Central Europe from the Bronze Age, [in:] E. Andersson Strand, M. Gleba, U. Mannering, Ch. Munkholt, M. Ringgaard, NESAT X, Oxford 2010, p. 9, see also fig 3.1.

[11] J. Maik, Kleidung und Kulturidentität, p. 25-26.

The earliest cooperation between archaeologists and natural science is the one concerning dyes in Antiquity. Chemists and biologists work hand in hand with textile researchers to determine the dyestuffs in ancient materials. The geography of Roman dyeing is not only important for our understanding of the textile industry[12], but can also reveal the complexity of exchange between different parts of the world in Roman times and the richness of trading routes. Trade or exchange in general was necessary to obtain rare dyestuff, but this fact does not determine that the whole textile industry was based on commerce.

However, one of the most urgent problems of the Roman textile research is the question of the so-called imports. These are very fine fibres, often found in sepulchral context and accompanied by object of Roman provenance. They were named after archaeological sites: the first one – z/s spun 2/2 twill or 2/2 diamond twill, 20/18 repeat, thread count 16 per cm – the *Virring* type and the other one – variant of 2/2 diamond twill, shifted along the wrap and symmetrically broken along the weft – the *Mogontiacum* type. It seems that these types were originally woven in Western Roman Provinces and in the Roman Period they were exported to Free Germania. They may also be discovered in different locations, from Scandinavia to Egypt, *i.e.* inside and outside the Roman borders[13]. Their status as Roman imports has been widely discussed[14], their Roman provenance is questionable, in contrast to silk and knotted pile rugs, which could only get to Northern Europe through Roman traders[15].

If *Virring* and *Mogontiacum* types, textiles from which clothes were made, were indeed of Roman origin and if Germanic tribes imported them, it would show how deep the Roman influences reached into Free Germania and how they could influence even the cultural identity of its inhabitants. Regrettably, the answer to that question is not as simple as it would seem.

[12] J.P. Wild, The Roman Textile Industry, 25; for the outline of method see P. Walton, Wools and Dyes in Northern Europe in the Roman Iron Age, Fasciculi Archaeologiae Historicae, 6, 1993, p. 63.

[13] J. Maik, Włókiennictwo kultury wielbarskiej, p. 114-117; L. Bender Jørgensen, Forhistoriske textile i Skandinavien (Prehistoric Scandinavian Textiles), Kopenhagen 1986, p. 346-348.

[14] The best outline of the discussion: L. Bender Jørgensen, J.P. Wild, Clothes from the Roman Empire. Barbarians and Romans, [in:] L. Bender Jørgensen, B. Magnus, E. Munksgaard (eds.), Archaeological Textiles. Report from the 2nd NESAT Symposium 1-4.V.1984, Copenhagen 1988, pp. 65-98, see also J. Maik, Włókiennictwo kultury wielbarskiej, p. 113-117.

[15] J. Maik, Włókiennictwo kultury wielbarskiej, p. 117-118.

Archaeologists can determine whether an object is imported or not by addressing the following questions: what is the context of the find (is it found in the proximity of other imports)? is the material from which an object is made local or not? is the technology local? did local people possessed skills and knowledge to produce the object? By answering these questions, textile archaeologist tried to determine whether certain textile types were imported. Unfortunately, they could not get a conclusive answer, due to the reasons I already stated above: the similarity of technology of textile production all around the Roman Empire and in Free Germania, but also the quality of the raw material, i.e. wool, which did not differ from the textiles which were named local.

The wool analyses might be one of the most important factors to determine foreign provenance of the textile. There are three types of wool discernible in archaeological material, from which one is of very high quality, comparable to or even better than the wool of the Merinos sheep, one of the best wool types known today. It has been recognized in 35% of Roman period textiles found on modern Poland territory[16]. This type of wool is probably identical[17] with the wool of *oves pellitae* as described by Collumela[18]. If it is indeed the wool of Roman origin, there are three possibilities of how it could get on the Free Germania territory: on animals, as a raw material or as ready-made textile[19]. All of the possibilities are probable[20]. Moreover, the wool analyses are time-consuming and arduous and despite many interesting results, without material to compare (from Italy for example[21]), they cannot provide us with new information.

The solution for this impasse could be the strontium analysis, a method applied by Karin M. Frei from National Museum in Denmark. The method itself has long been known to archaeologist as a method to determine the

[16] J. Maik, Jak było na początku, p. 103-104, see also P. Walton, Wools and Dyes, p. 61-63.

[17] J. Maik, Tkaniny z pomorskich cmentarzysk kultury wielbarskiej w świetle najnowszych badań, [in:] M. Fudziński, H. Paner (eds.), Nowe materiały i interpretacje. Stan dyskusji na temat kultury wielbarskiej, Gdańsk 2007, pp. 104-105, idem, Włókiennictwo kultury wielbarskiej, p. 67.

[18] Col. 7, 2, 5.

[19] J. Maik, Jak było na początku, p.104; P. Walton, Wools and Dyes, p. 66-67.

[20] Z. Kaczmarek, Tkactwo w relacjach kulturowych Cesarstwa Rzymskiego z Barbaricum (I-III wiek), Gniezno 2016, pp. 156-157.

[21] Much of the material of Italian provenance still await study (M. Gleba, Italian textiles from prehistory to Late Antique times, [in:] S. Bergerbrandt, S.H. Fossøy (eds.), A Stitch In Time. Essays in Honour of Lise Bender Jørgensen, Gothenburg 2014, p. 145).

human or animals migration routes[22]. What Frei did, was to apply this method to ancient textiles.

Strontium is one of the alkali earth metals traceable in soil. It consists of four naturally occurring isotopes, from which three are stable and one, ^{87}Sr, is radiogenic (variable). The strontium isotope method analyzes the variations of ratios of $^{87}Sr/^{86}Sr$. The proportion depends on age, nature and type of the bedrocks. The amount of the radiogenic isotope ^{87}Sr increases in time in rocks rich with concentration of strontium and rubidium. The process of production of radiogenic ^{87}Sr is so slow, that we can assume that the ratios of $^{87}Sr/^{86}Sr$ is constant from the point of view of men's history. Moreover, one can acknowledge the differences in strontium concentration depending on the region, what allows to determine the specifics of the region and so the distinction of the origin of the samples. Frei assumed that, the amount of the isotope ^{87}Sr in soil equals the amount of the isotope in wool of the sheep grazing on that soil. The experiments she conducted proved the thesis right[23] and so the strontium analysis could be applied to textile research.

The method required a couple of supplementary analysis, like the analysis of the contamination of the site or the analysis of the modern sheep wool[24]. But the studies conducted on Huldremose finds have shown the potential ability of the strontium isotopic tracer system to woollen archaeological textiles and other organic fibres as a unique method for characterizing the origin[25].

However revolutionary and promising, the strontium isotope method has serious limitations. First, to determine the provenance of archaeological textile, an information about strontium isotopes ratios in biosphere is needed, i.e. a kind of map, where the isotopic composition of the area where sheep were grazing would be marked[26]. Secondly, due to the fact that the ratios of strontium isotopes in soil are similar in different geographical

[22] K.M. Frei, I. Skals, M. Gleba, H. Lyngstrøm, The Huldremose Iron Age Textiles, Denmark: an attempt to defie their provenance applying the strontium isotope system, Journal Of Archaeological Science 36, 2009, p. 1965.

[23] K.M. Frei, Exploring the potential of the strontium isotope tracing system in Denmark, Danish Journal of Archaeology, 2013, pp. 1-10; eadem, Provenance of Pre-Roman Iron Age Textiles – Methods Development and Application, Copehagen 2010, pp. 15-27; see also Z. Kaczmarek, Pochodzenie tkanin archeologicznych – analiza izotopowa strontu, Studia Europaea Gnesnensia 5, 2012, pp. 343-344.

[24] K.M. Frei, I. Skals, M. Gleba, H. Lyngstrøm, The Huldremose, p. 1965.

[25] Ibidem, p. 1970; K.M. Frei, Provenance Studies of Ancient Textiles: A New Method Based on the Strontium Isotope System, [in:] J. Banck-Burgess, C. Nübold (eds.), NESAT XI, pp. 146-147.

[26] Eadem, Provenance Studies, p. 146.

regions, the results of the analyses cannot be conclusive. Moreover, bioavailable strontium does not always reflect bedrock values of $^{87}Sr/^{86}Sr$, because different factors, like weathering, can influence the variation of the isotope[27]. That is why, the strontium isotope analysis is more suited to determine non-local origin. Thirdly, the method is destructive, that means, that the samples gets destroyed in the process of analysis. The problem is that a rather large sample is required for the purpose of analysis and some of the archaeological textiles are really small. Finally, every contamination of the sample (like for example deposition in the salty water) can be fatal for further analyses[28]. Nevertheless, the strontium isotopic tracer is for now one of the best methods to learn about provenance of textiles.

Another method of exploring the origin of the raw material of the archaeological textiles is light stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$, $\delta^{2}H$). The basis of the method is a fact that there is a connection between the isotopic composition of the body and the isotopic composition of the organism's diet[29]. This means that the isotopic composition of the sheep's body is dependent on the isotopic composition of graze plants, fodder plants and drinking water and hence dependent on the nature and location of the pasture(s) sheep graze on. The isotope values of the plants, on the other hand, depend on the species of the plant and their growing conditions, but also on the rainwater isotope values. The isotope values of the rainwater and plants vary across Europe with climate, reflecting the various influences of latitude, altitude, longitude, continentality and season. Foliar tissue $\delta^{13}C$ and $\delta^{15}N$ values are correlated with mean annual precipitation and mean annual temperature. Foliar water composition reflects local meteoric and groundwater inputs to plants (although the photosynthesis and water transport through the plant can influence the composition as well). The main assumption of the method is that the carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and non-exchangeable hydrogen ($\delta^{2}H$) isotopic composition of archaeological woollen textiles can indicate their geographic origin. The results of the light stable isotope analysis carried out for medieval textiles proved that the method is

[27] Ch.A. Makarewicz, J. Sealy, Dietary reconstruction, mobility, and the analysis of ancient skeletal tissues: Expanding the prospects of stable isotope research in archaeology, Journal of Archaeological Science 56, 2015, p. 150.

[28] K.M. Frei, Provenance Studies, pp. 136-140.

[29] I.C.C. von Holstein, An introduction to Carbon, Nitrogen and Hydrogen Stable Isotope Provenancing for Archaeological Wool [in:] J. Banck-Burgess, C. Nübold (eds.), NESAT XI, p. 151.

suited for identification of non-local materials, although it is easier to detect long distance movements rather than the shorter ones[30].

This method, similarly to the strontium isotope method, requires some extra analysis - it is important to measure the degree of degradation of hair fibres in anoxic waterlogging, in which conditions archaeological textiles are found in Northern Europe[31].

The drawback of the method is that the pasturing and hence the diet of the animals is often influenced by men. The farmers can provide the animals with food and water of another region or send the animals to the different altitude (the upland summer pastures for example) and therefore disturb the described geographical relationship. Those men's actions, which affect sheep's diet and consequently tissue composition differ much according to the region, time period and culture, consequently the modern patterns of variability of the isotopes in herbivore tissue will not be necessarily the same in archaeological material. One must also remembers about taking into account the changes of isotopic composition over longer time scale, *i.e.* the climate changes. Moreover, there are also differences within the sheep flock caused for example by age or health status, however one can expect that the isotope values of sheep wool from a single flock will cluster[32]. Furthermore, the research must also take into account the period of formation and turnover of wool, which is not metabolically remodelled once formed and so its isotopic composition will reflect only the sheep diet of the period between shearing, but bone collagen reflects a herbivore's diet of a longer time period, even a lifetime of an animal. Nevertheless, the samples of wool keratin and bone collagen can be compared within the same site and the same time period. Imported textiles, *i.e.* textiles deriving from different climates or farming traditions, will vary in isotopes values. Similar to strontium isotope analysis, the carbon, nitrogen and hydrogen isotopes analysis is a mass spectrometric technique. The sample also gets destroyed during the analytical process, although one need smaller sample than that required for strontium

[30] Ibidem, pp. 151-152; I.C.C. von Holstein, P. Walton Rogers, O.E. Craig, K.E.H. Penkman, J. Newton, M.J. Collins, Provenancing Archaeological Wool Textiles from Medieval Northern Europe by Light Stable Isotope Analysis ($\delta^{13}C$, $\delta^{15}N$, $\delta^{2}H$). PLoS ONE 11, 10, 2016.

[31] I.C.C. von Holstein, P. Walton Rogers, O.E. Craig, K.E.H. Penkman, J. Newton, M.J. Collins, Provenancing Archaeological Wool Textiles.

[32] I.C.C. von Holstein, An introduction to Carbon., p. 151; I.C.C. von Holstein, P. Walton Rogers, O.E. Craig, K.E.H. Penkman, J. Newton, M.J. Collins, Provenancing Archaeological Wool Textiles; see also Ch.A. Makarewicz, J. Sealy, Dietary reconstruction, p. 148-149.

isotope analysis[33]. The light stable isotope analysis of archaeological textiles is a promising method, which combined with other methods of textile analysis may characterise the non-local origin of wool[34].

Textiles are very impermanent, they can survive in good shape only in extremely rare conditions, like deserts or bogs[35]. The textiles, which survive to our days are often small, colourless (brownish to be more precise), heavily deteriorated. To „read" them properly a specialized studies are required, studies that combine different specialist, representing different areas of sciences, examples of which are given above. Unfortunately, one can acknowledge the lack of standards determining what and how should be analysed[36]. This results in the situation when some textiles (often the „popular" ones – for example from bogs) are perfectly described and analysed and others not. Moreover, they can be easily damaged every time they are examined, what means that they are re-examined only in special need (for example when a new method is being developed). The results of these examinations are published with the use of symbols and language inapprehensible to non-specialists. That is why sharing knowledge about archaeological textiles is very difficult, not only among archaeologist, but also other scholars[37].

This is a reason why a new, non-invasive method of textile analysis should be introduced. The answer to that need could be 3D visualisations. The method is being developed by Maria Cybulska from Technical University of Łódź, Poland[38]. By application of computer graphic method[39], she

[33] I.C.C. von Holstein, An introduction to Carbon, p. 151; I.C.C. von Holstein, P. Walton Rogers, O.E. Craig, K.E.H. Penkman, J. Newton, M.J. Collins, Provenancing Archaeological Wool Textiles.

[34] I.C.C. von Holstein, An introduction to Carbon, p. 153.

[35] M. Cybulska, J. Maik, Archaeological Textiles – A Need for New Methods of Analysis and Reconstruction, Fibres and Textiles in Eastern Europe, 15, 5-6 (64-65), 2007, p. 185; E.H. Peacock, The Contribution of the Experimental Archaeology to the Research of Ancient Textiles, [in:] P. Walton Rogers, L. Bender Jørgensen, A. Rast-Eicher (eds.), The Roman Textile Industry and its Influence. A Birthday Tribute to John Peter Wild, Exeter 2001, p. 184.

[36] Ibidem; J.P. Wild, The Roman Textile Industry, p. 24.

[37] M. Cybulska, J. Maik, Archaeological Textiles, p. 189.

[38] I am grateful to M. Cybulska, PhD, for reading the fragment of the text presenting her method. Any faults are my own.

[39] M. Cybulska, To See the Unseen – Computer Graphic in Visualisation and Reconstruction of Archaeological and Historical Textiles, Computer Graphics, N. Mukai (ed.), London 2012, pp. 213-220; M. Cybulska, T. Florczak, J. Maik, Virtual Reconstruction of Archaeological Textiles, [in:] E. Andersson Strand, M. Gleba, U. Mannering, Ch. Munkholt, M. Ringgaard (eds.), North European Symposium for Archaeological Textiles X, Oxford 2010, pp. 36-37; M. Cybulska,

reconstructs textiles found on Polish archaeological sites. This provide an opportunity to reconstruct the general look of the textiles, the complexity of the textile's structure, generally the properties the textile had in the past. The reconstruction can be static or animated, the latter allows to rotate the object or to place it in a different background, like the find context. For the first time this method was used to reconstruct the textile form Leśno, Pomerania[40]. It is worth mentioning that the method is also suited to reconstruct even highly degraded textiles[41] and, together with the experimental archaeology (see below), to create the visualisation of the textile, which is only known from its description in ancient sources[42].

This method has to face some difficulties. In order to reconstruct the textile one has to have knowledge about the object, the results of textile analysis, *i.e.* information about raw material, dyes, structure of the object and its components[43]. When those data are unavailable, the information about analogical objects is used (textiles from the same time period, place or of the same type[44]).

Of course, the method of textile reconstruction is well known on the field of experimental archaeology, *i.e.* practical tests performed to answer the questions related to archaeological data[45]. Although the method is quite controversial (there is a constant problem with its definition and it has been questioned as a scientific method[46]), it is still being developed. Therefore, a special guidelines for experiments were created in order to keep the results reliable, clear and easy to relate to[47]. These rules remind those of the natural

R. Pancer, Analysis of woven fabrics using image analysis, Proceedings of VI International Conference ArchTex 2004, pp. 124-129.

[40] M. Cybulska, Reconstruction of Archaeological Textiles, Fibres and Textiles in Eastern Europe, 18, 3 (80), 2010, pp. 101-102.

[41] Eadem, T. Florczak, J. Maik, Virtual Reconstruction, pp. 36-37.

[42] E. Andersson, M. Cybulska, Textile Production, Tools and Technology – How to Make Textiles Visible on the Basis of an Interpretation of an Ur III text, [in:] H. Koefoed, M.L. Nosch, E. Andresson Strand (eds.), Textile Production and Consumption in the Ancient Near East. Archaeology, Epigraphy, Iconography, Oxford 2012, pp. 113-127.

[43] M. Cybulska, Reconstruction of Archaeological Texti, p. 100.

[44] See M. Cybulska, S. Kuberski, J. Maik, E. Orlińska-Mianowska, Figural Embroidery from Tum Collegiate Church – Analysis, Reconstruction and Identification, [in:] J. Banck-Burgess, C. Nübold (eds.), NESAT XI: The North European Symposium for Archaeological Textiles XI, Rahden 2013, pp. 205-213.

[45] E. Andersson Strand, Experimental Textile Archaeology, [in:] E. Andersson Strand, M. Gleba, U. Mannering, Ch. Munkholt, M. Ringgaard (eds.), North European Symposium for Archaeological Textiles X, p. 1; E.H. Peacock, The Contribution, pp. 182-183.

[46] Ibidem, pp. 1-3.

[47] E. Andersson Strand, Experimental Textile Archaeology, p. 2.

sciences' experiments and thus give a proper methodology for better understanding the use of for example textile tools. The results of the experiments, although concern different time periods, can be easily converted to the Roman period, since the weaving technology changes slowly.

The problem is that the experiments in archaeology are very difficult to conduct, one has to be a skilled weaver him- or herself, and time consuming (the work can take up to several months). Furthermore, it is also very costly as not only the raw material and the labour costs, but replicas produced this way need proper storage and conservation (just like archaeological textiles)[48].

Another example of cooperation between archaeology and technical sciences is the PENELOPE Project. It is situated at the Research Institute for the History of Technology and Science at Deutsches Museum in Munich and the research team consists four scientists representing different areas of knowledge: from philosophy to mathematics and programming. The Project's aim is „to integrate ancient weaving [mainly ancient Greece – Z.K.] into the history of science and technology, especially digital technology"[49]. With the purpose of completing the task ancient sources and weaving techniques are being analyzed. There is a PENELOPEan laboratory where ancient models and topologies are being detected and where codes are being developed to virtually explore those models[50]. The idea of using codes in textile research comes from the assumption that weaving is digital from the very beginning[51], *i.e.* the weavers calculated the weaving patterns and that is why it is possible to use digital tools for simulating them. The pattern matrix, which was created in PENELOPEan laboratory, is well suited for exploring ancient models of textile weaving and it is better than the knowledge of the experienced weaver, because the weaver can never fully explore the patterning possibilities of the upright loom, since the process of creating and recreating patterns is time consuming. This is the reason why a new simulation tool was needed. The works on the device have just begun, the project aims high, wanting to develop a live coding setting for a warp-weighted loom and to construct the mechanism that operates the loom or

[48] M. Cybulska, Reconstruction of Archaeological Textiles, p. 100.

[49] Penelope a study of weaving as technical mode of existence [online]. Penelope [2017-02-02]. Available at: <http://penelope.hypotheses.org/1>.

[50] Ibidem.

[51] For more information visit: Weaving codes – coding weaves [online]. Kairotic [2017-02-07]. Available at: <http://kairotic.org/about/>, see also E. Cooker, Live notation: reflections on a kairotic practice, Performance Research, Journal of the Performing Arts, 18, 5, 2013, pp. 69-76.

even undo the weaving, just like the mythological Penelope did[52]. Since the project has just started (October 2016) and will last five years, it is difficult to determine what will be the results

In the light of ancient sources, both material and literary, the Roman textile industry is highly developed. There are organisations of the weavers and textile traders, even the state *gynaecea* (from the 4th century AD), and personal careers based on textile production, like the one of the Secundinii family[53]. We can also acknowledge the impressive knowledge about sheep breeding and wool processing. The iconographical sources, the funerary reliefs, inform us about the care which the vendors showed towards the ready-made textile (*i.e.* scenes of inspection[54]). From the written sources we can also learn about the textiles[55] and sheep[56] being transported over large distances.

Textile industry on the territory of Free Germania was on the high level of development as well, what can be the best exemplified on the cloaks called *Prachtmantel*, if they were of Germanic origin[57]. There are not as many sources to document textile production and consumption in Free Germania as there are for the Roman Empire, but we can acknowledge the high quality of wool in the archaeological textiles (better than the wool of the Pre-Roman Iron Age and the wool of Migration and Medieval Periods) and the plurality of textile types, which all can be found also within the Roman borders. There are no basis to assume that *Germani* did not possess the skills or abilities to weave more complicated textiles like *Virring* or *Mogontiacum*, since they

[52] Laboratory [online]. Penelope [2017-02-07]. Available at: <http://penelope.hypotheses.org/laboratory>; E. Harlizius Klück, AlgoMech symposium –– PENELOPE [online]. YouTube [2017-02-08]. Available at: <https://www.youtube.com/watch?v=a5lOH5Dp_Eg&feature=youtu.be>.

[53] J.F. Drinkwater, The Wool Textile Industry of Gallia Belgica and the Secundinii of Igel: Questions and Hypotheses, Textile History 13, 1, 1982, pp. 111-128.

[54] A. Young, Representations of Cloth Vendors and the Cloth Trade on Funerary Reliefs in Roman Gaul and Italy, [in:] D. Cardon, M. Feugère (eds.), Archéologie des textiles des origins au Ve siècle. Actes du colloque de Lattes, octobre 1999, Montagnac 2000, pp. 221-226.

[55] Treb. Poll., Gall. (SHA) 6,4 – this is just an anecdote about the emperor Gallienus, but it illustrates well the possibilities of the textile transport in Roman Empire.

[56] Iul. Cap., Maxim. (SHA) 12, 6, 8; Fl. Vop., Prob. (SHA) 14, 3; Cass. Dio. LXXII, 11, 2.

[57] Although it was discussed whether a type of clothes named by Schlabow *Prachtmantel* was the same type of clothes the Romans called *sagum* (and thus of Gallo-Roman origin), it seems that this kind of cloak was typically Germanic, which thesis can be confirmed by, for example, the iconographical evidence: J. Maik, Wyroby włókiennicze z grobu książęcego nr 1 w Leśnie, st. 1, [in:] K. Walenta, Leśno i mikroregion w okresie rzymskim, Chojnice 2009, p. 234, 239-240; L. Bender Jørgensen, J.P. Wild, The Roman Textile Industry, pp. 71-73, 82-84; K. Schlabow, Textilfunde der Eisenzeit in Norddeutschland, Neumünster 1976, pp. 61-68.

were able to weave *Odry* and *Donbæk*[58] textiles, also of very high quality (*Odry* – 2/2 twills, most frequently made from 4z/4s spun yarns, 10-16 threads per cm, *Donbæk* – spin patterned twills, 4z,4s/4z,4s or the dog's tooth pattern 16-20 threads per cm).

This high level of textile industry on the territory of Free Germania, especially when compared to earlier and later periods, can create some problems. The most important is whether Romans are the ones, who influenced the sheep breeding and thus the textile industry in general on this territory? There are no doubts that Germanic tribes imported textiles as evidenced by the already mentioned silks and knotted pile rugs[59], same there are no doubts that Romans exported (whether willingly or by the means of spoils is not an issue here) their material culture to Free Germania. In case of textiles we can also acknowledge that the Germans exported their textiles into the Roman Empire. The best known example are trousers, which characteristically barbarian, were used by Roman troops as the best costume in the Northern climate[60]. We can also acknowledge the presence of Roman captives on these territories[61], but also suppose that the mixed marriages between Roman citizens and „Barbarians" existed. This means that the transfer of technology could be done not only by importing/exporting ready-made textiles, but also by exchanging ideas. Nevertheless, both worlds stayed in constant contact mutually benefiting from each other. But still the question is how deep these contacts and therefore influences reached? As I already stated above, for now it is impossible to survey this issue on the basis of traditional historical methods.

That is why the methods I described above bring hope that this time the science will help to address this crucial problem of the textile industry in Roman times or at least will help to understand its complexity. Despite its flaws, the most promising is the strontium analysis, especially when

[58] L. Bender Jørgensen, North European Textiles, pp. 56-57, 126-127.

[59] However an interesting example of probable import is a cross-tunic found in Reepsholt Mose, its width and its shape are more suited for the warmer climate, what may indicate its southern origin (J. Kolendo, M. Mączyńska, Opis stroju germańskiego w Germanii Tacyta. Próba konfrontacji tekstu i danych archeologicznych, Kwartalnik Historii Kultury Materialnej 3, 1991, p. 255; M. Hald, Ancient Danish Textiles from Bogs and Burials. A Comparative Study of Costume and Iron Age Textiles, Copenhagen 1980, p. 336-338; K. Schlabow, Textilfunde, pp. 75-76).

[60] N. Morley, Trade in Classical Antiquity, Cambridge 2007, p. 22; L. Bender Jørgensen, Forhistoriske textiler i Skandinavien (Prehistoric Scandinavian Textiles), Kopenhaga 1986, p. 351; J.P.V.D. Balsdon, Romans and Aliens, London 1979, p. 221.

[61] Cass. Dio LXVII, 6; J. Kolendo, Jeńcy rzymscy w Barbaricum i ich wykupywanie, [in:] idem, Świat antyczny i barbarzyńcy. Teksty, zabytki, refleksja nad przeszłością, Warszawa 1998, pp. 221-229.

combined with other methods of light stable isotopic analysis, also described above. The works on those methods continue and hopefully most of their drawbacks will be eliminated. However both methods cannot give a definitive answer where did the given textile came from. Basing on the result of the isotope analysis it is only possible to determine whether a textile was local or non-local.

The 3D visualisations on the other hand, are essential for building a bridge between the textile archaeologists and other researchers, who find it difficult to follow specialized rapports from textile analyses and therefore are incapable to include archaeological textiles in their studies. The method is also important for reconstructing the structure, the „look" or the find context, which can also be important, especially when we consider the possibility of importation.

The PENELOPEan pattern matrix is a completely new tool giving opportunity to recreate the possibilities of the upright loom. Although the works focus mainly on the period of Greek Antiquity, the weaving technology did not change until the Roman times, so it will also give insight into the Roman weavers abilities. Hopefully, when the works on the project are completed, we will know more about the richness of textile patterns in Antiquity. It is important as textiles are perishable source and are rarely found in the archaeological material.

We can also expect new and interesting results from experimental archaeology. Textile tools, opposite to textiles themselves, are often found during excavations, but until very recently, basing only on these finds, we were not able to reconstruct the details of textile productions. Thanks to the experimental archaeology the situation changes and, although archaeological textiles are still irreplaceable, we are able to say more about the kinds of threads and the materials produced on the site basing only on the textile tools.

Today, researchers have many methods to investigate archaeological textiles, some of them I only managed to mention in the text. There are traditional comparative and anthropological studies, classical written sources analyses, typical fibre counting, determining the spin direction and other recognition techniques[62], context analysis and function analysis. There are

[62] The 21st century brings new devices for those analysis, i.e. microscopes, which give new possibilities of material analysis (even in situ) owing to the large depth of focus of the images (A. Fisher, Current Examination of Organic Remains using Variable Pressure Scanning Electron Microscopy [VP-SEM], [in:] E. Andersson Strand, M. Gleba, U. Mannering, Ch. Munkholt,

also methods like 14C dating techniques or chemical analysis. The projects which combine history, archaeology and natural sciences, described above, bring better understanding of ancient textile technology and the new possibilities of ways one can employ textiles for better recognition of not only everyday life, but also the cultural exchange, trade, migration or even warfare[63] in Antiquity. In case of textile production and consumption in Roman Provinces and Free Germania, it is important to develop traditional methods of analysing archaeological textiles, which, for now, are the best way to learn about textile industry in Free Germania. It is equally essential to determine what and how should be analysed, to eliminate the problem of disproportionate description of textile finds. New methods to determine the provenance of textiles cannot yet provide us with answer concerning the intensity of Roman influence in Free Germania or the possibilities of the influence of the Germanic tribes on Roman provinces, since they only give information about whether the product was locally made. This information is also valuable and it gives hope, that maybe one day these methods will achieve the accuracy we need to determine the place of production. Either way, I believe that the textile research can enrich our knowledge about the past, providing us with information which no other material or written sources can give – information about cultural attitudes of ancient societies, since clothing is a crucial part of one's cultural identity.

Summary

The researches on archaeological textiles are gaining on popularity not only among archaeologists but also among other scholars. The 21st century, owing to technological development, brings new devices and new methods of textile analysis. And since textile industry was vital for Roman economy and trade and clothes are one of the key-elements of one's identity, they should also find their rightful position in modern archaeological and historical studies.

M. Ringgaard (eds.), North European Symposium for Archaeological Textiles X, pp. 57-62). There are also new microscopic techniques allowing to identify in non-destructive way the original fibres and providing the conservators with useful information (Ch. Margariti, D. Eastop, G. Moraitou, P. Wyeth, Potential and Limitations of the Application of FTIR Microscopy to the Characterization of Textiles excavated in Greece, [in:] E. Andersson Strand, M. Gleba, U. Mannering, Ch. Munkholt, M. Ringgaard (eds.), North European Symposium for Archaeological Textiles X, pp. 162-166).

[63] S. Mōller-Wiering, War and Worship: Textiles from 3rd to 4th-Century Ad Weapon Deposits in Denmark and Northern Germany, Oxford 2011.

One of the most urgent problems of the Roman textile research is the question of the so-called imports. These are very fine fibres, often found in sepulchral context and accompanied by object of doubtlessly Roman provenance. The status of textile types *Virring* and *Mogontiacum* as Roman imports has been widely discussed, in contrast to silk and knotted pile rugs, which could only get to Northern Europe through Roman traders. New methods and perspectives, which are presented in my contribution, aim to solve the problem of the provenance of archaeological textiles and to expand our knowledge of the development of textile industry.

Following methods of textile analysis were presented: strontium isotope analysis, carbon, nitrogen and hydrogen stable isotope provenancing for archaeological wool method and 3D visualisations, but also latest project like PENELOPE. These projects which combine history, archaeology with technology and natural science, are only examples of the new directions in textile and textile tools analysis. They bring better understanding of ancient textile technology and give new possibilities of ways one can employ textiles for better recognition of not only everyday life, but also the cultural exchange, trade, migration or even warfare.

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