

# Archaeological Textiles Review

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Dear Readers,

If you are one of the many who have enjoyed the visual textile abundance in the popular Netflix drama series *Bridgerton*, which is based on the books by Julia Quinn, you are familiar with this short but powerful introduction and know that it heralds something super exciting. In the world of the *Archaeological Textiles Review* (ATR), “Dear readers” is the signal for a new issue of the journal containing a mix of interesting articles including Icelandic and northern mittens, Inuit clothing, an interesting textile survey, and millennia of Danish wool fibres. Maybe this is not quite as colourful as an episode of *Bridgerton*, but it is definitely not bland.

This issue also showcases the profusion of new research projects focusing on archaeological textiles and on textile heritage. The pages in ATR 66 report only a selection, but they still illustrate the vitality of the textile research field and promise new knowledge and future research. This is particularly well exemplified by the recent foundation of a new research centre dedicated to archaeological textiles, hosted by the Sapienza University, in Rome, Italy. The new A3Tex centre will focus on the integration of archaeometry into textile heritage research. We are looking forward to hearing more about it, seeing its activities grow, and reporting them here!

In other news, Eva Andersson Strand became professor in archaeology at the University of Copenhagen and was presented with a *Festschrift* which was (astonishingly) kept a complete secret from her for more than two years despite the stellar cast of authors who contributed to it from across Europe. We all know how fast news spreads through the textile network. Successfully swearing so many people to silence was quite an accomplishment.

This year we are sad to report the loss of textile research pioneers Nettie K. Adams and Amica Sundström. Nettie K. Adams was a textile archaeologist from the US, who drove the discipline through her life-long work on Nubian textiles in Egypt and Sudan. Nettie’s personal archives were accepted at the Centre for Textile Research (CTR) by ATR co-editor Elsa Yvanez, who had the opportunity to compile a comprehensive obituary tracking Nettie’s career and her rich bibliography. Amica Sundström from Sweden, who passed away far too young, was a dear and very much appreciated colleague. She was a competent and capable craftsperson within the world of north European textiles. Amica was among those educated at the Weaving School in Borås in Sweden. It was here that she was introduced to the North European Symposium on Archaeological

Textiles (NESAT) community for the first time through her participation in the 1996 conference (NESAT VI). In 2018, she was employed at the Swedish History Museum in Stockholm as curator of their amazing textile collections, including the Viking Age Birka textiles which she competently and openly shared with interested colleagues. Amica Sundström will be deeply missed. A memorial fund has been established in her honour. It will provide scholarships for people who work with textiles. Her friend and colleague Maria Neijman (who wrote the obituary in this issue) and Amica’s daughter, Ester Spetz, are collecting donations for it. For details on how to contribute, see the Historical Textiles Facebook page and search for “memorial” (<https://www.facebook.com/historicaltextiles1/>).

A new feature for this issue is the “trip down memory lane” by Lise Bender Jørgensen, who shares her lifetime of interesting work with us all. It is a lovely testimony to research before the digital age but also to the power and importance of personal relationships. Such bonds are fostered by in-person get togethers and collaborative projects. This year’s section reporting conferences and projects rivals last year’s impressive achievements and there is no doubt that these events will have sowed the seeds of forthcoming friendships and professional exchanges. They all show how textile research keeps growing and is able to attract both talented people and substantial funding.

Achievements for people in ATR’s editorial team include Elsa Yvanez’s appointment as the new director for CTR from 2025 and Jane Malcolm-Davies is now associate professor and senior lecturer in textile studies at Uppsala University.

Keep sending articles in good time for our annual deadlines, and please take great care to conform to the author’s guidelines. The deadline for articles for each issue is the 1 May. We need project reports preferably before the end of June but we can accept conference reports right after the conferences, if they are held no later than 30 November. The same deadline applies to all other announcements.

All the past issues of ATR are available from the website (<https://atnfriends.com/>) but it is still possible to order a printed copy of any of the journals from the web shop at the University of Copenhagen in Denmark ([www.webshophum-en.ku.dk/shop/archaeological-textiles-664s1.html](http://www.webshophum-en.ku.dk/shop/archaeological-textiles-664s1.html)).

So – Dear Readers – please do enjoy ATR 66 and spread the word about it. The ATR editorial team wishes you a colourful and super exciting new academic year 2025.

*The Editors*

Lise Bender Jørgensen

# Textile research in the recent pre-digital past

## Introduction

Recent decades have seen great changes in textile research, introducing digital microscopes, digital photography, databases, and a series of new methods such as CT-scanning, AMS dating, SEM microscopy, EDS Spectroscopy, dye analysis by HPLC and UPLC, strontium and stable isotope analyses, aDNA analyses, etc. Even publications are now mainly digital, preferably in Open Access. How was it possible to carry out textile research before the digital revolution? Here, I tell the story of my work on archaeological textiles in the 1970s and 1980s. This included visiting museums in most of Northern Europe at the time of the Iron Curtain, followed by field work in Egypt during the 1990s.

## Beginnings

My interest in textiles started almost 60 years ago, when as a teenager I took part in an international work camp at what is now called *The Land of Legends*, located in Lejre in Denmark (<https://sagnlandet.dk/en/about-lejre-land-of-legends/>). At one point, the person in charge of the group was unwell. To keep us occupied, the leader of the textile workshop, Nina Rathje, took charge and dressed us in Iron Age clothing, so that we could act as Iron Age people and entertain the visitors. She also taught us to spin on a hand spindle. I enjoyed that and continued to practice it. When, a few years later, I began studying archaeology, my skill with the spindle proved useful at public events on excavations and at the National Museum of Denmark in Copenhagen (fig. 1). I also demonstrated weaving on a warp-weighted loom, and tablet-weaving (Bender Jørgensen and Foltmann 1974). After one such event, a fellow student suggested that I should do my

*mag.art.* thesis on textiles. When my professor Carl Johan Becker agreed, I went on to learn weaving at an evening school, taught by Inger-Grethe Hjortkjær. She was a close friend of the textile conservator at the National Museum, Else Østergård (Skals and Bender Jørgensen 2018) and she told Else Østergård of this unusual pupil she had who only wanted to make brown fabrics. In this way I was introduced to Else Østergård. When I began asking how the different weaves were constructed, they recommended that I followed a specialised course on weaving theory taught by the Printer's and Weaver's Guild which I did during the winter 1974–75.

## A happy chance

In 1972–73 I took part in the excavation of Early Roman and Viking period burials at Stengade on the island of Langeland in Denmark (Skaarup 1976). Here, remains of textiles were often found attached to metal artefacts in the burials. The excavator, Jørgen Skaarup, knew that I was interested in textiles, and had confidence in my abilities. He told me: 'you're writing the chapter on textiles in my book', and gave me time off from digging to study the textiles in the museum, borrowing the conservator's microscope. I was very green but thought that I could do it by comparing my results with those of Margrethe Hald's doctoral dissertation (Hald 1950; 1980). In this, I got a surprise. While the Stengade textiles from the Viking period fitted well into Margrethe Hald's work, those from the Early Roman period did not. They were mainly made from z- or z/s twisted yarns and therefore corresponded with Margrethe Hald's Corselitze group that was dated to the Late Roman/Migration period, rather than with her early Iron Age Huldremose group as I



Fig. 1: Demonstrating spindle spinning at the excavation of a Viking period village at Trabjerg in 1974 (Image: Torben Skov)

had expected (Bender Jørgensen 1976, 205–206). I also realized that I had more *dated* textiles from Stengade than Margrethe Hald had for her entire doctoral dissertation – based as it was on Danish bog finds that could not be dated very well at that time. This gave me a research question: Why were the Stengade textiles different? And a method: small textile fragments attached to *datable* artefacts in burials with known find spots made excellent data, numbers making up for their small size.

### Roman Iron Age textiles in Denmark

For my *mag.art.* thesis, I rummaged the stores of the National Museum of Denmark for burials dated to the Roman Iron Age. This resulted in 157 finds, mainly from the first to third centuries CE. Sorting them chronologically as well as mapping them made it clear

that textiles with s-twisted yarns, a hallmark of Hald's Huldremose group, were only found in the northern parts of Denmark, while textiles with z-twisted yarns, as in her Corselitze group, were restricted to southern Denmark. This was further emphasized later when finds from neighbouring countries were added to my maps. Further, warp-locks, Margrethe Hald's evidence for a tubular loom, were found in northern Denmark but not in the south; here, on the other hand, starting borders and loom weights suggested that the warp-weighted loom prevailed. These results, combining chronology and geography, gained me my degree (Bender Jørgensen 1998a, note 4), and the method has remained at the core of my work (Bender Jørgensen 1979).

### Making friends

It was a lonely passion studying textiles in Denmark in the 1970s. The professor was positive but had neither specialist knowledge nor any particular interest in this field of research and had little help to offer. Moreover, he told me that Margrethe Hald was a difficult woman, which discouraged me from contacting her. Margrethe Hald had already retired from her position at the National Museum of Denmark in 1967, and in fact I never met her before she died in 1982. So instead, I went on a study trip to the Textilmuseum Neumünster in Germany in 1975 and met its young curator, Klaus Tidow and this was a revelation. Finally, someone who immediately understood what I was talking about! We kept contact, and a few years later, when I had taken my degree and was working as education officer at Langelands Museum, we met again and decided we wanted to meet the other textile scholars. This resulted in the first North European Symposium for Archaeological Textiles (NESAT), held at the Textilmuseum Neumünster in 1981 (Bender Jørgensen and Tidow 1982). That gave me a lot of new friends and colleagues, such as John Peter Wild from the University of Manchester, Frances Pritchard of the Museum of London, Sandra Comis of the Albert Egges van Giffen Instituut in Amsterdam, Jerzy Maik of the IHKM PAN, Lodz, Poland, and Bente Magnus from the University of Bergen, Norway, all of whom were of great help in the coming years (Bender Jørgensen 2010).

### Widening the scope

In 1982 I got a three-year grant from the University of Copenhagen to continue my work, widening my scope from the Danish Roman Iron Age to include all textile finds until the end of the Viking Age. I immediately set about going through the stores of the

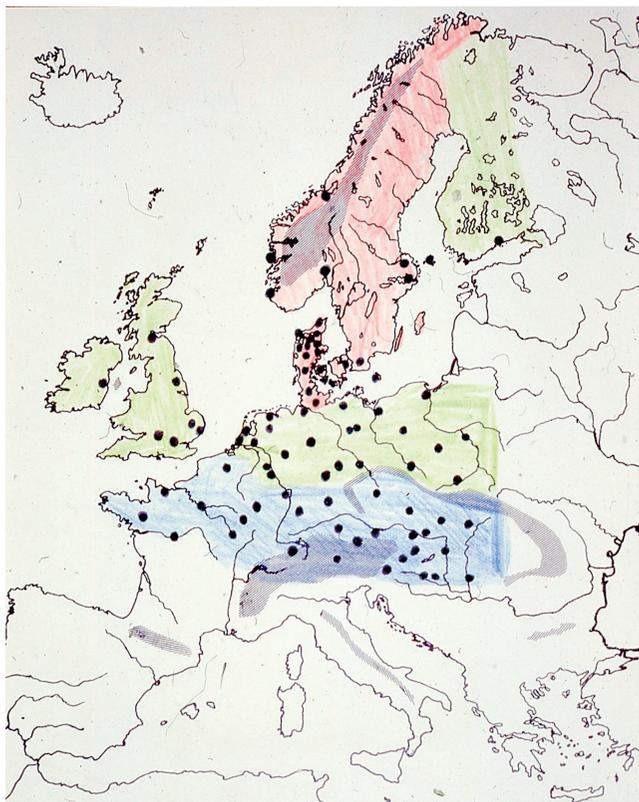


Fig. 2: Map of Europe showing museums visited 1982-87 (Image: Lise Bender Jørgensen)

Danish museums, and then on to the main museums in Sweden and in Norway (Bender Jørgensen 2013). This resulted in about a thousand new records of sites with textile remains (Bender Jørgensen 1986). The following years I went on to the United Kingdom, to Ireland, the Netherlands, and the northern parts of what was then Western Germany. In 1984, Eastern Germany, Poland and Finland followed (Bender Jørgensen 1992a). A grant from the Carlsberg Foundation made it possible to add Central Europe in 1987 (Bender Jørgensen 1991; 1992a; 2005a). In total, I visited almost 100 museums in what was then 16 countries (fig. 2). The records made during these journeys meant that I could define a number of textile types and map their distribution. On my way, I was helped by the colleagues I had met at the NESAT conferences. I also met several new fellow textile scholars, who became part of the NESAT community.

### Behind the Iron Curtain

All of this work was undertaken when the Iron Curtain was still in place dividing Europe into an open west and a very closed east (Bender Jørgensen 2013). It also meant that in order to work behind the

Iron Curtain, planning had to be done well in advance, starting with choosing and writing to the museums I wanted to visit, suggesting a date, and hoping for a quick reply. If no answer came, I usually asked the staff at the first museum if they would check with their colleagues at the museum that did not reply. If it was the first museum that hadn't answered (luckily, this only happened once), I telephoned them. After lots of clicks on the line I got through, a surprised voice answered, but yes, of course, they had got my letter and were expecting me. Hotel reservations also had to be done early, paid for in advance in western currency, and could not be changed. I had to guess how much time I needed at each museum; sometimes it was too little, which was frustrating, but it could also prove too much. In those cases, I had a lot of time to kill.

On arrival, I was usually received by the Director who wanted to know what I was doing. For this, my distribution maps of textiles with s and z-twisted yarns in Early Roman Period Denmark (Bender Jørgensen 1986, figs. 210–211) proved very useful. After a coffee, I was handed on to the relevant staff and taken to the storerooms. Here, I would organise my work base, ask for a lamp for my microscope, proceed to find out how the stores were organised, and start looking for items from inhumation burials. In East Germany, the staff assisting me were forbidden to fraternise with me after work; nonetheless, some did, and it was a special pleasure to be able to welcome the textile conservators Antja Bartel and Heidemarie Farke to the NESAT meetings after 1989, when the demolition of the Berlin Wall eventually resulted in a reunified Europe. In Poland, things were easier, as it was the time of the



Fig. 3: My working equipment: a binocular microscope borrowed from the National Museum, previously used by Margrethe Hald; half-hidden behind it my box of insect pins; a borrowed lamp; and a stack of filled-out index cards. The measuring tape is not in evidence; it was probably around my neck (Image: Lise Bender Jørgensen)

*Solidarnosc* movement which many sympathised with. I also had a couple of friends in Poland, notably Jerzy Maik that I met at the first NESAT in 1982, and Andrzej Prinke who took part in the Stengade excavation on Langeland in 1973 and who turned out to be the person commissioned to help me at the Poznan Museum. Still, the country was under martial law, and all kinds of supplies were short. I therefore travelled with cardboard boxes full of coffee and other western delicacies as gifts for colleagues, as well as spare parts for my car, a green Fiat 127 that faithfully brought me around on my long adventurous journeys.

### How did I do it?

My main recording tool was a simple binocular microscope without a lamp or any other finesse as I never knew what conditions I would meet in the various museums, especially behind the Iron Curtain (fig. 3), but they usually had a lamp I could borrow, and access to electricity. Further, I brought a box with insect pins and a measuring tape, and pre-printed index cards on which I noted my description of the textile I

was examining, its find place, museum number, and – if possible – a list of all items in the burial (fig. 4). Many of the textiles I found derived from sites that were published or catalogued by the excavator or other scholars. If that was the case, details of the publication were noted too, to be looked up in the library back home. There was also a space for the place and date of recording it. Dating the finds was anyway essential, so I brought a sheaf of chronological charts such as Reinecke's and Müller-Karpe's phases Bz A–D and Ha A–D for the Bronze and early Iron Ages, Eggers' *Stufen* and Almgren's Fibula types of the Roman Period (Almgren 1923; Eggers 1951; Müller-Karpe 1959) and others. In order to locate the find spots on a map I bought local road atlases, which were often sufficiently detailed for looking up most locations.

This was well before the creation of databases, so I organised my index cards in archive boxes, according to country and date, and findspot (fig. 5). My travels across Europe resulted in six such boxes containing thousands of records of textiles from North and Central Europe.

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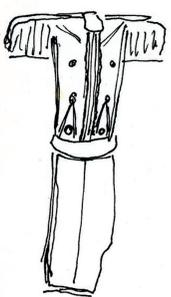
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b	Reps bort med alle æggen 2/2 kiper i 2/2 gesn, ca 12/14-16 målt over 1/2 m. Kiper: 205 1/2, lodtal: ca 24/8-16					
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Fig. 4: An example of a completed index card (Image: Lise Bender Jørgensen)

## Before computers

In 1986 I got my first word processor, an Amstrad CPC – up to then, everything had been written on a typewriter. Texts usually had to be written three times: first a rough draft, then an improved draft, and finally a clean copy that could be sent to the printers. Copies were made by inserting one or two layers of carbon paper. Illustrations were either drawings on paper, made by a professional from my drafts, or prints of photos, usually ordered from the museum that possessed the textile, as I took very few photos myself. Getting a computer was a miracle, allowing multiple changes without re-writing the whole thing. Illustrations slowly became digital too.

When we edited the first two NESAT volumes, everything was typewritten, illustrations few and preferably presented as drawings as the printing quality we could afford did not accommodate photos very well (Bender Jørgensen and Tidow 1982; Bender Jørgensen et al. 1988). For the NESAT 4 volume that I organised with archaeologist and curator at the National Museum of Denmark Elisabeth Munksgaard (Bender Jørgensen 1998b), all contributions except three were submitted on paper, but typing them onto my new Mac computer proved a useful way of getting to know it. Printing was done cheaply in Hungary, paper and photo quality were improved (Bender Jørgensen and Munksgaard 1992). Six years later, when editing the NESAT 6 volume, I had been given a PC at my new job at the Norwegian University of Science and Technology in Trondheim, Norway and learnt the use of it in the same way as I had the Mac. This time, all papers except three were submitted as digital files; one author had sent the illustrations in digital form too, almost causing me to panic as I could not see them and did not know what to do with them (Bender Jørgensen and Rinaldo 1998). My book on Scandinavian textiles (Bender Jørgensen 1986) was entirely typewritten, the next (Bender Jørgensen 1992) was based on early computer files, but none of the illustrations were digital.

## Specialist analyses and collaboration with textile craftspeople

During my visit to the UK in 1983, I had met Penelope Walton (later Walton Rogers) who worked on the textiles from Viking York and other sites in Britain (Bender Jørgensen and Pritchard 2023). She also carried out wool and dye analyses using recently developed methods such as Michael L. Ryder's system of fleece typing (Ryder 1969; Wild and Walton Rogers 2015), and G.W. Taylor's method for measuring light

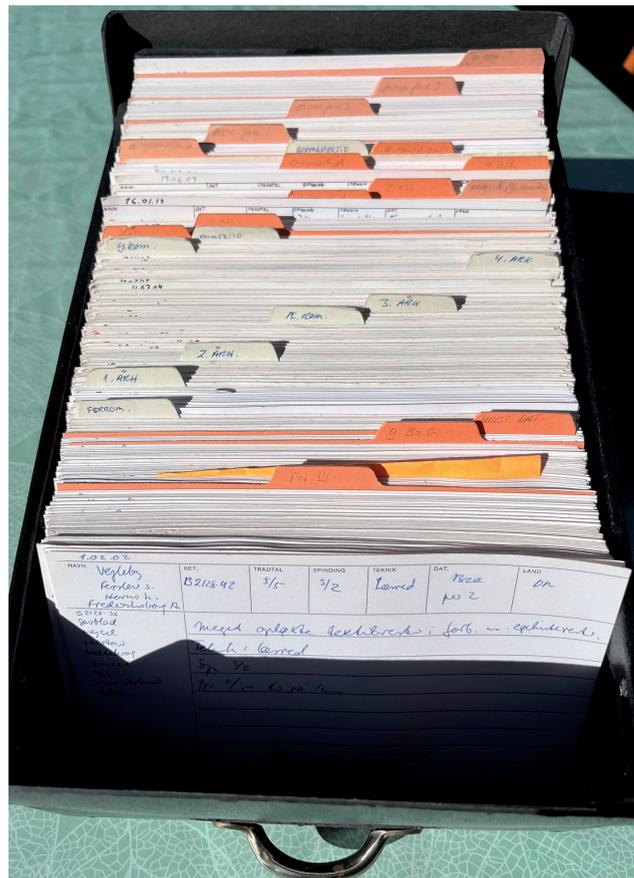


Fig. 5: Box of index cards of textile finds from Denmark, sorted according to chronology and topography (Image: Lise Bender Jørgensen)

absorption with a U.V./Visible spectrophotometer and thin layer chromatography (Taylor 1983). This led to Walton examining a series of samples from Danish, Norwegian and German textiles for fleece types and various dyes (Bender Jørgensen and Walton 1987, Walton 1990).

Throughout my career I've often worked with textile craftspeople. Learning weaving from Inger-Grethe Hjortkjær and the weaving theory course meant that I understand the basics of the craft and can discuss it with experienced weavers. Over the years, I've worked with several of the weavers from Lejre in Denmark, and when Anna Nørgård began working as an independent handweaver specializing in making museum reconstructions (Nørgård 2021), she was included in the King Canute's clothing project where a tailor, a designer, an embroideress, a silk weaver, a tablet weaver, a shoemaker and I worked together, along with Else Østergaard and Elisabeth Munksgaard from the National Museum of Denmark (Bender Jørgensen 1992b).

When I moved to Sweden in 1993, I met Christina Rinaldo, Head of the Weaving School at Borås University close to Gothenburg in Sweden (Bender Jørgensen 2019), and here I met two of her students, Lena Hammarlund and Martin Cizuk, who became involved in the Mons Claudianus textile project (Cizuk 2000, 2004; Cizuk and Hammarlund 2008). I also co-organised NESAT 6 in Borås together with Rinaldo. Later, in 2002, I was offered an adjunct professorship in textile science/handloom weaving at Borås University, and taught philosophy of science and research methodology to students of handweaving, textile and fashion design as well as textile engineering. After my move to Norway in 1996, I met Amy Lightfoot who ran a textile workshop specializing in producing wool sails for Viking ships. This led to a project, *Textiles of Seafaring*, involving the craftspeople at Amy Lightfoot's workshop as well as Anna Nørgård and Lena Hammarlund (Bender Jørgensen 2005b; Cooke and Christiansen 2005; Cooke, Christiansen and Hammarlund 2002; Lightfoot 1997; Nørgård 2016).



Fig. 6: Working away on textiles from Mons Claudianus, measuring tape around my neck (Image: Ulla Mannering)

## New challenges in Roman Egypt

In 1989 I was approached by a professor in Papyrology from the University of Copenhagen in Denmark, Adam Bülow-Jacobsen, on behalf of an international team excavating the Roman quarry at Mons Claudianus in Egypt. He wanted me to look at the textiles they kept finding in still greater numbers. I was hesitant as I knew that Gillian Vogelsang-Eastwood, living in Leiden in the Netherlands, had already been asked to be the site's textile specialist. For various personal reasons her trip to Egypt had been postponed several times, and as the number of textiles kept increasing, the excavators were getting impatient. I thus phoned Gillian, asking what to do, and we ended up deciding that I should accept, and then come to her in Leiden to be coached for the task. Gillian also had another project on hold, a late Roman fort at 'Abu Sha'ar, and I ended up taking that on too (Bender Jørgensen and Vogelsang-Eastwood 1990). Both sites had lots of textiles combined with very precise datings. At Mons Claudianus the thousands of textiles were mostly dated between 104 and 154 CE, while 'Abu Sha'ar supplied about 1200 textiles dated from 310 and to the Arab conquest (Bender Jørgensen 2018). Many textiles from a single site context were the opposite of what I had been working with in Northern Europe where I had thousands of sites with a few textiles each. A new challenge!

When I first arrived at Mons Claudianus in 1990, I was placed in the finds tent along with other specialists, set up my microscope, measuring tape etc., was handed bags of textiles just found, and had a go at them, recording find spot, size, colour, fibre, weave, yarns, thread counts and any other details that could be observed (fig. 6). What instantly struck me was that most of the textiles were totally different from the textiles I had studied in Northern Europe, although some types I had seen before. I also encountered some that I had heard about from Gillian Vogelsang-Eastwood or John Peter Wild, such as block damasks, compound weft-faced tabby (taqueté) that Vogelsang-Eastwood had written her doctoral thesis about, and resist-dyed textiles (Bender Jørgensen 1990).

I had not brought my usual index cards but was given a packet of those the papyrologists used. They also gave me boxes for the cards. This was useful but proved problematic when we later wanted to re-examine textiles recorded during the first seasons. A box full of cards is heavy, our luggage allowance was only 20 kg including clothes, microscope etc, so we made miniature copies of all the index cards, gathered 16 of them per page, and brought those out to add information to (fig. 7).

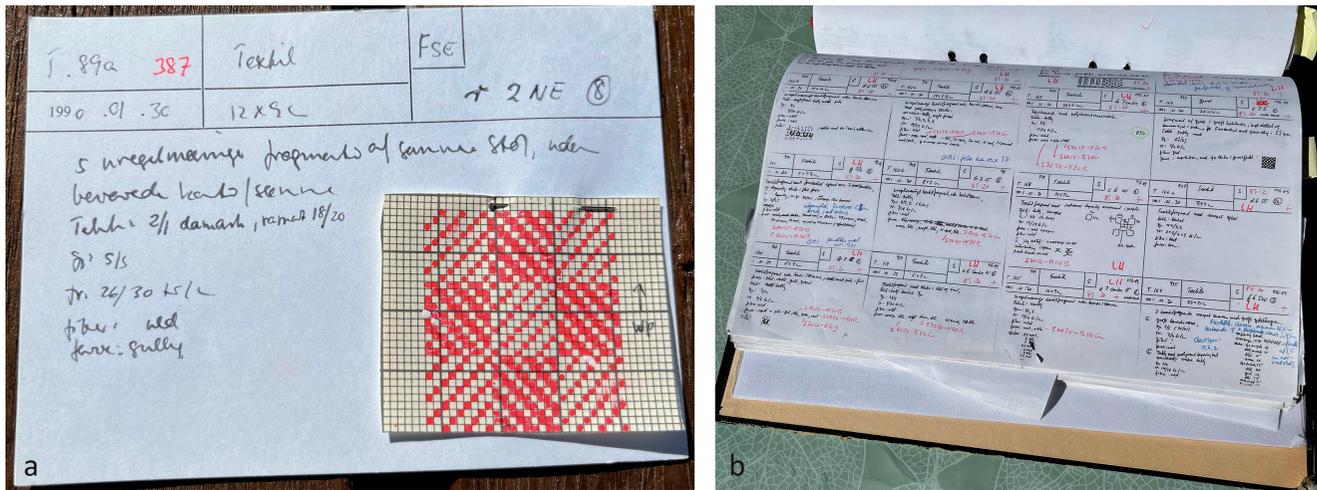


Fig. 7: a – Sample index card; b – Sheaf of miniature index cards to bring to the desert (Images: Lise Bender Jørgensen)

Bülow-Jacobsen took photos of the most interesting textile pieces for me. He tended to treat them like ostraca, the potsherds with writing that he studied, but I wasn't too happy with the results and the following year I brought my own camera. Nevertheless, it still took me a couple of years – and better lenses – to develop the best photo technique. This was in the 1990s, before digital cameras. I brought out 30 slide films for artificial lighting each year, photographed as many textiles as I could, went home, submitted the films for development and hoped for the best. Ten years later, I would just have shot away, and instantly been able to see if the result was okay. As it is, today, I only have photos of about half the recorded textiles, in varying quality. The slides now live in six boxes sorted according to their index card number and have since been scanned. Another lot of boxes contain slides of special pieces, items of clothing, and duplicates.

During my first season at Mons Claudianus I managed to analyse about 450 textiles. As it obviously was a major task, the following year I brought a student assistant, Ulla Mannering, from Denmark. This time, we worked not only on the excavation site, but also in the stores of the Egyptian Antiquity Service in Dendera, where the backlog from preceding excavation seasons was kept. It consisted of 12 large metal boxes crammed with plastic bags with textiles. We soon realised that we would never be able to analyse them all. At that point we had recorded about 900 textiles, and we decided that they would have to serve as a representative, random sample, and went on to go through all the boxes for anything special: twills, damasks, taquetés, items of clothing, and anything else with special features. We managed to record another 900 pieces,

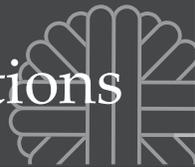
termed the selected sample (Bender Jørgensen 1991b; Bender Jørgensen and Mannering 2001).

Later, Lena Hammarlund came to Egypt with me to have a closer look at the many tabbies, while I went through earlier recorded pieces once again, photographing as many as I could, as well as checking them and adding information. We also re-packed the textiles individually and sorted them in number order. Describing colours was a special problem, so in order to create a standard of reference I compared them with the Natural Colour System (Bender Jørgensen 2015). Working on the textiles from 'Abu Sha'ar was much like at Mons Claudianus, but with fewer facilities. Records were kept in notebooks, not on index cards; and photography done haphazardly as very little equipment was available.

### Databases

Working with the textiles from the two Egyptian sites was different from my previous studies in many ways. One of them was that we were able to make databases. Ulla Mannering created one for the Mons Claudianus textiles, and I followed her model making one for 'Abu Sha'ar textile corpus. It meant that while my work in Europe basically had consisted in establishing textiles as archaeological types and mapping them chronologically, I could now use the databases to calculate the composition of fibres, yarn types, weaves, thread counts etc at each site. Type definitions became more detailed, especially after Lena Hammarlund established categories among the tabbies and twills (Hammarlund 2005).

Moreover, it was possible to compare the Mons Claudianus textiles with those from 'Abu Sha'ar, as well as with contemporary sites from the region



such as the forts of Krokodilô and Maximianon, where Dominique Cardon from France has published statistics of the textiles (Cardon 2003), and the port of Myos Hormos from where Fiona Handley from the UK has presented similar data (Handley 2011). Comparisons, for example, showed that bast fibres were rare at the desert sites compared to the coastal ones, and while tabby was always the most common weave, twills were much more common at the military sites than at Mons Claudianus and Myos Hormos, which both had mainly civilian inhabitants (Bender Jørgensen 2004, 2018).

### Getting (partly) digitalised

After a slow start, my work began benefitting from the digital revolution. Becoming confident with computers and databases I also began to use a digital camera. Offprints were replaced by pdfs around 2010, and soon afterwards, online platforms like *academia.edu* and *researchgate.net* became the place to exchange publications and look for new interesting ones. However, I have never become fully digital. While my students happily carried out the layout of their master- and doctoral theses on their computers, and used photoshop to make illustrations (or enhance them), I have never gotten round to mastering these aspects of the Brave New World. When, in 2010, I purchased a Dino-lite microscope, the IT guy did not succeed installing the necessary software on my laptop. Instead, it was installed on my master student's laptop. This marked the point where I was left standing on the platform by the digital revolution, while the Norwegian student, Sølvi Helene Fossøy, went ahead using the digital microscope to the benefit of our project on *Creativity in craft production in middle and late Bronze Age Europe (CinBA)*, as well as for her master's thesis (Bender Jørgensen, Sofaer and Sørensen 2018).

### Still enjoying research

Since my retirement in 2015 I no longer do textile analysis myself anymore and prefer to leave this to younger colleagues and specialists. Instead, I enjoy delving into old publications of textiles, querying them and their dating. This proved useful during our work on the Çatalhöyük textiles where Antoinette Rast-Eicher from Switzerland examined the textile remains and carried out fibre identifications and Willeke Wendrich, then at the UCLA in the US, took care of the basketry, while my main task was establishing a body of comparative material and updating what was known about them (Bender Jørgensen et al. 2023). Doing this work, I was able to use my wide knowledge

of archaeology in Europe and the Near East, acquired during my studies at the University of Copenhagen and kept up by teaching undergraduate students in Trondheim, my long experience with archaeological textiles, my old-fashioned library habits as well as my limited digital skills in finding and perusing relevant literature – through Google Scholar as well as other media and search tools. I am thus happily and actively doing textile research in the digital age, feeling that I am still contributing to our important knowledge on ancient textiles.

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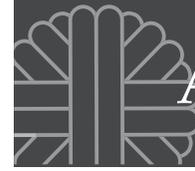
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# Assessment of material resource usage in Inuit skin clothing

## Abstract

This study focuses on reliable methods for measuring the use of resources determining the extent or amount of skin used in Inuit garments. A collection of parkas of known provenance dating from approximately 1830 to 1940 CE currently housed at the National Museum of Denmark was measured using three quantitative metric methods: 3D-measurement with a FaroArm (Method 1), tape measurement (Method 2), and 2D-measurement of digital images (Method 3). Methods 1 and 3 produced statistically reliable results, while Method 2 failed. This research is a sub-study within a project that aims to reconnect Inuit garments that are currently only provisionally numbered with their original provenance information by applying measuring methods. The hypothesis supporting this study posits that three parameters: 1) design, 2) animal species, and 3) material resource usage, provide sufficient data to categorise unidentified items geographically and identify the gender for whom the garments were earmarked.

**Keywords:** Material resource usage, area measurement, Inuit skin parkas, provenance, FaroArm

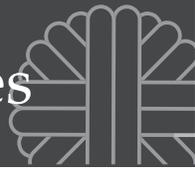
## Introduction

In cultural-history museums, the absence of an original accession tag or inventory number may cause problems as unidentified objects cannot provide information about their origin, use, date, etc. Without contextual data, the museum often considers these items less valuable, insignificant, or even candidates for cassation. At the National Museum of Denmark (NMD), several unique historical Inuit skin garments have lost their original inventory numbers. Thus, these parkas, trousers, footwear, mittens, etc. have no link to the information on provenance contained in museum inventories and archives, such as geographical origin, cultural affiliation, animal species, design, date, gender, donor, acquisition, etc. In 2024, this is the case for 22% of the garments from Greenland (135 out of a total of 602) and 4% of those from the Bering Strait region, Alaska, and Arctic Canada (25 out of 569) inventoried in the NMD registration database GENREG on 1 July 2023 and available at the NMD website Skin Clothing

Online. The *Inuit Skin Clothing* project at the NMD attempts to re-establish links between unidentified skin garments and information on their provenance. The hypothesis supporting the study submits that by combining three parameters: 1) design assessment, 2) species identification, and 3) material resource usage, it is possible to identify Inuit clothing. In this study, “material resource usage” denotes the total area of skin material used for the garment, including the garment’s fur trimmings and edgings.

## Background

The term Inuit refers “... both to the present occupants of the area from the coast of Chukotka in Siberia to Kalaallit Nunaat (Greenland) and to their immediate forebears, who descended from the Thule culture peoples” (Issenman 1997, 7). The major Inuit groups can be divided geographically, from west to east, but with floating boundaries. The western Inuit consist of the Alutiiq on the Alaskan Peninsula and southern



coast, Yupiit in western Alaska, Yupiget on St Lawrence Island and in Siberia, and the Inupiat and Iñupiat in northern Alaska. The Central Inuit in Arctic Canada comprise the Inuvialuit, Inuinait, Netsilingmiut, Aivilimmiut, Kivallirmiut, Iglulingmiut, and Nunatsiarmiut. On the Labrador Peninsula are the

Nunavimmiut and Nunatsiavummiut. The eastern Inuit in Greenland consist of the Inughuit in northern Greenland, the Kalaallit in western Greenland, and the Iivit in eastern Greenland (Balickci 1970; Issenman 1997; Krupnik 2016). The Inuit names mentioned are those currently in use.

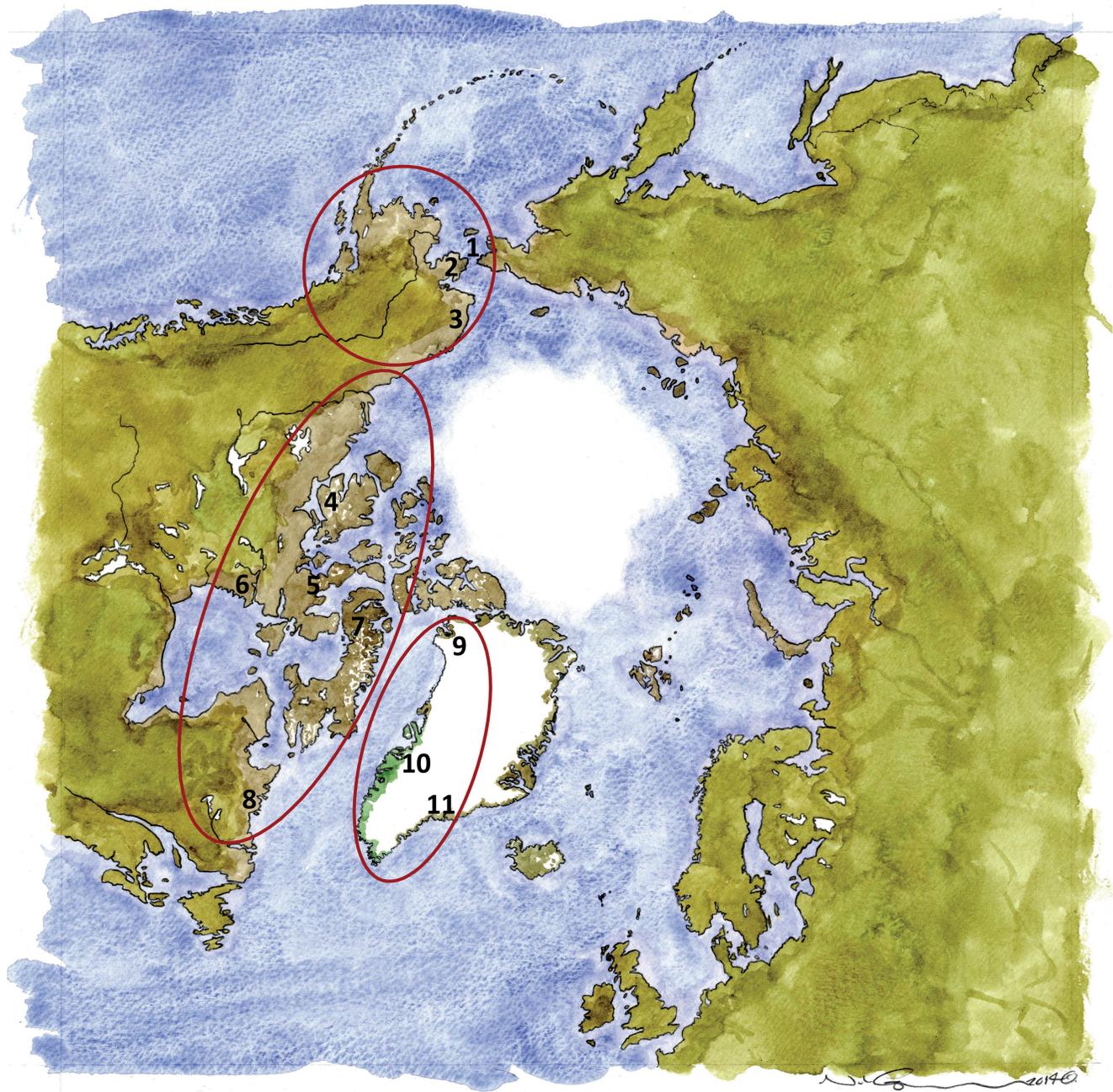


Fig. 1: Map showing the provenances of the Inuit parkas included in this study. From the western Inuit: the Yupiit (1) along Bering Strait, the Yupiget (2) on St Lawrence Island and in Siberia, and the Iñupiat in northern Alaska (3). From the Central Inuit in central Arctic Canada: Inuinait (4), Netsilingmiut (5), Kivallirmiut (6), Iglulingmiut (7), and from the Labrador Peninsula, the Nunatsiavummiut (8). From the eastern Inuit in Greenland: the Inughuit (9), Kalaallit (10), and Iivit (11). The encircled areas should be considered with floating boundaries (Image: Nuka Konrad Godtfredsen)

Geographical region: Inuit groups	Number of garments	Men	Women	Gender not defined / children
Western Inuit in the Bering Strait region and Alaska: The Alutiiq, Yupiit, Yupiget, Inupiat, and Iñupiat	Total 146	All items: 69 Parkas: 24 Analysed: 3	All items: 18 Parkas: 7 Analysed: 1	All items: 59
Central Inuit in Arctic Canada: The Inuinait, Netsilingmiut, Kivallirmiut, Iglulingmiut, and Nunatsiavummiut	Total 423	All items: 223 Parkas: 68 Analysed: 4	All items: 88 Parkas: 27 Analysed: 5	All items: 112
Eastern Inuit in Greenland: The Inughuit, Kalaallit, and Iivit	Total 602	All items: 220 Parkas: 75 Analysed: 9	All items: 215 Parkas 48 Analysed: 10	All items: 167
Number of NMD Inuit garments	Total 1,171	All items: 512 Parkas: 167 Analysed: 16	All items: 321 Parkas: 82 Analysed: 16	All items: 338

Table 1: Areas inhabited by Inuit groups

Inuit clothing of skin and fur maintained local design features within different groups until the early 20th century despite overlapping geographical divisions. The appearance of fur clothing was influenced by colonisation, the commercial fur trade, Christian missions, and the interactions between migrating Inuit groups. However, the traditional clothing construction, initially established by the Inuit centuries ago, persisted as they selectively incorporated a few elements from outsiders that suited their needs (Issenman 1997, 174–175). Specific traits in Inuit clothing design and the clothing of some eastern Siberian groups demonstrate the migration of groups from Siberia to Arctic North America and Greenland (Hatt 1969, 98–109; Issenman 1997, 98, 232–238; Schmidt in press).

The oldest Greenlandic Inuit garments in the current NMD collection were collected in 1834 on the initiative of the museum’s first director, Christian Jürgensen Thomsen (1788–1865) (Jensen 1992, 309). The Arctic collection gradually grew, mainly due to the collecting activities of government officials, traders, and missionaries. Between 1916 and 1928, the number of items of Inuit clothing more than doubled at the NMD. This increase was a result of a research-based collection procedure, for example, as practiced by Danish ethnographer Kaj Birket-Smith (1893–1977) (1924; 1929; 1945) and archaeologist Terkel Mathiassen (1892–1967) (1928). From 1938 until the present day, the NMD has collected only a few items of Inuit clothing, as modern clothing made of fabric, leather,

rubber, etc. replaced traditional clothing in the Arctic. The NMD collection covers a span of approximately 110 years, documenting the transition from the original production and daily use of traditional skin clothing among the Inuit to the use of imported materials and current western fashion. It is important to note that traditional patterns are still maintained among contemporary Canadian Inuit, where a woman’s amauti is now made from fabric (Issenman 1997; Pharand 2012). In Greenland, women’s festive trousers and footwear are still made from seal skin, and the material resource for men’s hunting trousers in northern Greenland is polar bear skin.

#### *The Inuit Skin Clothing project*

The project aims to create an identification key applicable to unlabelled garments, allowing them to be matched with their original accession data in museum inventories or archives. By reconnecting these items with their initial data and inventory number, the aspiration is to restore their cultural value in alignment with the ICOM (International Council of Museums) Code of Ethics for Museums. This research is particularly relevant in collection care. Section 2.18 of the code entitled “Care of Collections” states, “Museum collections should be documented according to accepted professional standards. Such documentation should include a full identification and description of each item, its association, provenance, condition, treatment, and present location. Such



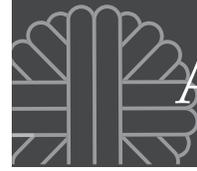
data should be kept in a secure environment and be supported by retrieval systems providing access to the information by the museum personnel and other legitimate users.” (Anonymous 2017, 14). Some NMD parkas have remained unidentified for a century or more (for example, Hatt 1969, 49, 52; Birket-Smith 1924, 187), and remain so to this day according to the museum registration carried out in 1986, when the collection was registered digitally.

It is important to apply standardised measurement methods to document and compare historical or archaeological clothing items. However, museums

often have their own embedded practices that are not well-documented. Researchers have called for the need to introduce standard methods of measuring clothing (Issenman 1997, 140). Despite this, museum staff continue to use century-old conventional methods utilising grid paper, pencils, measuring tapes, and pins to document clothing patterns (Flecker 2007). These methods are unsuitable for fragile materials, such as bird skin and gut skin, which could easily be torn by inserting needles or through pressure from handling. Numerous records of patterns of Inuit skin clothing have been published without attaching a



Fig. 2: 16 parkas for Inuit men. Western Inuit: AsM1, AIM1, AIM2. Central Inuit: CoM1, NeM1, CaM1, IgM1. Eastern Inuit: NGM1, NGM SQ, WGM1, WGM SQ, WGM SQX, WGM3X, EGM1, EGM SQ, EGM3X (Images: Roberto Fortuna)



reference scale (for example, Murdoch 1892; Hatt 1969; Birket-Smith 1924; Birket-Smith 1929; Mathiassen 1928; Jenness 1946; Holtved 1967; Chaussonnet 1988; Issenman 1997; Buijs 2004; Oakes and Riewe 2007; Pharand 2012). Some works present patterns, which include a scale bar (for example, Holtved 1954; 1967; Møller 1989; Oakes 1991; Issenman 1997; Buijs 2004). No accurate area measurement has been applied to the

research material resource usage in skin clothing apart from one study (Jensen et al. 2012). Some publications mention the quantity of animal skins required for making garments. For example, one polar bear skin was used to make three pairs of trousers for Inughuit men (Issenman 1997, 74). Inuit caribou or sealskin parkas were typically made using two skins (Hatt 1969, 36; Birket-Smith 1924, 172).

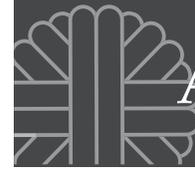


Fig. 3: 16 parkas for Inuit women. Western Inuit: AIF1. Central Inuit: CoF1, NeF1, CaF1, IgF1, LaF1. Eastern Inuit: NGF1, NGF2, NGF3X, WGF1, WGF2, WGF3, WGF4, EGF1, EGF2, EGF3X (Images: Roberto Fortuna)



Geographical group, Inuit name	Gender	Acronym	Inventory number	Accession year	References to specific garment	METHOD 1 3D-measured area, incl. tape-measured edgings (sqm)	METHOD 2 Tape-measured area, <i>not</i> compensated (sqm)	METHOD 3 2D-measured area, <i>not</i> compensated (sqm)	Method 3 / Method 1 (%)	Cause of photo-measuring failure
Western Inuit, Yupigiet	Man	AsM1	Kc.99	1860	Schmidt et al. 2013, 66, 69. Schmidt 2024, 118.	1.824	1.746	1.363	-	Many folds
Western Inuit, YUPIIT	Man	AIM1	P.152	1913		2.290	2.526	2.446	-	No hood
Western Inuit, Inupiat	Man	AIM2	P32.5	1926	Schmidt 2024, 116.	1.666	1.727	1.485	89,1	
Central Inuit, Inuinait	Man	CoM1	P30.2	1927	Birket-Smith 1945, 144.	1.167	0.965	0.962	82,4	
Central Inuit, Netsilingmiut	Man	NeM1	P29.8	1924	Birket-Smith 1945, 28, 30.	1.529	1.600	1.386	90,6	
Central Inuit, Kivallirmiut	Man	CaM1	P28.6	1924	Birket-Smith 1929, 200-202.	1.464	1.615	1.221	83,4	
Central Inuit, Iglulingmiut	Man	IgM1	P27.410	1924	Mathiassen 1928, 161, 163.	1.496	1.656	1.347	90,0	
Eastern Inuit, Inughuit	Man	NGM1	L.9549	1928		1.421	1.072	1.237	87,1	
Eastern Inuit, Inughuit	Man	NGM2	L.2097	1905	Birket-Smith 1924, 173-174.	1.503	1.694	1.334	88,8	
Eastern Inuit, Kalaallit	Man	WGM1	Ld.31a	1883	Hatt [1914] 1969, 45.	1.059	0.974	0.869	82,1	
Eastern Inuit, Kalaallit	Man	WGM2	L.8500	1924		1.096	0.983	0.930	84,9	
Eastern Inuit, Kalaallit	Man	WGM2X	L.7822	1918	Birket-Smith 1924, 172-173.	1.327	1.233	1.140	85,9	
Eastern Inuit, Kalaallit	Man	WGM3X	L.7830	1918	Birket-Smith 1924, 170-172.	1.123	0.954	0.835	-	Cylindrical shape
Eastern Inuit, Iivit	Man	EGM1	Ld.17	1881		1.316	1.169	1.131	85,9	
Eastern Inuit, Iivit	Man	EGM2	L.4990	1911		1.241	1.310	1.094	88,2	
Eastern Inuit, Iivit	Man	EGM3X	Ld.16	1881		1.138	1.087	0.980	86,1	
Western Inuit, Alaska	Woman	AIF1	P32.1	1926		1.758	1.906	1.511	85,9	
Central Inuit, Inuinait	Woman	CoF1	P30.15	1927	Birket-Smith 1945, 154-155.	1.323	1.544	1.057	79,9	
Central Inuit, Netsilingmiut	Woman	NeF1	P29.10	1924	Birket-Smith 1945, 37-38; Issenman 1997, 121.	1.856	1.590	1.436	-	Many folds
Central Inuit, Kivallirmiut	Woman	CaF1	P28.10	1924	Birket-Smith 1929, 217-218.	1.585	1.698	1.392	87,8	
Central Inuit, Iglulingmiut	Woman	IgF1	P27.453	1924	Mathiassen 1928, 175-177.	1.971	1.844	1.456	-	Many folds
Central Inuit, Nunatsiavummiut	Woman	LaF1	P.230a	1922	Issenman, 1997, 168.	1.273	1.458	1.038	81,5	
Eastern Inuit, Inughuit	Woman	NGF1	X.233	1921		0.976	1.173	0.745	-	Long-haired fur
Eastern Inuit, Inughuit	Woman	NGF2	L.9554	1928		1.159	1.321	0.900	77,7	
Eastern Inuit, Inughuit	Woman	NGF3X	L.4357	1909	Hatt [1914] 1969, 43.	0.763	0.842	0.631	82,7	
Eastern Inuit, Kalaallit	Woman	WGF1	L.7819	1918	Birket-Smith 1924, 200-201.	1.076	1.073	0.880	81,8	
Eastern Inuit, Kalaallit	Woman	WGF2	Ld.32a	1883	Birket-Smith 1924, 193-195; Hatt [1914] 1969, 44.	0.694	0.716	0.572	82,4	
Eastern Inuit, Kalaallit	Woman	WGF3	Lc.187a	1844	Hatt [1914] 1969, 44; Birket-Smith 1924, 195-197; Bahnson 2005, 86-87.	0.818	0.762	0.646	79,0	
Eastern Inuit, Kalaallit	Woman	WGF4	L18.140a	1938		0.858	0.813	0.686	-	No hood
Eastern Inuit, Iivit	Woman	EGF1	L.5064	1911		1.061	1.072	0.959	90,4	
Eastern Inuit, Iivit	Woman	EGF2	L.5066	1911		0.773	0.944	0.690	89,3	
Eastern Inuit, Iivit	Woman	EGF3X	Lc.378	1854		0.875	0.945	0.770	88,0	
Statistical validity, i.e., normal distribution of data						METHOD 1 Valid	METHOD 2 <i>Not valid</i>	METHOD 3 Valid		
								Mean value 25 parkas	85,2,2%	
								Standard deviation	3,7%	
								Compensation factor	1,174	

Table 2: Data sets on the 32 parkas



The primary focus of this paper is to reliably measure material resource usage. It attempts to answer the following questions: is it possible to identify Inuit parkas' geographical and cultural origin based on their material resource usage? Is it possible to differentiate men's and women's clothing by area measurement? Can material resource usage stand alone as a metrically identifying parameter?

To address these questions, the paper is divided into two parts. First, the testing of accuracy, validity, non-damaging effect, and costs of three methods for quantifying the material resource usage for skin garments are described: 3D-measurement with a FaroArm (Jensen et al. 2012) (Method 1), tape measurement (Method 2), and 2D-measurement performed on digital images of garments (Method 3). Apart from Method 1 (Jensen et al. 2012), no similar studies on material resource usage regarding clothes or garments was found. The aim is to determine which of the compared methods is the most reliable, least harmful, accessible, and cost-effective. The reproducibility, equipment and time costs, and ease of performance are evaluated.

Secondly, the study aims to assess the validity of material resource data as a critical parameter in identifying Inuit clothing from the Bering Strait region, Alaska, Arctic Canada, and Greenland. Fur and skin parkas from the NMD provide the main material for examination.

### *The Inuit parka*

Parkas are a part of the traditional Inuit skin clothing outfit for outdoor use, which also comprises trousers, footwear, and mittens. These items are often double layered, with the fur side either turned inward (toward the body) or outward (exposed to the elements). Apart from the Inuit in the Bering Strait region and southern Alaska, where some parkas are hood-less, the parka is usually a hooded garment, closed at the front and pulled over the head. Men's parkas have relatively tight-fitting hoods; cut straight across on the lower hemline. Women's parkas either have a hood and a spacious back, shaped to carry small children (Inuktitut: amauti, Greenlandic: amaat) or a pointed hood without the roomy back. Women's parkas have substantial front and back flaps (that is, tails, pointed or u-shaped) (Birket-Smith 1924, 197).

So-called double hood roots (that is, two-pointed skin gores, sewn from the hood to the front, occasionally also to the back, like illusory walrus tusks) (Fitzhugh and Kaplan 1982, 146), sleeve gussets and a triangular top piece in the hood are western designs. Eastern designs are characteristic by their so-called single

hood root (that is, a square gusset connecting the hood under the chin) and a median top seam in the hood (Hatt 1969, 106).

Pattern components for skin clothing are cut symmetrically out of the skin, and the corresponding parts in the finished garments match as on the animal (Issenman 1997, 87).

### **Empirical material**

According to the NMD GENREG-database, the museum's collection currently numbers 1,171 pieces of Inuit clothing (covering all types of garments, with sets of outfits, such as a pair of boots, stockings, mittens, etc., counting as one item) (for example, described in Holm 2010; Hatt 1969; Thalbitzer 2010; Birket-Smith 1924; 1929; 1945; Mathiassen 1928; Issenman 1997; Bahnsen 2005; Schmidt et al. 2013; Schmidt 2014; 2019). The extent of the NMD collection identified by region and Inuit groups is presented in table 1. This study specifically focuses on measurements taken on parkas, so these items are specified.

### **Methodology**

#### *Criteria for selection of items for the study*

The following criteria are employed in the selection of garments from the NMD's collection:

An inventory number must be attached to the item to ensure a correct link to provenance, gender, and date. The item must be of known provenance, affiliated with an Inuit group, specific gender, etc. Items without inventory numbers are omitted.

Garments from the late 19th to early 20th century are prioritised for identification of the design characteristics, and clothing with the oldest design is preferred within this period.

The selected items are evenly distributed between men and women. Children's clothing is considered too variable in size to be included. On average, Inuit men are approximately 12 cm taller than women. At the end of the 19th century, the average height of Inuit women in Greenland was approximately 148 cm, while men were approximately 160 cm tall (Roser et al. 2021). In 1960, anthropometric studies from Kodiak Island, Alaska, indicated that Inuit women had an average height of approximately 149 cm, while men were approximately 160 cm tall (Jørgensen 2002).

Where possible, the study includes various designs from the same Inuit group. Both inner (skin's hair side turned inwards) and outer (hair side turned outwards) parkas were selected.

As per the NMD's digital documentation, the collection items are categorised based on American anthropologist George Peter Murdock's (1897–1985)

*Outline of World Cultures* (Murdock 1963). The items are sorted from west to east, grouping the western Inuit in the Bering Strait region and Alaska as NA1, NA3, NA6, NA9, NA10, NA13, and RY5 (Murdock 1963, 91–92, 150). The Central Inuit in Arctic Canada are classified as follows: Inuinait: ND8, Netsilingmiut: ND13, Kivallirmiut: ND6, Iglulingmiut: ND5, and Nunatsiavummiut: N15 (Murdock 1963, 93–94, 97). The eastern Inuit in Greenland are categorised as Inughuit: NB5, Kalaallit: NB6, and Iivit: NB4 (Murdock 1963, 91–92).

A total of 32 Inuit parkas – 16 for adult men, 16 for adult women – constitute the empirical and statistical base for testing and comparing the three methods of area measurement. For the geographical distribution of the 32 parkas, that is, the areas inhabited by the Inuit groups are listed in table 1 (figs 1-3). Table 2 provides a data set on the 32 parkas with inventory numbers and code names.

#### *Methods of quantifying material resource usage*

Three non-destructive methods for measuring skin garments are presented and assessed in the following sections. In addition to the somewhat costly, complicated, and time-consuming 3D-measurement with a FaroArm (Method 1), two less expensive and more easily executed procedures are evaluated for their suitability and statistical validity: Method 2 involves the physical measurement of clothing with a tape measure, and Method 3 entails 2D-measurement carried out on digital images of garments.

#### *Method 1: 3D-measurement of clothing with a FaroArm*

3D-measurements of the 32 parkas were carried out using a FaroArm (Sterling, model 10-02 and FARO EDGE) according to a procedure established in an earlier research project aimed at developing a non-destructive method to document the design patterns of Arctic skin or fur clothing (Jensen et al. 2012).

To establish a 3D-model of the skin clothing, the probe of the flexible measuring arm is passed along all seams and edges of each component (fig. 4). For a parka, this comprises the front, back, hood and sleeves. Secondly, an imaginary line of points is measured on the surface of each component, approximately 2 cm from the seams and edges. Each measured point is represented by a set of 3D-coordinates. Using these 3D-coordinates, the software programmes Matlab, Rhino, and AutoCAD are employed to calculate and construct a 2D-pattern for each component. The material resource usage for the parka is measured by summing up the calculated areas of each component. For practical reasons, the



Fig. 4: Method 1: 3D-measurement of Inughuit women's parka NGF2 (inventory number L.9554) with a FaroArm in 2011 at the National Museum (Image: Roberto Fortuna)

garment's narrow edges and trimmings are measured with a tape measure, and the area is calculated and added (Jensen et al. 2012).

Method 1 requires a skilled operator with access to a costly FaroArm and special software (Rhino). The average processing time, including pattern description, is up to 10 hours per garment. The garment must be carefully mounted on a mannequin specially adapted to the item. As the 3D-measurement is performed without touching the item, possible contact with biocide-treated garments is not a necessary consideration. The time consumption, demand for skilled staff, and costly equipment (FaroArm, Rhino programme) are considerable.

#### *Method 2: Tape measurement of clothing*

Garments were previously meticulously documented, with measurements taken with a tape measure. The tape measurements were undertaken following a detailed protocol, with the tape held tightly between the measuring points.

The procedure is to measure the outer edges of the skin garment, that is, not the end of the hair on a hood brim or the ends of fringes. The parkas are recorded using 12 different tape measurements (fig. 5). It seems reasonable to follow the same breakdown of garments into components, that is, hood, front and back (torso), and sleeves that is used in Method 1.

The hood can be described as an equilateral cylinder where 'Crown length' (measurement 3) is the diameter and 'Hood height' (measurement 5) is the height of the cylinder. 'Crown length' also provides a measurement for the head circumference, which is significant when determining gender, size, age, and use (for example, a women's parka could be used for carrying a small

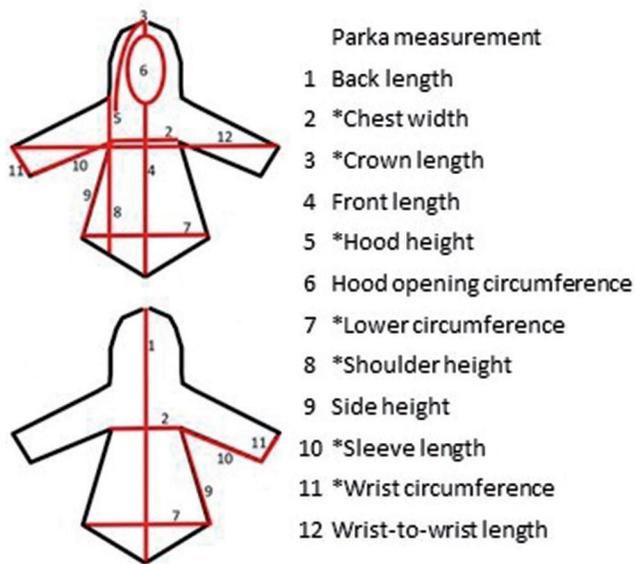


Fig. 5: Method 2: Tape measurement of Inuit parka. \* indicates measurements used for parka area calculation (Drawing: Anne Lisbeth Schmidt)

child). By comparing the measurements of the parka hood opening to the crown area, the performed measurements in the present study show that the area of the hood opening is equal to the crown area. The formula for the hood area is thus:

$$A = d \times h$$

That is, *Hood area = Crown length x Hood height*

The front and back of the parka can be regarded as one component, as they have the same dimensions. The upper body forms what can be considered a trapezoid. "Chest width" (measurement 2) and "Lower circumference" (measurement 7) are the parallel sides of the trapezoid and 'Shoulder height' (measurement 8) is its height. Even though the chest width is measured under the arms, it is the same when extended to over the shoulders. It should be noted that this calculation does *not* include front and back flaps, which may be of minor or substantial size. The formula for the torso area is:

$$A \times h$$

That is, *Torso area = (Chest width + Lower circumference): 2 x Shoulder height*

The sleeves are two rectangles, where "Sleeve length" is the length and "Wrist circumference" is the width:

$$A l \times w \times 2$$

That is, *Sleeve areas = (Sleeve length x Wrist circumference) x 2*

The sum of the area of the hood, torso, and sleeves constitutes the total material resource usage for the parka. The areas of two hood-less parkas are

calculated using the area of the torso and sleeves. For a representative quantity of measurements, the standard deviation between the material resource usage obtained in Method 1 and Method 2 must be low and normally distributed about a mean value. Method 2 takes approximately 30 minutes per garment. The method requires careful handling, knowing that the skin material can be fragile and contaminated with biocides. Time consumption and cost of equipment (tape measure) are minimal.

### Method 3: 2D-measurement of digital photos

In previous digital photo documentation, care was taken to place each garment flat on a low-iron (Weiss) glass table to prevent any greenish-blue tint in the photos. To avoid shadows, the items were illuminated from below and images were taken of the front and back with a scale bar, colour patches, and printed inventory number in the lower right corner. A Hasselblad camera, equipped with a Schneider Kreuznach 80 mm lens, was positioned centrally above the item. The camera was levelled horizontally using a spirit level. A few larger items, notably large parkas, necessitated using a wide-angle lens. Long scales were placed perpendicularly in the photograph to control camera aberration, and subsequent measurements showed negligible deviation.

Measurement of the high-definition photos of the skin clothing are used in Method 3. In contrast to the 3D-measurement used in Method 1, Method 3 measures the areas within the outer edges of the garment on the front and the back, without taking the individual components into consideration (fig. 6). Because the garments are not entirely flat when laid out on the glass table, the assumption is that Method 3 records a certain percentage of the total area, that is, a smaller part of the factual material resource usage obtained with Method 1. Consequently, the item's total area can be measured using Method 3 and calibrated by multiplying the number by a factor representing the estimated difference between Methods 1 and 3. For this hypothesis to be valid, certain criteria must be fulfilled.

For a representative quantity of measurements, the standard deviation between the material resource usage obtained in Method 1 and Method 3 must be low and normally distributed about a mean value.

The process of obtaining a value for the material resource usage of items of skin clothing using 2D-measurements of digital images is as follows:

The highly accurate digital image of the front and back of the garment is imported into a computer-aided design and drafting software application (CAD).



Fig.6: Method 3: 2D-measurement of digital photos of a Kalaallit women's parka, WGF2 (inventory number Ld.32a). The parka's outer edges, front and back, were 2D-measured on the photo (marked with red line), using digital software (CAD) and the inner area was calculated (Image: Roberto Fortuna, Klaus Støttrup Jensen)

Using the scale bar included on the digital images, these are scaled to 1:1.

The garment's boundaries are digitised, creating two multipoint polygons (from the front and back). Each time the boundary geometry changes a digitisation point is added. The number of digitised points varies from about 100 for smaller items to 300 for larger ones. The areas of the front and back are calculated using the CAD application's area calculator and subsequently summed, thereby giving a value for the material resource usage of a given item.

Several digital images of skin garments are digitised several times to evaluate the accuracy of the actual digitisation procedure. The deviation between the areas of polygons for the same item is less than 0.5%, that is, negligible.

Method 3 takes about 30 minutes for each piece of clothing, with minimal handling of the garment apart from arranging for front and back photography. Nevertheless, possible contamination through contact with biocides should be considered. Levelled digital photos could be taken with a less advanced camera than the one used here, for example, a high-definition

camera phone. The CAD software used for drawing the garment's outlines is standard. Regarding Method 3, the time and equipment costs are affordable.

### Findings

See table 2 regarding the results following Methods 1, 2, and 3.

### *Method 1: Statistical assessment of 3D-measurement of clothing*

An estimate of the accuracy and precision of areas determined by Method 1 was calculated in accordance with standard procedures for testing surveying equipment.

The parka es\_68927, WGF2 (inventory number Ld.32a) was measured using Method 1, and a pattern containing 12 components was produced. Based on this pattern, a copy was cut in felt, consisting of all components. Before the felt components were sewn together, each individual component was photographed. The 'true' area of the felt components was determined by measuring the photographic image using Method 3. This area is as close as one can get

to the true area. The felt components were then sewn together to create a parka, which was measured using Method 1 (fig. 7), whereby the area of the garment was calculated. The two determinations of the 12 areas were thus completely independent.

*Accuracy*

For each component, the difference in area between the true area and the area found using Method 1 was calculated (table 3). Thus, the accuracy of an area of one component was estimated. The standard deviation was 0.002 m<sup>2</sup>. Employing the law of error propagation, the accuracy of the total area was 0.007 m<sup>2</sup>, corresponding to 1.1% of the total area of the parka.

*Precision*

Six of the 12 components of the felt copy were then measured twice using Method 1. By calculating the difference in area for each of the components (table 4), the precision of the area of one component could be estimated. The standard deviation was 0.001 m<sup>2</sup>. Employing the law of error propagation, the precision of the total area of the parka was 0.004 m<sup>2</sup>. This corresponds to 0.6% of the total area of the parka.

**Method 2: Statistical assessment of physical (tape) measurements of clothing**

The areas of 32 parkas measured by Method 2 ranged between 75.4% and 122.1% of the areas calculated by Method 1. These deviations were *not* normally distributed, and the calculation of parka areas from tape measurements was consequently *not* a valid method for quantifying their material resource usage.

**Method 3: Statistical assessment of 2D-measurement of digital images**

The material resource usage of 32 parkas was quantified using Method 3. Seven parkas were subsequently excluded from the statistical dataset as they deviated significantly due to their large volume or hoodless design, see the Appendix ‘Survey of Inuit parkas’. The areas of the remaining 25 parkas obtained by Method 3 corresponded to an average of 85.2% of the material resource usage obtained by Method 1, with a standard deviation of 3.7%. The deviations were evaluated as normally distributed.

Consequently, 2D-measurement of digital images is a valid method to use to obtain approximate values for the material resource usage of parkas. Multiplying the



Fig. 7: The replica of Kalaallit women’s parka, WGF2 (inventory number Ld.32a) sewn in felt, from the back and front (Image: Roberto Fortuna)



Component no	'True' area Method 3 square meter	Area Method 1 square meter	Difference square meter
es_68927 a1	0.061	0.064	0.003
es_68927 a2	0.020	0.021	0.001
es_68927 a3	0.045	0.047	0.002
es_68927 b1	0.042	0.044	0.002
es_68927 b2	0.035	0.033	- 0.002
es_68927 c1	0.101	0.104	0.003
es_68927 d1	0.047	0.048	0.001
es_68927 a1	0.061	0.063	0.002
es_68927 a3	0.045	0.042	- 0.003
es_68927 b2	0.035	0.033	- 0.002
es_68927 c1	0.101	0.103	0.002
es_68927 d1	0.047	0.046	- 0.001

Table 3: Calculations of the areas using Method 1

Component no	Area1 Method 1 square meter	Area2 Method 1 square meter	Difference square meter
es_68927 a1	0.064	0.063	0.001
es_68927 a2	0.021	0.021	0.000
es_68927 b1	0.044	0.042	0.002
es_68927 b2	0.033	0.033	0.000
es_68927 c1	0.104	0.103	0.001
es_68927 d1	0.048	0.046	0.002

Table 4: Estimation of the precision of the area of one component

area obtained by method 3 by a factor of  $100/85.2 = 1.174$  gives the expected real value for material resource usage of a parka with an accuracy of  $1.174 * 3.7\% = 4.3\%$  of the expected real value.

#### *The applicability of Method 1: 3D-measurement of clothing*

The optimal method of measuring the actual material resource usage for skin garments is the 3D-measurement procedure (Jensen et al. 2012) because of its high accuracy and high reproducibility. However, the previous project (Jensen et al. 2012), which measured 103 skin garments, including parkas, coats, trousers, and footwear showed that items deformed by wear, made of uneven material (for example, gut skin), or skin with long fur and hidden seams (for example, polar bear skin) were not measurable using Method 1. The traditional but destructive measuring method, using pins, paper, and tape measure, may be the only possible way to measure

the material resources of such items. However, the accuracy of this method is unknown, it is damaging, and the garment's possible biocide contamination must be considered.

Method 1 is challenging because of the need for costly special apparatus with skilled operators. Regarding the usefulness of Method 1, it is noted that the pattern measurements provide accurate patterns of all components, which, accompanied by a description and high-resolution photos, make it possible to produce an exact copy of the original garment. Making exact clothing replicas, after careful measurement with Method 1, gives researchers new opportunities to examine and spare delicate, perhaps contaminated original materials. Replicas allow museum audiences to wear the garments and experience how warm, water- and wind-proof, and comfortable the clothing is without fear of damaging the original material. The experience gives an immediate sense and respect for the craftsmanship and skill in the making of the garment.

**The precision of Method 2: Tape measurement of clothing and Method 3: 2D-measurement of digital images**

Methods 2 and 3 are assumed to be less precise and less accurate than Method 1. This is due to the following considerations:

Method 1: The area is calculated based on 2D-coordinates for numerous points representing the seams and edges of each component of the garment.

Method 2: Only a few selected dimensions are measured for each component. The dimensions form parts of simple geometrical shapes, such as cylinders, trapezoids, and rectangles. The resulting area therefore becomes larger or smaller than the 'true area'. The precision and accuracy are only at the same level as in Method 1 in cases where the component or item is flat and can be divided into a few simple shapes. Data about hood width and the size of flaps, which may have been useful, were not measured.

Method 3: The area is calculated based on 2D-coordinates for numerous points representing the outline of the entire item. The calculated area will be systematically smaller than the 'true area', but if the

item is totally flat the precision and accuracy are only slightly lower than those achieved with Method 1.

Method 1 provided results with 1.1% standard deviation. In some cases, it was not possible to measure items with undulating surfaces or hidden seams. Method 2 was not statistically valid for parkas. Method 3 proved statistically valid for most parkas, with a standard deviation of 3.7%. Folded items, and items with long fur were omitted. The object's flatness and, thus, suitability for photographic measurement with Method 3 is essential. It is recommended that a method involving 3D-laser scanning be further investigated in the future.

**Material resource usage in relation to design in Inuit parkas**

In Fig. 8 the material resource usage for the 32 Inuit parkas is seen. The area in square metres from the 3D-measurement is inserted as the X-value, while the tape-measured back length in meters serves as the Y-value. With a few exceptions, the men's parkas are located below the median line, while the women's

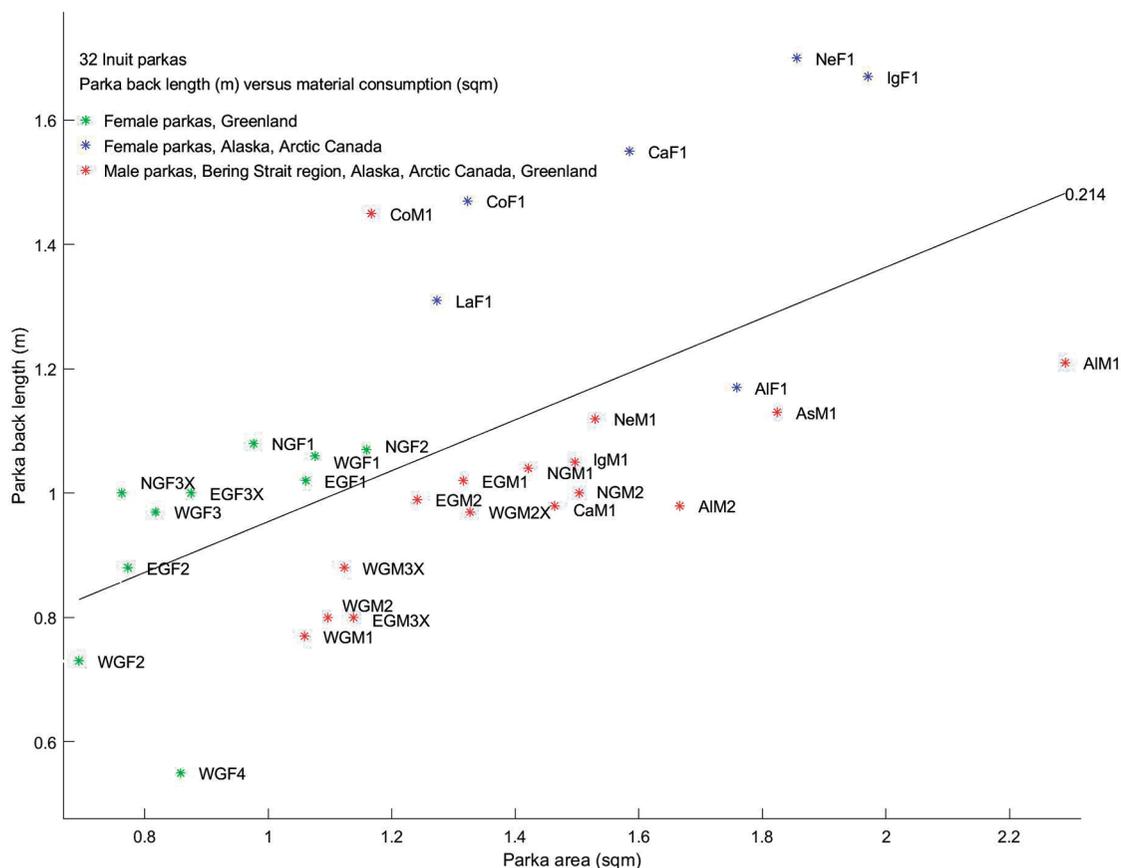


Fig. 8: Area of material versus back length for 32 parkas. Areas obtained by Method 1: 3D-measurement (Image: Karsten Jensen)



parkas are located above. Over the median line, eight small women's parkas from eastern Inuit in Greenland form one cluster (green), while five large women's parkas from Central Inuit in Arctic Canada form another (blue). One Central Inuit man's parka (CoM1) (orange) lies alone over the median line. Under the median line are two small Kalaallit women's parkas from Greenland (WGF2, WGF4) and one large women's parka (AlF1) from western Inuit in Alaska. From eastern Inuit, four men's minor parkas from Greenland form a cluster (orange); adjacent, five men's medium-sized parkas from Greenland form another cluster (orange) with three Central Inuit men's parkas. One large men's parka from the Bering Strait region (AsM1) and two large men's Alaskan parkas (AlM1, AlM2) lie solitary; all are from the western Inuit.

Six men's parkas (WGM1, WGM2X, WGM3X, EGM1, EGM2X, EGM3X) from eastern Inuit in Greenland (Kalaallit and Iivit) are generally small, with back lengths ranging from 0.77–1.02 m and areas ranging from 1.059–1.327 m<sup>2</sup>, due to their tight-fitting design, with or without miniscule flaps. Three men's parkas (CaM1, IgM1, NeM1) from Central Inuit and two from eastern Inuit (Inughuit) (NGM1, NGMM2) have larger areas, due to their design with a longer front and back; back lengths range from 0.98–1.12 m and areas from 1.167–1.503 m<sup>2</sup>. One Central Inuit man's parka from the Inuinait (CoM1), stands out because of its long back-flap and tight-fitting design. The sample size is too small to enable further distinction between the Central Inuit. From the western Inuit in Bering Strait region and Alaska, one man's parka (AsM1) from the Yupiget, and two men's parkas from the YUPIIT (AlM1), and Iñupiat (AlM2) have the largest material resource usages, due to their voluminous design. Moreover, AlM1 is hoodless.

The ten women's parkas from eastern Inuit in Greenland (NGF1, NGF2, NGF3X, WGF1, WGF2, WGF3, WGF4, EGF1, EGF2, EGF3X) differ significantly from the six women's parkas from western and Central Inuit (AlF1, CoF1, CaF1, NeF1, IgF1, LaF1). In the smaller women's parkas from Greenland, the back lengths range from 0.55–1.07 m and the areas from 0.694–1.159 m<sup>2</sup>. The smaller areas are linked to the close-fitting garment, small or miniscule flaps and a generally tight-fitting design. The sample size is considered too small to differentiate further, but two women's parkas stand out: WGF4, a hoodless festive Kalaallit parka, with a short back length, and NGF2, an Inughuit parka, with a large area, apparently sewn for a European woman. In the voluminous six

women's parkas from western and Central Inuit, the back lengths vary from 1.17–1.70 m. Compared to the ten eastern Inuit women's parkas (0.694–1.159 m<sup>2</sup>), the material resource usage for Central Inuit (1.273–1.971 m<sup>2</sup>), is for some, approximately two and a half times as high. The large areas are due to the elongated hood, large flaps, and a generally roomier fit. The sample size is too small for a distinction to be made between the western and Central Inuit.

This study confirmed the results of the initial studies of material resource usage undertaken using 3D-measurements by a FaroArm, which indicated that such measurements provided information enabling identification of origin and gender for items of traditional Greenlandic Inuit skin clothing (Jensen et al. 2012, 985–990). Furthermore, this study also confirms the previously demonstrated conclusion that material resource usage enabled the distinction of origin between skin parkas from Greenland, Arctic North America, Siberia, and North Scandinavia (Schmidt 2014).

## Discussion

### *Tailored design?*

The Canadian Arctic researcher, Bernadette Driscoll Engelstad (1952–), points out that "... the outward appearance, pattern construction, design features, and choice of animal resources indicate two major divisions in the clothing design of the North American Arctic" (Engelstad 2020, 235–236). One is the horizontally tiered design (used in parkas), made from bird skin, marine mammal gut skin, and small mammals used by the Inuit in the Bering Strait region and southern Alaska (Unangax, Alutitq/Sugpiaq, Yup'ik, and YUPIIT). The other is the tailored design, made from caribou and seal skin by the Inuit in northern Alaska, Arctic Canada, and Greenland (Engelstad 2020, 236). In this study, only one parka, (AlM1), has a design with horizontally stitched panels of gut skin. This long, roomy YUPIIT men's parka without hood, has the largest material resources of all 32 parkas, 2.290 m<sup>2</sup>. If Engelstad's 'tailored design' is understood as made-to-measure and tight-fitting, the smaller areas used for men's parkas from Arctic Canada and Greenland indicate that these parkas were tailored, and with no superfluous material added to the garment. Also, Birket-Smith observed slim-fit garments, stating that the Kalaallit man from *Godthaab* (Nuuk) dressed like a "dandy", in a short, close-fitting tight parka in contrast to the Central Inuit's voluminous parkas for men (Birket-Smith 1929, 199–200). The Greenlandic women's parkas all have low material resource



use, indicating tight-fitting designs. In contrast, the six women's Alaskan and Canadian parkas have voluminous outfits, initially measured, cut, and sewn to the wearer, however, not tight-fitting.

### ***Animal species in relation to material resource usage***

The reasons for the men's and women's differences regarding parka volume are due to the difference in gender body size, the purpose for clothing, climatic demands, and the animal species of the skin garment. In this context, the study limits the options and solely reflects on the animal species. western and Central Inuit parkas are mostly made from large land mammals, that is, caribou (Schmidt et al. 2023). This study shows that western and Central Inuit parkas are generally the most voluminous. For parkas, the eastern Inuit predominantly used skin from smaller sea mammals. However, they also used skin from caribou, Arctic fox, domestic dog, polar bear, birds, and gut skin from sea mammals (Schmidt et al. 2023). This demonstrates that measurement of material resource usage alone does not provide a complete answer regarding the origin of the garment.

Methods 1 and 3 for quantification of material resource usage provide reliable information useful in the upcoming task of identifying garments of unknown origin, and material resource usage will certainly be included alongside studies of design and identification of animal species in the attempts at identifying such items in forthcoming studies of the NMD's collection. A more detailed analysis of the 2D-patterns provided by Method 1 is also required to reinforce the design assessment.

### **Conclusions**

Regarding Method 1: 3D-measurement, this time-consuming method has the lowest standard deviation and is the most accurate method. Regarding Method 2: calculation based on tape measurement, is not statistically valid for quantification of parka area. The study revealed that Method 3: 2D-measurement of digital images is a viable, fast option when it comes to estimating material resource usage in parkas. Method 3 is less accurate compared to Method 1, and furthermore, it is less time consuming. However, it is important that the garment does not have long fur or folds. Some parka surfaces are too distorted and uneven to measure, and thus neither Methods 1 nor 3 are suitable. Regarding measuring parkas, if possible, it is recommended to use both methods to confirm the results and prevent errors.

Distinguishing geographic origin between Inuit parkas of known provenance, especially regarding

women's clothing proves possible when applying measurements of material resource usage. Men's parkas from Central and eastern Inuit appear, on the face of it, to be more homogeneous, but among these there are also outliers. Men's parkas, from western Inuit distinguish themselves by their larger areas.

This study states, that measurement of material resource usage is important for the identification of Inuit parkas regarding men and women's clothing, as well as their Inuit connection. However, without classifying the parka design and identifying the used species of fur and skin, the conclusion is that quantification of material resource use cannot stand alone. The design and animal species are vital parameters which must also be taken into consideration.

With regards to assessing material resource usage in traditional, historical skin clothing from other population groups, or garments made of fabrics, or archaeological garments, the options are open – but accurate assessment requires the inclusion of a comparative reference collection of items of known provenance. To document material resource usage of fragile, perishable skin parkas, two measurement methods, Method 1: 3D-measurement, and Method 3: 2D-measurement of digital images are recommended. Consistent museum practice provides many opportunities. Hence, the findings of this study could motivate cultural history museums to adopt documented practices, which include capturing images of garments of various types and materials in a flat position (both front and back), photographing them with a scale bar, and using measuring tapes following a specific procedure for measurements.

This project's scope does not allow for an analysis of reasons for minor material usage among some Inuit, whether due to the longevity of traditional designs, animal resource limitations, climate, or other factors. However, further research, including archaeological finds, will provide valuable perspectives and insight into clothing material usage.

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the garment. The unique, skilful, clever, and uniform designs fortunately preserved in museum collections are a treasure.

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Irene Skals, Ulla Mannering and Eva Andersson Strand

# Wool fibre quality in Danish prehistoric textiles: a 3,000 year survey

## Abstract

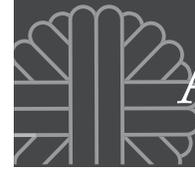
During the last 15 years analyses by fibre diameter measurements of a wide range of yarn samples from Danish archaeological wool textiles dated from the Early Bronze to the Viking Ages (circa 1800 BCE to 1050 CE) have been made. The extraordinary preservation of these textiles makes them ideal for interpretations regarding wool fibre development and processing. The aim of this paper is to investigate possible changes in fibre quality through time that can be related to either differences in the raw wool or in the work process preparing the wool for spinning. The standard statistical calculations of the wool fibre diameters which form the basis for classifying prehistoric wool have been used but slightly elaborated to extract more detailed information and facilitate the interpretation of the collected data. The fibre qualities in the textiles from the different archaeological periods have been compared and the principles for wool development and processing assessed for each. The results have revealed that a similar kind of wool was used for a long period of time in the Danish area with only minor changes that could indicate adjustments of the production and processing to meet the demands for textile appearance. Further, the results show that a change took place in the textile fibre quality between circa 400 CE and 600 CE which indicates the introduction of a different sheep breed and processing strategy. In this way, new and more specific knowledge has been acquired about wool fibre development and the work, desires, and choices of prehistoric textile craftspeople through a long period of time.

**Keywords:** Danish prehistoric textiles, wool, fibre diameter analysis, fibre processing, textile design

## Introduction

Through fortuitous environmental and microbiological coincidences, a large number of prehistoric textiles made from sheep wool has been preserved in Denmark, dating from the Bronze Age to the Viking Age (circa 1800 BCE to 1050 CE). They consist to a large extent of complete or fragmented pieces of garments and coverings recovered from bogs and burials (Bender Jørgensen 1986; Hald 1980). Evidence of the use of sheep wool for textiles before the Early Bronze Age has not yet been found in Denmark although sheep were introduced in Scandinavia with the neolithic lifestyle. In recent years, this unique collection of well-preserved wool textiles has formed the basis for comprehensive studies regarding the complexity of interactions necessary for the production of textiles (Andersson

Strand et al. 2024; Demant et al. 2021; Frei et al. 2017; Mannering et al. 2010; Skals and Mannering 2014; Skals et al. 2018, 2024; Vanden Berghe et al. 2009). The focus of the present study is the fibre composition of the wool spun into yarns and is based on statistical calculations of measurements of individual fibre diameters. For a long time the method has been used to develop an evolutionary theory of sheep and define differences in fleece types resulting from breeding (Rast-Eicher 2008; 2013; Ryder 1983a). The material selected for this study contains samples of warps and wefts from each sampled textile, in many cases two samples from each, and when possible, additional yarns such as sewing or embroidery threads and cords. It is ideal for tracking nuances in the fibre composition that may be related to the processing of the raw material. By comparing



the results from the different yarns in the textiles from different time periods, it has been possible to distinguish differences that may either be interpreted as related to the raw wool or the processing. This approach emphasises the skills, desires, and choices of prehistoric textile craftspeople with regard to the available wool and contributes knowledge about the tacit part of textile production. These are important for understanding the quality and properties of the final product (Bender Jørgensen 2012).

The sampled textiles have all been preserved in their organic state but the conditions for their preservation were varied and resulted in different degrees of degradation. The Bronze and Early Iron Age textiles are from waterlogged conditions and are extremely well preserved while the Roman Iron Age textiles are from inhumation graves, primarily in sandy soil, and are much more degraded. One group of the Late Iron Age textiles is from graves and preserved by metals, although not yet mineralised, while another was found in a settlement. The Viking Age textiles have been found in both waterlogged and dry conditions. To what degree these different circumstances have influenced the diameter of the individual wool fibres is not thoroughly researched. The measurements from prehistoric wool fibre analyses in general can only be approximate (Skals et al. 2018). It is thanks to the large quantity of analyses representing a long period of time that this study can contribute knowledge regarding the use of wool in prehistory.

### Research history

Sheep wool used as a textile material is believed to have developed through selective breeding during the transformation of wild sheep to domesticated breeds. The coat of the wild ancestor moulted yearly and consisted of long straight hair called kemp, covering short, differently pigmented fine wool. This wool was unsuitable for spinning into yarn but with time the domesticated woolly sheep developed a coat of slightly longer fine wool and coarse fibres which were not so thick. Early selective breeding seems to have resulted in the development of unpigmented fibres (Gleba 2012; Rast-Eicher 2012; 2013). The process started in areas around south-west Turkey and the Near East during the third millennium BCE and spread from there to Europe (Bender Jørgensen and Rast-Eicher 2018; Bender Jørgensen et al. 2023; Ryder 1983a; 2005). Through interdisciplinary research studies of Near Eastern archaeology, texts, iconography and archaeozoology, it is now known that two varieties of sheep with characteristically different fleeces co-existed in the Neolithic Near East (Breniquet 2014;

Breniquet and Michel 2014; Vila and Helmer 2014).

The use of wool for making textiles is believed to have resulted in methodological innovations in textile production and possibly also new spinning and weaving tools. This development is documented by abundant finds of textile tools in the Aegean and Middle Eastern Early Bronze Age cultures (circa 3500 BCE to 3200 BCE), where textile finds are very rare, but where written sources and iconography testify to the presence of a large-scale textile production (Andersson Strand 2015; Breniquet and Michel 2014; Sabatini et al. 2019). In Scandinavia, the situation is reversed. Here many textiles are preserved from the Early Bronze Age, circa 14th century BCE and onwards but the tools, especially from the earliest periods, are rare (Andersson 1996; 2003; Lerke and Hjorth-Jørgensen 2015). A large number of textiles made from sheep wool has also been preserved in the salt mines at Hallstatt in Austria, dated between 1200 BCE and 700 BCE (Late Bronze and Iron Ages) (Grömer 2012; 2013; Grömer and Saliari 2018; Rast-Eicher 2013; Ryder 1990). Other Central European textile finds are most often mineralised and preserved in connection with metals but these finds have also been studied successfully using scanning electron microscopy (Gleba 2012; 2014b; Rast-Eicher 2008).

The material available for prehistoric wool studies consists of the woven textiles and in some cases skin items. The specific sheep breed from which the wool or skin has come is not known and wool fibres are far from identical. Their quality and thickness will depend on where on the body they grew as well as the age, gender, and health of each animal. Furthermore, no two sheep within the same flock will be similar (Andersson Strand and Mannering 2017). This means that the wool for each specific textile could have been specifically selected quite early in the process.

The wool can be spun immediately after plucking/shearing, but the quality of a finished textile greatly depends on how well the fibres are prepared. The wool has to be sorted by hand, according to criteria such as fibre fineness, colour, length and strength. Teasing the wool by hand or flogging it with a whip will help remove dirt and tangles. Finally, before spinning, long and short fibres are separated, and the fibres arranged parallel to each other using combs with long teeth (Andersson Strand and Mannering 2017; Christiansen 2004; Gleba and Mannering 2012).

### *Prehistoric wool fibre analysis*

Prehistoric wool fibre analysis builds on modern industrial standards for classifying wool quality and to estimate the use and price of each fleece. These



standards comprise evaluations of factors such as staple length and strength, the number of fibres with medulla (air-filled centres found in coarser fibres), the colour, and the mean fibre diameter of each fleece. Fibre diameters are measured in microns whereby 1,000 microns equal one millimetre. The finer the diameter of the fibres the softer the wool will feel to the skin. Generally, soft, non-prickly fibres measure less than 22 to 23 microns while rough and prickly fibres measure more than 32 to 34 microns (Wilson and Laing 1995). Dimensions on that scale need to be observed under magnification. In the wool industry, several thousand measurements from each sheep fleece are made automatically with different types of specialised equipment such as optical-based fibre diameter analysers, airflow apparatus or laser scan technology ([www.nzwta.co.nz](http://www.nzwta.co.nz)). Modern sheep can be bred to have fleeces with a uniform fine fibre profile, preferably with a mean diameter of less than 30 microns, and no outer hairs, and these characteristics have the highest market value ([www.jwto.org](http://www.jwto.org)). This differs from the so-called primitive sheep breeds which have fleeces closer to the ancient breeds consisting of an outercoat and an undercoat of coarse and fine fibres respectively.

During the 1960s, the standards from the modern wool industry were adapted to analyses of prehistoric wool by Michael Ryder (Ryder 1964; 1969). The required standard number of diameter measurements was set to a minimum of 100 fibres per sample. These measurements were obtained using a projection microscope (Walton 1988) or on images from optical or scanning electron microscopy (Gleba 2014a;

Rast-Eicher 2008; 2012; 2013; Skals et al. 2018). The extent of pigmentation and medullation is noted and quantified when possible but can be obscured by discolouration and staining due to degradation. Measuring fibre length was generally not possible because the analyses were made on small samples cut from yarn. The fibre diameter is therefore the primary indicator of fibre quality from ancient contexts.

In line with the industrial methods, Ryder's system calculated results with similar statistics and interpretations in terms of fleece types. By comparing fibres from prehistoric textiles and skins to wool from so-called primitive sheep breeds living in isolated areas in the 1960s to 1980s, Ryder developed an evolutionary theory of sheep and defined six fleece types to represent changes to the wool using the terms hairy, hairy medium, generalised medium, medium, fine, and short (Ryder 1983a). Standard histograms were used to illustrate the differences in the fibre profile from the earliest fleeces where the measurements were distributed in two groups of bars separated by a wide gap – in comparison to the 20th century fleece which formed a coherent and symmetrical curve. It was further discovered that the development towards more uniform fibre profiles resulted in a slight coarsening of the finest fibres, the appearance of medium fibres, and the disappearance of the very coarse fibres. These changes are considered to be important steps away from the primitive towards more evolved sheep breeds (Ryder 1983a).

In the late 20th century, several Danish Bronze and Early Iron Age textiles and sheep skins were analysed according to Ryder's system. A few samples

**Table 1: Ryder's model of sheep fleece classification - attributed to Danish Bronze and Iron age skins and textiles**

DEFINITION				NUMBER OF SAMPLES		
MODE DIAM.	MAXIMUM DIAM.	DISTRIBUTION	CLASSIFICATION	BA TEXTILES	IA SKINS	IA TEXTILES
30-40 microns	> 100 microns	Continuous	Hairy (H)	4	7	
30 microns	> 60 < 100 microns	Skewed to fine	Hairy Medium (HM)	6		40
20 microns	55 microns	Skewed to fine	Generalised Medium (GM)			6
30-40 microns	60 microns	Symmetrical	Medium (M)			1
20 microns	35 microns	Symmetrical	Fine (F)	8		3
25 microns	40 microns	Symmetrical	Short (S)			8

Table 1: Ryder's model of sheep fleece classification attributed to Danish Bronze and Iron Age skin and textile finds. Ryder's model uses the mode, the maximum diameter, and the distribution of the results to classify the fleece types, with the hairy type being closest to the wild sheep. The majority of the prehistoric Danish wool and skin samples were classified as hairy medium. Samples with random very coarse fibres are classified as hairy



with extraordinary low mean measurements and very coarse kemp were defined 'Mouflon type' or 'Intermediate' between the wild and the hairy types but the majority were classified as hairy and hairy medium. A few exceptions interpreted as generalised medium, medium, fine and shortwool were seen as evidence of the co-existence of differently evolved sheep breeds (Bender Jørgensen and Walton 1986; Ryder 1983b; 1988; Walton 1988) (table 1).

Ryder's method was subsequently disputed because it neglected to take the process of fibre selection, sorting and preparation for spinning into account (Andersson Strand 2012; 2015; Christiansen 2004; Gleba 2012; Good 1999; Nosch et al. 2013). A different classification system was developed by Antoinette Rast-Eicher based on a fleece type definition from the late 19th century which identified four main types termed hairy, mixed, coarse and fine, and fine. Their differences are, as in Ryder's system, exemplified by standard histograms and seen as evolving towards the more uniform fibre types. Medullation, pigmentation and fibre lengths added further information to the evolutionary stage of the wool (Rast-Eicher 2008; 2013; Rast-Eicher and Bender Jørgensen 2013).

The two least developed types, hairy and mixed, are most relevant for prehistoric wool studies and defined as consisting of an outer coat of coarse hair fibres and an undercoat of fine wool fibres. The terms fine, medium and coarse are used to describe relative differences in the fibre dimensions although not specifically defined. A medulla will, according to this system, only appear in the coarser hair fibres and will be interrupted in the mixed fleece type. Both fibre types can have dimensions in the medium range. The histogram of the hairy type has two separated curves whereas, in the case of the mixed fibres, the two curves are connected (Rast-Eicher and Bender Jørgensen 2013).

In addition to the wool-type identification, Rast-Eicher created a system of 11 categories, AAA to F, to assess the processing. This system is based on analyses of prehistoric Central European textiles. The processing of each sample is defined by differences in the percentage profiles of fibres measuring less than either 25, 30, or 40 microns and 60 microns used to define the outliers (Bender Jørgensen and Rast-Eicher 2018; Rast-Eicher 2008; 2012; 2013).

#### *The Danish wool fibre study*

Rast-Eicher's system was used from the beginning of the Danish fibre study which consisted of the Early Iron Age textiles. Based on the fibre measurements alone, the fleece type for this group of textiles could



Fig. 1: Wool fibres seen with transmitted light microscopy at circa 100x magnification. The wool used in Danish textiles dating from 1800 BCE to 400 CE consist of a large number of very fine fibres and a few random very coarse fibres. This fibre diameter distribution is clearly visible with the naked eye (Image: Irene Skals)

in all cases be defined as hairy because of a very large number of very fine and a few random coarse fibres (interpreted as outliers), although medullas were observed in fibres measuring less than 20 microns as well as in coarser fibres.

During the work, it was realised that Rast-Eicher's categorisation system failed to reveal the subtle nuances in the fibre profiles of the different Danish yarn samples. It was noted that yarn samples picked from the same textile and in several cases from the exact same yarn in the weaving fell into different categories. Thus, the system did not distinguish the diversity of handcrafted wool textiles to a satisfactory degree. It was assumed that the reason for this was the structure of the statistical system (the percentage profiles measuring less than 25, 30, 40 microns respectively and 60 microns or more). The Danish textile samples generally appeared homogeneous with large majorities of very fine fibres (less than 25 microns), almost no fibres in the medium range (25 to 40 microns), and random coarse fibres measuring more than 60 microns (fig. 1). One random coarse fibre among 99 very fine fibres could in this way cause the classification to shift from AAA to B (table 2).

At this point, more fibre data had been collected and now included results from the Early Bronze and Roman Iron Age textiles which could show that the raw material through this long period of time changed very little (Skals and Mannering 2014). Compared to this, the now added results from the Late Iron and Viking Ages indicate an interesting development of the raw wool in this area but it was necessary to find



DEFINITION		
% FIBRES OF DIFFERENT DIAMETERS	WOOL QUALITY CLASS	NO. OF EARLY IRON AGE SAMPLES
92% < 25 µm, 8% > 25.1 µm, 1% > 30 µm, max. 40 µm	AAA	35
85% < 25 µm, 15% > 25.1 µm, 3% > 30 µm, max. 60 µm	AA	8
93% < 30 µm 7% > 30.1 µm, 1% > 40 µm, max. 60 µm	A	0
80% < 30 µm, 15% > 30.1 µm 2% > 40 µm, max. 60 µm	AB	0
75% < 30 µm, 25% > 30.1 µm, 2% > 40 µm	B	16
66% < 30 µm, 10% > 45 µm, 1% > 50 µm	C	0
80% < 40 µm, 20% > 40.1 µm, 2% > 60 µm	CD	2
66% < 40 µm, 34% > 40.1 µm, 5% > 60 µm	D	0
60% < 40 µm, 40% > 40.1 µm, 10% > 60 µm	E	1
50% < 40 µm, 50% > 40.1 µm, 15% > 60 µm	EE	0
50% < 30 µm, up to 50% > 60 µm	F	0

Table 2: Rast-Eicher’s model of fibre classification attributed to Danish Early Iron Age textiles. This model differentiates between four different wool types, the hairy type being the most primitive. Eleven categories defined by different proportions of fibre groups classify the quality. More than half of the 62 Early Iron Age samples were categorised as AAA. One or two coarse fibres seen in wool with otherwise very similar fibre results caused a shift to Category B

a way to obtain an easy overview of the large quantity of data and to more easily differentiate between details in the finer fibre profiles believed to relate to the wool processing before spinning.

As all the results had been calculated and grouped in accordance with Rast-Eicher’s categorisation system, it was easy to select the following three fibre groups to describe the data: fine fibres (less than 25 microns), medium fibres (from 25 to 40 microns) and coarse fibres (more than 40 microns). In this manner the

fibres in the medium range, which are important in the development away from the primitive sheep, become more apparent, and the coarsest fibres are defined as everything above 40 microns.

Comparing the percentage profiles of these groups in the results from the first three archaeological periods (Bronze Age to Roman Iron Age) revealed differences that could be explained by different production traditions resulting in different textile appearances and the distinctions between the three fibre groups also turned out to be valuable for the analyses of the results from the Late Iron and Viking Age textiles. Fortunately, the large number of measurements from each sample compensated for measurement uncertainties and the fact that the diameter of a wool fibre varies along its length.

In combination with the standard histograms which display the frequency of the results at every second micron, the diagrams of the cumulative frequency shown here present the sum of the percentages of fibres at each different diameter as a curve. The steepness of the curve is a measure of the uniformity of the fibres in each sample. When comparing two or more samples, it is easy to see where along the curve the differences appear and to evaluate them in relation to the raw wool and the processing respectively.

To further corroborate this interpretation, a test to analyse to what degree combing affected the fibre profile was established. Two wool staples from a

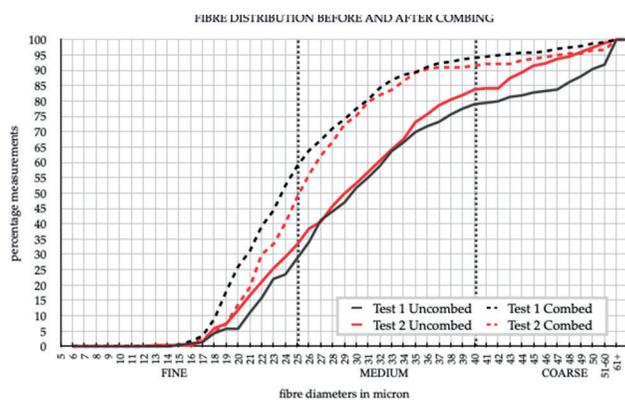


Fig. 2: Cumulative frequency diagram of two tests comparing uncombed and combed wool staples shows that combing results in a higher number of fine and medium fibres and fewer coarse fibres as shown by a steepening of the curves (Diagram: Irene Skals)

**Table 3: The effect of combing on the fibre content**

Test	UNCOMBED WOOL STAPLE					COMBED WOOL STAPLE				
	%Fine	%Medium	%Coarse	Range- $\mu\text{m}$	Category	%Fine	%Medium	%Coarse	Range- $\mu\text{m}$	Category
1	34	45	21	14-18, 20-58	E	64	30	6	14-43, 45-50, 54	CD
2	38	45	16	12, 16-40, 42-51, 53	CD	56	36	8	14-36, 39-40, 43-47, 49, 51, 55, 57, 60	CD

Table 3: Effect of combing a wool fibre staple. The fibre diameter distributions and the calculations of the fibre results from the uncombed and combed wool staples show that this process results in an increased number of fine fibres and a decreased number of coarse fibres. The number of medium fibres was unchanged in Test 1 and the categorisations were unchanged in Test 2. Minimum and maximum measurements did not change significantly

modern so-called primitive sheep fleece were combed by three strokes each. Fibre analyses were made of samples picked before the first and after each consecutive stroke. The results from both samples suggested that the number of fine fibres gradually increased, and the number of coarse fibres decreased (fig. 2, table 3). Although the number of coarse fibres in the prehistoric raw wool is unknown, its processing can be assessed by comparing the remaining quantities of coarse fibres in the different yarns.

### Method

The fibre diameter measurements in this study were made on digital photographs captured by transmitted light microscopy using camera software (a Primo Star iLED microscope from Zeiss with a 10x objective, equipped with an AxioCam ERc5s camera) with a minimum of 100 fibre diameters per sample, and with statistical data processing in Excel. The natural pigmentation of the fibres and the extent of medullated fibres were noted and evaluated with regard to the wool development where possible. It is on this basis that the percentage results of the fibre diameters were calculated, and cumulative frequency diagrams created (Skals et al. 2024). The results were further calculated according to Rast-Eicher's categorisation format (Rast-Eicher 2008; Rast-Eicher and Bender Jørgensen 2013) and the percentage results sorted into fine (less than 25 microns), medium (25 to 40 microns) and coarse (more than 40 microns) fibres groups. The interpretation of the changes recorded in the fibres that signify the development of the raw wool through time was approached by:

- Comparing the profile of the three fibre groups: fine, medium, and coarse in the different time periods
- Comparing the range of fibres in each specific period. For this purpose, the most and the least uniform samples from each period were

compared. They were defined by the steepest and gentlest cumulative frequency curves, the largest and smallest numbers of fine and coarse fibres and the minimum and maximum measurements

- Comparing the dimensions of the coarsest fibre from each period

The processing was viewed as two separate steps consisting of the selection of wool for different purposes and the combing:

- Selection and sorting: Differences in the fibre dimensions were dependent on the age and health of the sheep and where the fibres grew. Variations in the concentrations of similar fibres were therefore used to evaluate the selection. They were very subtle and most clearly illustrated by the heights of the peaks in the histograms and the widths of the coherent curves. In the samples from the first three periods, they were mainly found within the fine fibre range. Sorting according to colour was part of this work process.
- Combing: The extent of combing was assessed by comparing the quantities of coarse fibres remaining in the different yarns.

The nuances in the fibre composition in the different yarns from each textile due to processing were assessed by comparing their cumulative frequency diagrams and the different combinations of the three fibre groups: fine, medium, coarse.

### Results

The textile finds were grouped according to their context and dating. A total of 350 yarn samples were analysed and the data set constitutes 65,000 fibre diameter measurements:



Table 4: Textiles from the bronze age circa 1800 to 500 BCE				
Location	Textile		No. of samples	
Borum Eshøj A	Cape	B1397	warps, wefts, sewing thread	7
	Wrap around garment	B1399	warps, weft, sewing thread	4
	Belt	B1400	cord	1
	Foot cloths	B1402	warp, weft	2
Borum Eshøj B	Cape	B1405	warp, weft	2
	Wrap around garment	B1406	warp, weft	2
Borum Eshøj C	Net	B679	sprang, cord	2
	Blouse	B680	warp, weft, sewing thread	3
	Skirt	B681	warps, weft, sewing thread	4
	Belt	B682	dark and light warps, weft	3
	Belt	B683	warp, weft	2
	Piece of cloth	B684	warp, weft, sewing thread	3
Egtved	Blanket	B11833	warp, dark and light wefts	3
	Blouse	B11834	warps, wefts, sewing thread	5
	Belt	B11835	warp, weft	2
	Corded skirt	B11836	cord, weft, yarns from belt, sewing thread	5
	Cord	B11847	cord	1
	Bundle	B11849	warp, weft	2
Guldhøj	Cap	B5065	warp, weft, sewing thread	3
Hvidegård	Piece of cloth	9220e	warp, weft	2
L. Dragshøj	Fragment of cap	19464	warp, weft, embroidery threads	4
Muldbjerg	Cape	B3320	warp, weft	2
	Wrap around garment	B3321	warp, weft	2
	Piece of cloth	B3322	warp, weft	2
	Foot cloths	B3323	warp, weft	2
Nybøl	Textile type A	ÅBMx64	warp, weft	2
	Textile type B	ÅBMx64	warp, weft	2
	Textile type C	ÅBMx64	warp, weft	2
	Textile type D	ÅBMx64	warp, weft	2
	Textile type E	ÅBMx64	warp, weft	2
Skrydstrup	Net	B12961	sprang, cord	2
	Blouse	B12962	warp, weft, embroidery threads	3
	Belt	B12963	warp, weft	2
	Skirt	B12964	warp, wefts, sewing thread	4
	Foot cloth	B12966	warp, weft, sewing thread	3
	Blanket	B12969	warp, weft	2
Toppehøj	Fragment of cap	MDCCLXXXV	warp, weft, embroidery thread	3
Trindhøj	Cape	B19909	warp, weft, embroidery thread	3
	Wrap around garment	B19910	warps, wefts, sewing thread	5
	Belt	B19910	warp, weft	2
	Blanket	B19911-12	warp, weft	2
	Foot cloths	B19913	warp, weft	2
	Cap	B19914	embroidery thread	1
	Cap	B19918	sewing thread	1
V. Doense	Fragment	B3416	warp, weft	2
Voldtofte	Fragment	24636	sewing thread	1

Table 4: The textiles sampled from the Bronze Age in this study come from 14 finds



- The Bronze Age textiles (BA) consisted of finds from the oak coffin burials representing the period circa 1800 BCE to 500 BCE. Analyses were made of 118 samples from 46 textiles (table 4)
- The Early Iron Age textiles (EIA) consisted of finds from bogs representing the period circa 500 BCE to 1 CE. Analyses were made of 62 samples from 29 textiles (table 5)
- The Roman Iron Age textiles (RIA) consisted of grave finds representing the period circa 1 CE to 400 CE. Analyses were made of 79 samples from 37 textiles (table 6)
- The Late Iron Age textiles (LIA) consisted of finds from graves and a settlement representing the period circa 620/630 CE to 800 CE. Analyses were made of 31 samples from 17 textiles (table 7)
- The Viking Age textiles (VIK) consisted of finds from graves and settlements representing the period circa 800 CE to 1050 CE. Analyses were made of 76 samples from 35 textiles (table 8).

**Wool development circa 1800 BCE to 400 CE**

From the Bronze Age to the end of the Roman Iron Age, the wool in the Danish textiles appeared very similar. It was characterised by a majority of very fine fibres. In some cases, only fine fibres were recorded, with very sporadic medium fibres, and a few coarse fibres. The percentage profiles are listed and compared in tables 9 to 11 (based on 259 yarn samples from 107 textiles). This mixture of very fine and very coarse fibres classifies the wool as hairy, meaning that it is close to wild sheep with regard to sheep fleece development. Between the Bronze Age and the Early Iron Age, the diameter of the coarsest fibres becomes finer. In the Bronze Age, textile fibres measuring more than 100 microns and sometimes even 200 microns appear quite often, but they were rarely recorded in Early and Roman Iron Age textiles. Furthermore, in the Roman Iron Age, there was a slight increase in the number of medium fibres (table 10) which results in a small change in the variety of fibre types, although the

**Table 5: Textiles from the Early Iron Age circa 500 to 1 BCE**

Location	Textile		No. of samples	
Auning	Fragment	KHM 233-74	sewing thread	1
Borremose I	Fragment	C26451	warp, weft	2
Bredmose	Textile with checks	C24623	warp, weft, sewing threads	4
	Textile with composite bands	C24624	warp, weft, sewing threads	4
	Cap	C24626	sprang	1
Haraldskær	Scarf	C24627	warp, weft	2
	Fragment	3706	warp, weft	2
	Fragment, scarf?	3707 C1	light warp, light weft	2
	Fragment with checks	3707 C2	dark, light warp and wefts	4
Huldremose I	Cap	C37143	sprang	1
	Skirt	C3473	dark, light warp and wefts	4
Huldremose II	Scarf	C3474	dark, light, medium warp and wefts	6
	Tubular garment	D3505	warp, weft	2
Karlby	Textile with checks	D4854a	sewing thread	1
Krogens Mølle	Fragments with checks	D1310a	dark, light warp and wefts	4
	Fragment with stripes	D1310c	dark warp, light weft	2
	Fragments with checks	D1310e	dark, light warp and wefts	4
	Fragment	D1310i	sewing thread	1
Skærsø	Fragments	D1310j-l	warp, weft	2
	Textile with two components	D1310m	dark, light warp and wefts	4
	Skirt	D1310n-r	dark, light warp, weft	3
Skærsø	Rectangular textile	MKH 336	warp, weft	2
Unknown Prov.	Tubular garment	C37142	dark, mixed sewing threads	2
Ømark	Rectangular textile	C25184	warp, weft	2

Table 5: The textiles sampled from the Early Iron Age in this study come from 11 finds



Table 6: Textiles from the Roman Iron Age circa 1 to 400 CE				
Location	Textile		No. of samples	
Corselitze	Fragment	7325a	warp, weft	2
	Scarf	7325b	warp, weft	2
Hammerum	Dress		warp, wefts, ribbon, fringes, sewing thread	7
	2nd textile		warp, wefts	3
	3rd textile		warp, weft	2
Lønne Hede 1	Textile 1		warp, wefts	3
	Textile 2		warp, weft	2
	Textile 3		red warp	1
	Textile 4		red and blue yarns	2
	Textile 5		red warp, weft	2
	Textile 6		sample	1
Lønne Hede 1	Textile 1		warp, wefts	3
	Textile 2		warp, weft	2
	Textile 3		red warp	1
	Textile 4		red and blue yarns	2
	Textile 5		red warp, weft	2
	Textile 6		sample	1
Lønne Hede 2	Textile 1.3		warp, weft	2
	Textile 1.5		warp, wefts	4
	Textile 1.6		warp, wefts	3
	Textile 1.7		weft, sewing thread	2
	Textile 2.2		warp, weft	2
	Textile 2.3		warp, weft	2
	Textile 2.6		warp, weft	2
	Textile 6.2		sample	1
	Textile 12.1		warp, weft	2
	Textile 12.3		sample	1
Vorbasse I	Textile 1.1.7		warp, weft	2
	Textile 4.4.9		warp, weft	2
	Textile 4.4.67		warp, weft	2
	Textile 4.4.70a		warp, weft	2
	Textile 4.4.70b		sample	1
	Textile 4.4.B		warp, weft	2
	Textile 4.4.C1a		warp, weft	2
	Textile 4.4.Fa		warp, weft	2
	Textile 4.4.Fb		warp, weft	2
	Textile 4.4.Ha		warp, weft	2
	Textile 5.5.61		warp, weft	2
	Textile 5.5.ex		warp, weft	2
	Textile 13.13.8A		warp, weft	2
Textile 13.13.8B		warp, weft	2	
Textile 15.15.10		warp, weft	2	
Vorbasse III	Textile 2SB 2.2		warp, weft	2

Table 6: The textiles sampled from the Roman Iron Age in this study come from six finds

Location	Textile	No. of samples	
Nørre Sandegård Vest	9 258-3 k-l	loose threads	1
	9 258-3 n	warp?	1
	9 259 layer 3	warp, weft	2
	9 259.1 layer 1	warp, weft	2
	9 259.1 layer 2	warp, weft	2
	20-36 g-i	cord	1
	20-447 2c	warp, weft	2
	32-466	warp, weft, cord	3
	32-471	warp, weft	2
	70-810-11	warp, weft	2
	70-810-11 2a	warp, weft	2
	811-11 2d-e	cord	1
	70-815	warp, weft	2
	Ribe	x1098	warp, weft
x1228		warp, weft	2
x1232		warp, weft	2
x1387		warp, weft	2

Table 7: The textiles sampled from the Late Iron Age in this study come from two finds

coarse fibres were less frequent in this period (table 11). The lack of variety through this long period of time is illustrated by the closeness of the cumulative frequency curves representing the most and the least uniform samples from each period (fig. 3). The three most uniform samples almost consist of only fine fibres with resulting narrow ranges, and they have very fine minimum measurements. The least uniform samples still had large numbers of fine fibres but they were mixed with medium or coarse fibres and had slightly higher minimum measurements and wider ranges (table 12).

The development away from the very coarse fibres towards more varied fibre mixtures could be the result of breeding. Similarly, a slow development away from natural pigmentation is distinguishable. Pigmented fibres were seen in all three periods, but more distinctly in the Bronze Age wool than later, and white or lightly pigmented fibres appear more often in the Roman Iron Age textiles.

As the Bronze Age fibres were heavily pigmented, the possible presence of a medulla was often obscured. However, medullas were observed in fine fibres under 20 microns as well as in fibres in the 20 to 30 microns range in all three periods. They appeared both as continuous and interrupted in form but, because of the small sample sizes, this was difficult to determine precisely.

### Wool processing circa 1800 BCE to 400 CE

High concentrations of similar fibres were very distinct especially in the textiles from the Bronze and Early Iron Ages. This was interpreted as the result of specific selection and as an indication of a definite preference for very fine fibres. A remarkable example of this meticulous selection is found in the textiles

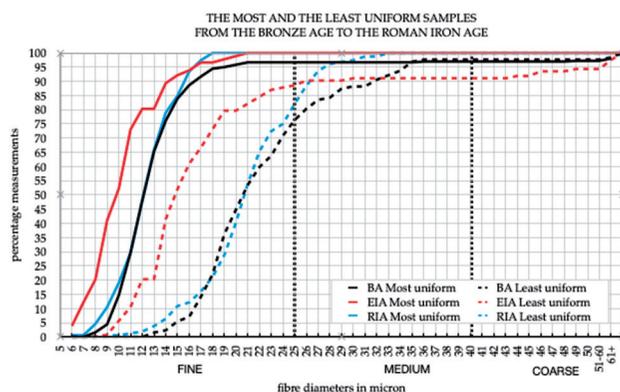


Fig. 3: Cumulative frequency diagram showing the most and least uniform samples from each of the three early time periods. They all have similar steep curves because of the large quantities of fine fibres, but the two Early Iron Age curves lie closer together than the curves from the Bronze and Roman Iron Ages because of the more uniform fibre results from that period. The curves also show that very fine fibres were recorded within the medium range (Diagram: Irene Skals)



Location	Textile		No. of samples	
Fløjstrup	Twill	C9266	warp, weft	3
	Tabby	C9266	warp, weft	2
Hedeby	Face mask, felt	14D	sample	1
	Stocking	H2	warp, weft	2
	Upper garment	H7	sample	1
	Caftan?	H11	warp, weft, lining	3
	Fragment, spencer dress?	H14 A-B	warp, weft	2
	Fragment, sleeve	H28A	warp, weft, dark textile	3
	Fragment, trousers	H39 A-B	warp, weft, sewing thread	3
	Fragment, felt	H42	dark, light samples	2
	Fragment, upper garment	H53 A-B	warp, weft	2
	Sleeve	H57	dark and light warps, and wefts	4
	Fragment, trousers	H72B	warp, weft	2
	Fragment (part of H72 A-B)	H91A	warp, weft	2
	Fragment, upper garment	H72C	warp, weft	2
	Liripipe hood	S3	warp, weft	2
	Hvilehøj	Band	S26	warp
Fragment, upper garment		S28	warp, weft	2
Fragment		C4280a	warp, wefts	3
Fragment		Ad C4290d	warp/weft unidentified and one random sample	3
Rolls of woven textile		Ad C4291	warp/weft unidentified	2
Jelling	Bundle of wool fibres	Ad C4273-97 Plate 1	fibres	1
	Fragment	C43096	warp, weft	2
Mammen	Fragment	19999	warp/weft unidentified	2
	Embroidered garment	C135a	warp/weft from two fragments; one random warp; embroidery	6
	Open tabby weave	C135b	warp/weft unidentified	2
	Tabby fragments	C135c	warp/weft unidentified	2
	Tabby band	C135d	warp/weft unidentified	2
	Tablet woven band	C136a	dark and light warps/weft	3
	Braided band	C136c		1
	Padding	C138		1
	Padding	C139		1
	Pillow	C144	warp/weft/embroidery	3
Slotsbjergby	Wool fibre bundle	C150		1
	Fragment	C9166	warp/weft unidentified	2
Trelleborg	Fragment	C37040	warp, weft	2

Table 8: The textiles sampled from the Viking Age in this study come from seven finds

**Table 9: Percentages of fine fibres in wool yarns circa 1800 BCE to 400 CE**

PERIOD	SAMPLES	100-80% of fibres measuring less than 25µm																					
		100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	
BA c. BCE 1500-500	% of 118	2	5	14	19	10	14	14	6	5	3	3	2	1	1	0	1	0	1	0	0	1	100
EIA c. BCE 500-1	% of 62	26	40	13	11	2	3	0	0	3	0	2	0	0	0	0	0	0	0	0	0	0	100
RIA c. 1-400 CE	% of 79	18	13	13	18	9	6	5	1	4	3	3	0	1	1	3	0	1	0	1	1	0	100

Table 9: The number of fine fibres in the wool yarn samples dated circa 1800 BCE to 400 CE. Fine fibres rarely constitute less than 90% in samples from the Bronze to the Roman Iron Ages. The majority in the Bronze Age vary between 98% and 94%, and between 100% and 97% in the other two periods

**Table 10: Percentages of medium fibres in wool yarns circa 1800 BCE to 400 CE**

PERIOD	SAMPLES	0-19% fibres measuring 26-40µm																				
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
BA c. BCE 1500-500	% of 118	17	24	14	13	14	3	7	1	1	3	0	1	0	0	1	0	0	2	0	0	100
EIA c. BCE 500-1	% of 62	40	39	13	5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
RIA c. 1-400 CE	% of 79	22	11	16	16	8	5	3	4	3	3	1	1	1	3	1	0	0	0	1	1	100

Table 10: The profile of medium fibres in wool yarn samples dated circa 1800 BCE to 400 CE. Medium fibres rarely exceed 10% in samples from the Bronze to the Roman Iron Ages. In the Early Iron Age, 5% was the largest percentage recorded whereas more varied results were seen in the wool from the other two periods

**Table 11: Percentages of coarse fibres in wool yarns circa 1800 BCE to 400 CE**

PERIOD	SAMPLES	0-10% fibres measuring more than 40µm											
		0	1	2	3	4	5	6	7	8	9	10	
BA c. BCE 1500-500	% of 118	14	24	28	22	7	3	1	0	1	1	0	100
EIA c. BCE 500-1	% of 62	63	29	3	0	0	2	2	0	0	2	0	100
RIA c. 1-400 CE	% of 79	77	13	9	0	1	0	0	0	0	0	0	100

Table 11: The number of coarse fibres in wool yarn samples dated circa 1800 BCE to 400 CE. Coarse fibres rarely exceed 5% in samples dated from the Bronze to the Roman Iron Ages. In a majority of yarns from the Early and Roman Iron Ages, none were recorded, whereas they appear more often in the Bronze Age

**Table 12: The overall fibre variety in the wool from the Bronze to the Roman Iron Ages**

Period	MOST UNIFORM SAMPLE				LEAST UNIFORM SAMPLE			
	%Fine	%Medium	%Coarse	Range in µm	%Fine	%Medium	%Coarse	Range in µm
BA	99	0	1	5, 7-17	80	17	2	12-29, 31-35, 60, 87, 100
EIA	100	0	0	5, 7-17	90	1	9	8-11, 13-25, 29, 43, 45, 48, 53, 55, 67, 109, 115
RIA	100	0	0	5, 7-17	81	19	0	8-31, 35-36

Table 12: The overall fibre variety in the wool from the Bronze to Roman Iron Ages. In the calculated numbers, the variations found in yarn samples from the Bronze Age and the Roman Iron Ages consist of differences in the percentages of fine and medium fibres. In the Early Iron Age, the differences lie in the percentages of fine and coarse fibres

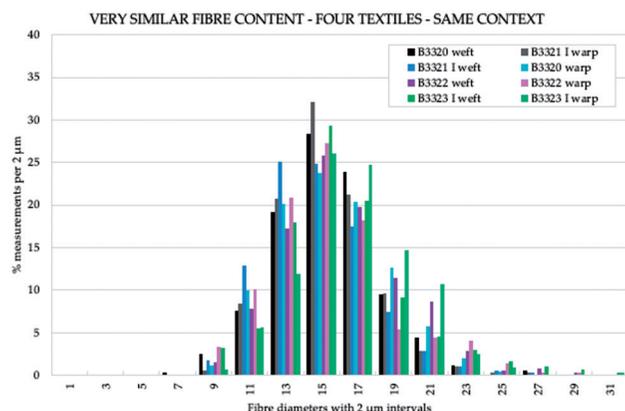


Fig. 4: Histogram showing the fibre diameter measurements of warp and weft samples from four textiles found in the same Early Bronze Age grave, Muldbjerg, in Denmark dated to 1365 BCE. The eight yarns have similar fibre diameter concentrations (Diagram: Irene Skals)

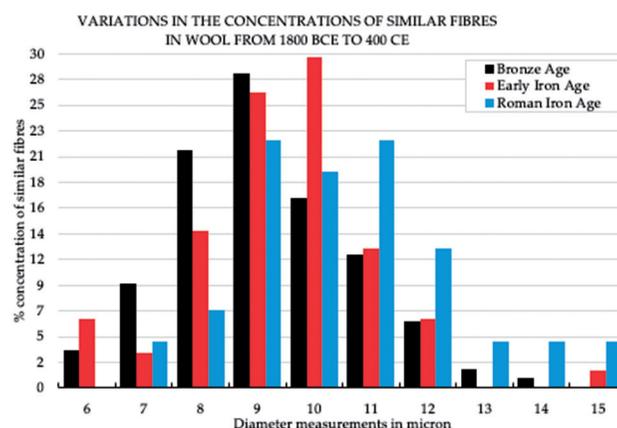


Fig. 5: Histogram showing the percentage variations in the concentrations of similar fibres in wool yarn samples from the Bronze to the Roman Iron Ages, circa 1800 BCE to 400 CE (Diagram: Irene Skals)

from the Bronze Age man’s grave from Muldbjerg which contains an oval cloak (B3320), a wrap-around garment (B3321), a blanket (B3322) and two foot cloths (B3323). The eight yarn samples from these textiles have similar fibre distributions (fig. 4) with histograms showing high peaks and narrow curves, indicative of a very similar selection of raw wool.

The Roman Iron Age results differ from the two earlier periods with slightly lower concentrations of similar fibres and wider curves (fig. 5). It has been suggested that broad curves and low peaks in the histograms could indicate that wool from different sheep of the same flock was mixed (Rast-Eicher and Bender Jørgensen 2013). If so, the Roman Iron Age results could then signify a different manner of selecting or sorting the wool.

To select and sort wool according to its natural pigmentation was common practice in the Early Iron Age (Mannering et al. 2011). The wool colour differences were used to create textile patterns such as checks and stripes (Hald 1980). In the Bronze Age, most textiles were monochrome in dark naturally

pigmented wool colours – although a striped woven belt and a textile made completely in white wool have been preserved (Broholm and Hald 1940).

Likewise, dyeing was commonly undertaken in the Early Iron Age, including textiles already patterned with naturally pigmented wool (Vanden Berghe et al. 2010), whereas the use of dyes in the Bronze Age has not been detected (Frei et al. 2017). During the Roman Iron Age, dyeing occurs less often than in the earliest part of the Iron Age (Andersson Strand et al. 2024; Møbjerg et al. 2019). Whether this is due to a craft change or the different preservation conditions in bogs and graves, respectively, is not known.

**Wool development circa 600 CE to 1050 CE**

The Late Iron Age results reveal that the wool fibre composition in the textiles changed sometime during the transition from Roman to Late Iron Age. The very high concentrations of fine fibres so common in the earlier periods were replaced with a wool mixture in which fine and medium fibres were recorded in equal quantities. This new kind of wool composition

		90% to less than 10% of fibres measuring less than 25µm																	
Period	Samples	90-86	85-81	80-76	75-71	70-66	65-61	60-56	55-51	50-46	45-41	40-36	35-31	30-26	25-21	20-16	15-11	<10%	
LIA c. 620-800 CE	% of 31	3	10	3	0	3	6	6	16	6	6	13	13	6	0	3	0	3	100
VIK c. 800-1050 CE	% of 76	1	3	4	5	4	1	9	9	8	12	9	5	9	4	3	7	7	100

Table 13: The profile of fine fibres in wool yarn samples dated circa 620 CE to 1050 CE. As opposed to the earlier time periods the percentages of fine fibres vary from less than 10% to 90%

**Table 14: Percentages of medium fibres in wool yarns circa 620 to 1050 CE**

		8 - more than 70% of fibres measuring 26-40µm																
Period	Samples	8-11	12-15	16-19	20-23	24-27	28-31	32-35	36-39	40-43	44-47	48-51	52-55	56-59	60-64	65-69	>70	
LIA c. 620-800 CE	% of 31	3	3	6	3	0	13	10	13	3	16	10	3	3	6	3	3	100
VIK c. 800-1050 CE	% of 76	0	3	7	5	7	4	18	14	12	7	5	9	5	4	0	0	100

Table 14: The profile of medium fibres in wool yarn samples dated circa 620 CE to 1050 CE. There were between 8% and more than 70% medium fibres in the Late Iron Age yarns with the highest concentrations between 40% and 51%. In the Viking Age yarns, 12% to 64% medium fibres were recorded, and the highest concentrations were from 32% to 43%

**Table 15: Percentages of coarse fibres in wool yarns circa 620 to 1050 CE**

		0% to more than 66% of fibres measuring more than 40µm															
Period	Samples	0	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	>66	
LIA c. 620-800 CE	% of 31	10	39	19	13	6	0	3	3	3	0	0	0	0	3	0	100
VIK c. 800-1050 CE	% of 76	7	24	14	12	8	5	9	5	1	3	3	5	0	3	1	100

Table 15: The profile of coarse fibres in wool yarn samples dated circa 620 CE to 1050 CE. In the Late Iron Age, the coarse fibres make up less than 15% (except in one cord sample) whereas the Viking Age samples were more varied as a result of the use of coarse fibres in the warps

became even more apparent in the Viking Age. The percentage profiles are listed in tables 13 to 15 (based on 100 yarn samples from 48 textiles). In terms of wool development, this kind of wool can be interpreted as the mixed type in Rast-Eicher's system. The appearance of medium fibres was the only main difference in the wool. There were no indications of changes to the dimensions of the coarsest fibres, and naturally pigmented wool, like the wool in the Roman Iron Age, was also still present. Consistent with the definition of the wool type, medullas are only recorded in medium range fibres and appear interrupted.

The much greater fibre variety is illustrated by the large gap between the curves of the most and least uniform samples from these two periods as opposed to the Roman Iron Age (fig. 6). The most uniform samples have very large numbers of fine fibres mixed with some medium fibres. The least uniform samples have very high numbers of coarse fibres mixed with some medium fibres, a fibre profile not seen in the earlier textiles (table 16). It is noteworthy that the curves of the most uniform samples from the Late Iron and Viking Ages coincide with the least uniform sample from the Roman Iron Age. The changes observed in the wool seem to happen abruptly and may indicate the introduction of a different kind of sheep breed into this area between the Roman and the Late Iron Ages rather than the results of deliberate breeding.

### Wool processing circa 600 CE to 1050 CE

The above-mentioned change in the wool fibre composition in the textiles seems to have altered the manner of selecting and sorting. Yarns with a majority

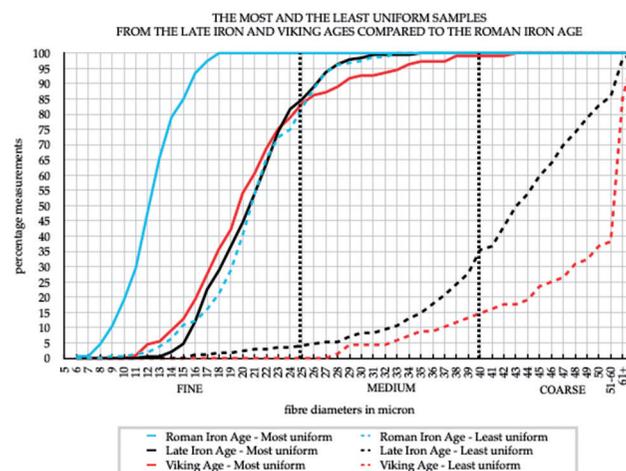


Fig. 6: Cumulative frequency diagram showing the most and least uniform samples from the Roman Iron, Late Iron and Viking Ages. The increased numbers of medium and coarse fibres that appear in the last two time periods are shown by the distance between the curves of the most and least uniform samples from each period. The most uniform Viking Age sample has a slightly larger number of fine fibres than the Late Iron Age sample, but the curves correspond with regard to the most uniform fibres (Diagram: Irene Skals)



Period	MOST UNIFORM SAMPLE				LEAST UNIFORM SAMPLE			
	%Fine	%Medium	%Coarse	Range in $\mu\text{m}$	%Fine	%Medium	%Coarse	Range in $\mu\text{m}$
LIA	89 %	11 %	0 %	11, 13-30, 34 $\mu\text{m}$	5 %	31 %	64 %	15, 17, 19-20, 22, 24-26, 28-29, 31-57, 60-61, 63, 68 $\mu\text{m}$
VIK	86 %	14 %	0 %	7-37, 44 $\mu\text{m}$	0 %	15 %	85 %	27-28, 32-34, 36-41, 43-60, 62-65, 67 $\mu\text{m}$
RIA	100 %	0 %	0 %	5, 7-17 $\mu\text{m}$	81 %	19 %	0 %	8-31, 35-36 $\mu\text{m}$

Table 16: The overall fibre variety in the wool from the Late Iron and Viking Ages. The most and the least uniform samples in the Late Iron and Viking Ages differ distinctly in all three fibre groups. This variety enabled the use of different fibre types for different yarn functions

LOW CONTENT COARSE FIBRES				HIGH CONTENT COARSE FIBRES			
warps	wefts	other	unid.	warps	wefts	other	unid
4	12	2	3	3	4	4	5
Total: 37							
MAJORITY OF MEDIUM FIBRES IN VIKING AGE YARNS							
LOW CONTENT COARSE FIBRES				HIGH CONTENT COARSE FIBRES			
warps	wefts	other	unid	warps	wefts	other	unid
1	4	1	3	7	5	1	2
Total: 24							
MAJORITY OF COARSE FIBRES IN VIKING AGE YARNS							
warps	wefts	other	unid				
7	0	1	3				
Total: 11							

Table 17: Fibre types and yarn functions in Viking Age textiles. In the Viking Age textiles, there is a distinct manner of sorting the wool with the intended function of the yarns in the weaves in mind

of fine fibres comparable to earlier were still seen, but so were yarns with equal or almost equal quantities of fine and medium fibres and yarns with a majority of medium or coarse fibres. Viewing these differences with respect to the functions of the yarns, very specific preferences were obvious (table 17). Wool consisting of a majority of fine or medium fibres was found in wefts and only in warps from textiles where warp and weft had similar fibre profiles. Wool with a majority of medium and a large number of coarse fibres or with a majority of coarse fibres was used for warps. This use of the coarse fibre differs distinctly from the earlier periods. It is not possible to know if this specific raw wool was characterised by a larger number of coarse fibres than in the earlier periods or that a societal demand for using all available fibre types initiated this different way of producing textiles. Nevertheless, this specific way of sorting the wool must have required organisation and training in new skills.

There are no preserved textiles from the Late Iron Age that document wool sorting according to natural pigmentation to make patterned textiles, but it was

practiced in the Viking Age. From Hedeby, two textiles have dark warps and unpigmented wefts (Hose H2 and Caftan H11). One textile is made with both one dark and one unpigmented warp and weft (Sleeve H57), and one felt textile is patterned with dark and unpigmented fibres (H42). Dyes have been detected in some Viking Age textiles (Vanden Berghe et al. 2023) while the Late Iron Age textiles have not been thoroughly analysed yet.

Rast-Eicher's categorisation system, which was found to inadequately characterise the early wool samples with the very large number of fine fibres, provides the Late Iron Age and Viking Age wool with much more nuanced results (table 18). In the Late Iron Age textile samples, the categories vary between AA and CD, and, in the Viking Age samples, between AB and EE. A few samples had fibre profiles which fell outside the categorisations.

### Discussion

Wool fibre preparation is a very important part of the process of producing a textile. It has a significant

**Table 18: Rast-Eicher’s model of fibre classification attributed to Late Iron and Viking Age textiles**

% FIBRES OF DIFFERENT DIAMETERS	WOOL QUALITY CLASS	NO. OF LATE IRON AGE SAMPLES	NO. OF VIKING AGE SAMPLES
92% < 25 µm, 8% > 25.1 µm, 1% > 30 µm, max. 40 µm	AAA	0	0
85% < 25 µm, 15% > 25.1 µm, 3% > 30 µm, max. 60 µm	AA	1	0
93% < 30 µm, 7% > 30.1 µm, 1% > 40 µm, max. 60 µm	A	2	0
80% < 30 µm, 15% > 30.1 µm, 2% > 40 µm, max. 60 µm	AB	2	5
75% < 30 µm, 25 % > 30.1 µm, 2% > 40 µm	B	4	4
66% < 30 µm, 10% > 45 µm, 1% > 50 µm	C	5	11
80% < 40 µm, 20% > 40.1 µm, 2% > 60 µm	CD	11	25
66% < 40 µm, 34% > 40.1 µm, 5% > 60 µm	D	1	7
60% < 40 µm, 40% > 40.1 µm, 10% > 60 µm	E	3	12
50% < 40 µm, 50% > 40.1 µm, 15% > 60 µm	EE	1	5
50% < 30 µm, up to 50% > 60 µm	F	0	0
No category		1	7

Table 18: Rast-Eicher’s model of fibre classification attributed to Late Iron and Viking Age textiles. This classification appears more nuanced when used for the wool from these periods.

impact on the quality and properties of the final product. Considering this, it is important to keep in mind that sheep breeding is, and was in prehistory, the result of a cooperation between the sheep farmers and the needs and desires of their immediate society. Sheep breeding for wool may have differed from sheep breeding for meat and, just as today, the quality of the product depended on the demand. The cause and effect of changes in the wool fibre composition and its processing were therefore interdependent and influenced by the sheep owners, the craftspeople, and the technology available to them, all of which were expressed in the textile design.

Through the results of these fibre analyses, it has been possible to trace about 3,000 years of development and use of wool in textile production in Denmark. Assuming that the quality of the wool was adjusted to demand, it is interesting to observe at what point in time changes appear.

The results show that wool from the Danish Bronze Age until the end of the Roman Iron Age was very similar with two distinct fibre types and almost no fibres in the medium range. During the transition between the Roman and the Late Iron Ages, this was replaced with wool with a wide range of medium

fibres. From this, it can be deduced that the textile producers used the same wool from the beginning of the Bronze Age to the end of the Early Iron Age, when a new fibre type seems to appear.

The decreased thickness of the coarsest fibres is one of the first parameters used to indicate a development away from the primitive wool towards the evolved wool. This characteristic change happens between the Danish Bronze and Early Iron Ages around 500 BCE. These results indicate no further fibre changes in this regard except for a significant change in the dimensions of the coarsest fibres shown by an increased number of fibres ranging from 40 to 80 microns in the Late Iron Age textiles (table 19). The appearance of fibres in the medium range is interpreted as yet another sign of development, and, in the Roman Iron Age results, a slight increased fibre variety was found, although it is not sufficiently significant to indicate the use of a different wool type.

Fibre roots and tips have not been observed in this study but both have been detected in Hallstatt wool by scanning electron microscopy and, in the same study, it was possible to establish the use of fibre combing in the individual yarns by studying the direction of the scale patterns on the fibres (Rast-Eicher 2013). With



Periods	40-59 $\mu\text{m}$	60-79 $\mu\text{m}$	80-100 $\mu\text{m}$	above 100 $\mu\text{m}$	Max. $\mu\text{m}$
% of 118 BA samples	3	7	14	64	224
% of 62 EIA samples	8	10	6	15	124
% of 79 RIA samples	11	9	8	6	125
% of 31 LIA samples	55	19	6	10	134
% of VIA samples	41	41	11	3	119

Table 19: This table shows changes in the dimensions of the coarsest wool fibres throughout the prehistoric period. The sizes of the coarsest fibres were comparable in the Bronze and Early Iron Age samples. Fibres measuring between 40 and 80 microns increase in the Late Iron and Viking Ages. Fibres larger than 100 microns were characteristic for the Bronze Age samples

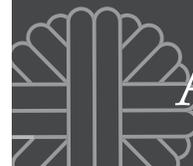
respect to deliberate choices of fibres, these results show that some yarns were made with uniform fibre profiles whereas others were slightly more varied. This most likely signifies conscious choices at work: the uniform fibre profiles with no medium or coarse fibres may indicate meticulous wool practices in the Early Iron Age.

It is not possible to determine whether the wool or the textiles from the early periods were locally produced or imported from these analyses. The results appear homogenous, and the use of the wool seems founded on similar standards and traditions. A distinct set of characteristics in the Danish Bronze Age wool, which so far has only been recorded in a few textiles outside Scandinavia, is the extreme fineness of the minimum size fibres, the large quantities of very fine fibres, and the almost complete lack of medium fibres. There are theories that a different sheep breed existed in this area compared to others (Rast-Eicher and Bender Jørgensen, 2013; Ryder 1983a; 1988; Walton 1988). The extensive uniformity of the fibre profiles results in very narrow ranges of measurements, few very high peaks in the histograms, and very steep slopes in the cumulative frequency diagrams. So far, similar results have only been recorded in two Italian textiles, from Castione dei Marchesi dated to about 1100 BCE and from Cogion dated to about 300 BCE, and in a textile from Pustopolje, Bosnia-Herzegovina, dated to 1600 BCE to 1200 BCE. None of the published Hallstatt results from Austria have comparable narrow ranges and fine minimum measurements (Gleba 2012; Grömer et al. 2018; Rast-Eicher and Bender Jørgensen 2013).

Yarn thickness and weave types differ in the different archaeological periods depending on the desired shape and drape of the textiles. This has required changes to the fibre profiles and the need for different wool processing. In this respect, the quantities of coarse fibres in the early wool are interesting. Experimental archaeology studies have documented

that it is difficult to spin thin yarns if the coarse hair and kemp are not removed (Grömer and Saliari 2018). It was suggested here that the number of coarse fibres decreases when teasing and combing the wool. The amount of sorting and combing and the thickness of the yarns are therefore interdependent. This means that the extent of coarse fibres in the yarns was a deliberate choice. In this respect, there were slightly larger numbers of coarse fibres in the wool from the Danish Bronze Age samples than in others. The yarns in these weaves were generally quite thick with a diameter of about one millimetre, single and evenly spun with a hard twist. In contrast, the decorative embroidered piles on the surface of the caps found in several men's graves were made with very thin plied yarns measuring about 0.3 mm (Skals 2020). The fibre analyses from these do not differ in any significant way, and it appears that both thick and thin yarns were made from wool with similar fibre composition. In the Early Iron Age results, the number of coarse fibres was very small (see table 9 to table 11) but samples of sewing threads, especially when used for repairs, generally have higher numbers of coarse fibres, perhaps indicating the intention of making a stronger yarn. A remarkable lack of coarse fibres is seen in the results from the Roman Iron Age where the wool in other ways appears quite similar to the earlier periods. It seems unlikely that the coarse fibres simply disappeared from the raw material and therefore this characteristic could be the result of thorough processing.

The coarse fibres cannot be used to interpret and understand the processing of the wool from the Late Iron and the Viking Age textiles. The selection and sorting of the different fibre types was now performed with the function of the yarn as warp or weft in mind and clearly illustrates the interdependence of the different processes in textile production. All fibre types were used in the textiles. The coarse fibres were used for making strong warps, whereas the fine and



medium fibres were preferred for the wefts. Similar practices have been documented in Central European Iron Age textiles (Rast-Eicher and Bender Jørgensen 2013) and that tradition continued for several centuries in Scandinavia, as documented by analyses of the archaeological textiles from the Norse settlements in Greenland dated from about 1000 CE to 1400 CE (Walton 2003).

### Conclusion

Although there is no evidence of the use of wool for textiles before the Early Bronze Age, there are no preserved textiles which indicate unprofessional workmanship. All the textiles appear to have been created by knowledgeable and experienced people. The terminology used to describe prehistoric wool and textiles often contributes to subjective impressions of them as primitive. The terms coarse and fine are, as this study shows, used in wool fibre analyses, and the results are interpreted with regard to the development of the wool from the coat of the wild or the primitive to the domesticated or the developed animal. Similarly, sheep breeds with undercoats of fine wool and overcoats of coarse hairs now living are called primitive breeds. This use of value-laden words colours the general impression of the quality of the textiles, and they are often thought to be prickly to the skin and uncomfortable to wear. These studies of the wool fibres tell a different story.

Reconstructions of prehistoric textiles are often made using wool from the modern primitive sheep breeds, but so far, finding a proper wool for reproducing the Danish Bronze and Iron Age textiles has proved almost impossible. The very fine fibres which have been the main component of these textiles cannot be matched with the fine underwool from today's primitive sheep breeds, but when it concerns the Viking Age wool quality, the situation is much better. A recent research project aiming at reproducing several different Viking Age textile qualities successfully found and processed comparable modern wool from primitive sheep breeds (Skals et al. 2024).

The way of evaluating the results from wool fibre analyses presented here has been possible because the Danish material is so extensive. The work was initiated by the need and desire to reveal the subtle information hidden in the large quantity of collected data, as well as the need to make the results accessible to people working with reconstructions of prehistoric textiles and wool fibre preparation. It has been surprising to find that the differences in the yarns which can be interpreted as the results of processing are very subtle. The degree of similarity found in each

archaeological period seems to indicate great skill but also that specific standards were taught and passed on over long periods of time.

### Acknowledgements

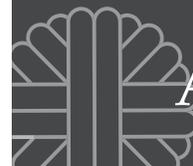
The analyses of all these textiles and the development of the fibre measurement methodology has been a long process and the work evaluated and adjusted thanks to many comments from knowledgeable colleagues.

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# Icelandic mittens from archaeological contexts

## Abstract

Protecting the hands from cold and damp conditions has been essential in northern Europe from prehistory to the present. Due to preservation, few examples of gloves and mittens have been recovered from archaeological contexts. Nonetheless, existing finds still reveal important information about everyday life in the past. Starting with three Icelandic finds we will discuss how mittens were produced with different techniques and how they were used and repaired from the 10th to the 17th centuries in the Nordic countries. A pair of well-preserved children's mittens from Heynes (Pjms. 1960-77), located in Hvalfjörður in western Iceland, sewn from woven cloth was recently AMS radiocarbon dated to 925–1030 CE. Another woven mitten (Pjms. 1940) from Garðar, near Akranes in western Iceland, was dated to 1310–1388 CE, whereas a mitten in nalbinding from the site of Arnheiðarstaðir in Fljótisdalur in eastern Iceland (Pjms. 3405) was dated to 1480–1640 CE. Other finds from Scandinavia and northern Europe are included, all showing different ways of making hand protections in a time before knitting became the dominant technique used for handwear.

**Key words:** Viking Age, nalbinding, Medieval, North Atlantic, weaving, wool, clothing, children's clothing

## Introduction

The cold and wet climate of the Nordic countries means that protecting the hands with gloves or mittens has been essential since prehistory. Due to preservation conditions, archaeological remains of gloves and mittens are limited, but the existing finds provide important information about everyday life in the past.

Today, the difference between mittens and gloves is defined by shape. Mittens are hand coverings with a single section for the four fingers and a separate thumb section. As opposed to this, gloves are fitted hand coverings with individual sections for each finger (Willemsen 2015a, 2). Enclosing the fingers is however not void of problems and the thumb must also be covered while maintaining the prehensile functions of the hand. The 'thumb problem' has been solved in numerous different ways across different time periods. Woven fabric or leather must be cut into shape and the thumb sewn on separately, whereas

when using the nalbinding technique it is easier to immediately create a three-dimensional shape.



Fig. 1: Map of Iceland indicating the locations of the sites the mittens discussed in this article, with reference to Reykjavík. Iceland Map by vemaps.com (<https://vemaps.com/iceland/is-03>)

Timeline	European Periods	Timeline	Icelandic Periods	Timeline	Danish Periods
500-1050 CE	Early Middle Ages	870-930 CE	Settlement Period	800-1050 CE	Viking Age
1050-1300 CE	High Middle Ages	930-1262 CE	Commonwealth Period	1050-1340 CE	High Middle Ages
1300-1500 CE	Late Middle Ages	1262-1550 CE	Foreign Rule to Reformation	1340-1536 CE	Late Middle Ages
1500-1750 CE	Early Modern Era	1602-1787 CE	Danish Trade Monopoly	1536-1660 CE	Renaissance
1750-Present	Modern Era	1788-1918 CE	Independence Movement	1661-1914 CE	Absolute Monarchy to Nation State

Table 1: Overview of time periods in Europe, Iceland and Denmark

From Iceland, three archaeological mittens from different sites have been recovered that demonstrate the importance of covering the hands for both children and adults (fig. 1). Meteorological evidence shows that Iceland’s annual temperature has risen 0.7°C per century over the last two hundred years (Jónsson 2008). Today, the average annual temperature in Iceland ranges between -2° and 9°C in inhabited regions under 400 metres of elevation (Björnsson 2003). Thus, considering the annually cool temperatures, mittens were likely essential for performing everyday outdoor tasks (e.g. fishing and farming) prior to the 20th century in Iceland, especially during the winters, which were often cold and stormy. The mittens discussed in this article, each dating to different periods, emphasise the continuity in handwear usage from the Settlement period in Iceland (870–930 CE), which overlaps with the Viking Age in Denmark (800–1050 CE), well into Early Modern times (table 1). It is believed that Iceland was fully settled by the mid-10th century. *The Book of Settlements (Landnámabók)* mentions 1,500 place names and over 3,500 people among the settlers (Eldjárn 2016). The Icelandic free state or Commonwealth period was established between 930 and 1262 CE, with the

creation of the Icelandic Parliament. Iceland then fell into a long period of foreign rule, first by Norway and then by Denmark. The Danish Trade Monopoly ended in 1787, which was followed by the reintroduction of the Icelandic Parliament in 1843. Iceland remained part of the Danish empire following the adoption of the constitutional monarchy in Denmark in 1848. Then in 1918, Iceland became a sovereign state in union with Denmark. Foreign rule finally ended in 1944 with a referendum for the Independent Republic of Iceland (Europa Publications 2003).

**The Heynes child mittens (Þjms. 1960-77)**

In 1960 a pair of children’s mittens were found on a farm in Heynes, Hvalfjarðarsveit in the county of Borgarfjarðarsýsla in western Iceland (fig. 2). The farmer discovered the mittens deep in the earth while building a new house. Thus, it was assumed that they were from the Viking Age as the site had been settled since the early 10th century (Guðjónsson 1994). In the previous summer, a piece of 2/2 wool twill was recovered from the same area (Þjms. 1959-123) but was estimated to be younger than the mittens based on the local stratigraphy (Guðjónsson 1992, 23, 26–27).



Fig. 2: The two child’s mittens from Heynes in Iceland, dated to 925–1030 CE. a – Palmar side. b – Back side (Images: Ívar Brynjólfsson)



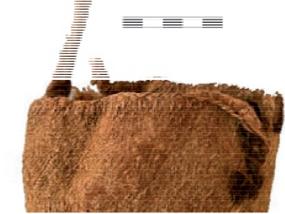
ID no. and size	Technique	Fibre & yarn diameter	Twist direction and angle	Threads/cm	Stitches	Photo
<p><b>Þjms. 1960-77 Heynes mitten A, left hand</b>            Length: 17.5 cm            Width shaft: 11 cm            Width wrist: 9 cm            Thumb length: 8.2 cm            Thumb width: 3.2 cm</p>	2/2 twill + herringbone twill on shaft	Wool, light brown  Warp: 0.5–0.7 mm Weft: 0.9–1.0 mm	Warp: z, 27–30° Weft: s, 20–25°	11–12/8–10	Stitches at thumb and buttonhole stitches sewn with 1.3 mm thick wool thread, S2z. Buttonhole stitches: circa 12 stitches/5 cm  Slit is closed with four whip stitches of dark brown wool, circa 2.3 mm thick Z2s plied. The stitches are circa 1–1.2 cm long, some only 0.4 cm though. The sewn area measures 3.2 x 1.5 cm	 
<p><b>Þjms. 1960-77 Heynes mitten A, braided cord</b>            Length (incl. knot): 8.5 cm            Width: 0.7 cm</p>	Braided with 3 strands	Wool, light brown  Braid: 0.7 mm  Small strands: 2-3 mm				
<p><b>Þjms. 1960-77 Heynes mitten B, right hand</b>            Length: 19 cm (edge) or 18 cm (middle)            Width shaft: 11.5 cm            Width wrist: 9.7 cm            Thumb length: 9.2 cm            Thumb width: 3.5 cm</p>	2/2 twill	Wool, light brown  Warp: 0.6–0.7 mm Weft: 1–1.1 mm	Warp: z, 30–35° Weft: s, 20–25°	12–14/8–10	Slit is closed with four whip stitches of dark brown wool, circa 2.3 mm thick Z2s plied. The stitches are circa 1–1.2 cm long, some only 0.4 cm though. The sewn area measures 3 x 1.4 cm	 

Table 2: Technical details of the mittens from Heynes (Þjms. 1960-77), the Garðar mitten (Þjms. 1940) and the Arnheiðarstaðir mitten (Þjms. 3405)



<p><b>Pjms. 1960-77</b>  <b>Heynes mitten B,</b>  <b>repair patch</b>            Covering hole of 4 x 4 cm</p>	2/2 twill	Wool, light brown  Warp: 0.5–0.6 mm Weft: 1.6 mm	Warp: z, 30–40° Weft: s, circa 20°	12/6–8	Random stitches with wool yarn, 1.7 mm wide, S2z plied.	
<p><b>Pjms. 1960-77</b>  <b>Heynes mitten B,</b>  <b>braided cord</b>            Length (sewn on):            47 cm            Width: 0.7 cm</p>	Braided with 3 strands	Wool, light brown  Braid: 0.7 mm  Small strands: 2–3 mm				
<p><b>Pjms. 1940</b>  <b>Garðar mitten</b>             Length: 30 cm            Width shaft: 19            cm            Width palm: 11            cm            Thumb length: 13            cm            Thumb width: 5            cm             Gusset: circa 9 x 8            cm</p>	2/2 twill	Wool, light brown  Warp: 0.7–0.8 mm Weft: 1.8–2.0 mm	Warp: z, 40–45° Weft: s, 30–35°	9/4	(not visible from the outside)	
<p><b>Pjms. 3405</b>  <b>Arnheiðarstaðir</b>  <b>mitten</b>             Length: 27 cm            Width shaft: 14            cm            Width palm:            12.5 cm            Thumb length: 10            cm            Thumb width: 7            cm             Height per row            circa 1 cm</p>	Nalbinding	Wool, red- brown Plied yarn: 1.8 mm (small threads 1.4 mm)	Z2s	-	Hald: Ila  Norland: 4/12  Hansen: UO/UOO  Common name: Oslo stitch	

Table 2 (continued): Technical details of the mittens from Heynes (Pjms. 1960-77), the Garðar mitten (Pjms. 1940) and the Arnheiðarstaðir mitten (Pjms. 3405)



Fig. 3: a – Schematic construction pattern of mitten A from Heynes in Iceland. b – Schematic construction pattern of mitten B (Drawing: Charlotte Rimstad/Mads Lou Bendtsen)

The two mittens (A and B) are made of a 2/2 wool twill textile and measure 17.5 x 11 cm and 19 x 11.5 cm respectively (table 2). The weave is relatively balanced, although the warp is thinner and more tightly spun than the weft. The fabric type is known as *vaðmál*, a woven textile that was used as a currency in Iceland up until the Early Modern period (Andersson and Granlund 1980, 409–416; Þorláksson 1988; 1991; Guðjónsson 1992, 14; Róbertsdóttir, 2008; Hayeur Smith 2018). The upright loom, for example, was used until the 19th century in Iceland (Hoffmann 1969, 288). The mittens are a pair but constructed in slightly different ways. The left-hand mitten (A) consists of four pieces: one palmar side, one backside and two smaller pieces forming the thumb (fig. 3a). The cuff measures circa 6 cm in length and unlike the rest of the mitten it is made in a herringbone twill weave. The 2/2 twill and the herringbone twill are part of the same fabric, and the herringbone pattern is likely to derive from the selvages of the fabric, where the heddles were set-up in a different way. The herringbone pattern is most clearly visible on the palmar side of the mitten and was probably used deliberately as a subtle decoration to mark the cuff area. The right-hand mitten (B) consists of one large piece, folded lengthwise, and two smaller pieces sewn together for the thumb (fig. 3b). This mitten was repaired on the backside with a patch covering a 4 x 4 cm square hole (see table 2). The patch is also made of a 2/2 twill weave and could be from the same textile. It is unusual to find wear on the backside of a mitten, as the palmar side is more often worn than the backside, and thus the hole in the mitten is more likely to have

occurred by accident rather than by long term wear. The cuff edge on both mittens is reinforced with blanket stitches, about 0.5–0.6 cm long, which are made to prevent the fabric from unravelling. On the little finger side, each mitten has a small cuff slit measuring 4–4.7 cm, which has been laced together with three to four whip stitches with a black or dark brown thread. Both thumbs are inserted into a hole, cut in the fabric, with a point facing towards the cuff. The palm size of the mittens, about 7 cm wide, leaves no doubt that they were worn by a child, but the age of the child is difficult to determine. Children have different hand sizes, even at the same age, but based on modern standards, the mittens would fit a 4 to 6-year-old child.

Parts of a 0.7 cm wide braided cord are attached to the two mittens, most likely used to connect them. As the cord is broken in two pieces, the original length is uncertain. About 8.5 cm of the cord is attached to mitten A with a knot going through a hole in the cuff edge, while a 47 cm long cord is attached to mitten B with the same black thread as in the slit. The cord consists of three strands, each 0.2–0.3 cm in diameter. It most likely functioned as a way of preventing the mittens from becoming separated while also enabling the owner to hang-dry them when not in use. Keeping mittens together with a stay-lace is still known today, passing through one sleeve of a jacket and out the other to prevent their loss. The current length of the cord on the Icelandic children's mittens is however too short for such a purpose, though it is unknown if parts of the cord are missing (Guðjónsson 1992, 27; Coatsworth and Owen-Crocker 2018, 397). Another possibility is

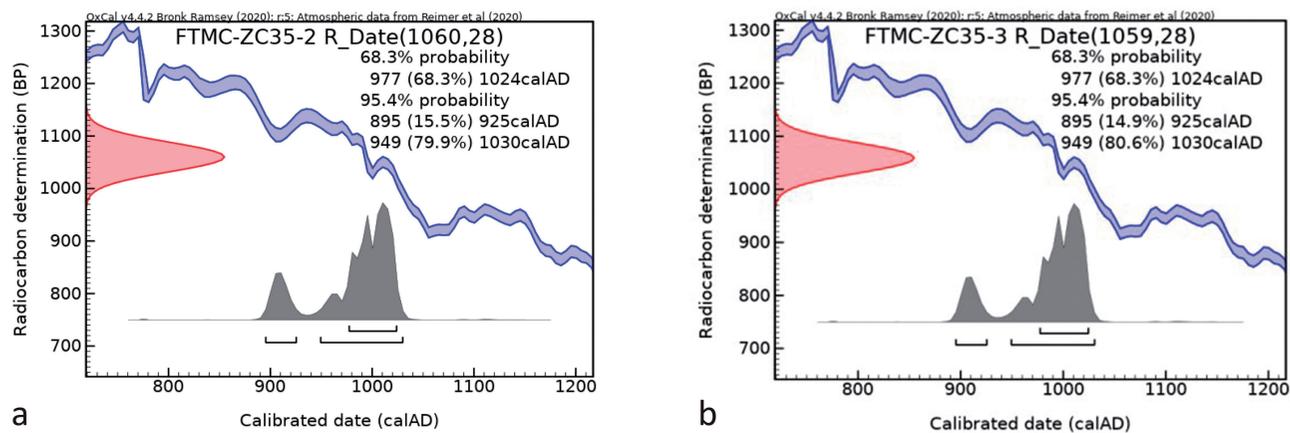


Fig. 4: a – AMS Radiocarbon results derived from the sampled mitten (Pjms. 1960-77). b – AMS radiocarbon results derived from the sampled braided cord (Pjms 1960-77). Both samples provided a date range of 925–1030 calCE

Museum Number	Site Name	Type	AMS Date (calCE)	Radiocarbon age (BP)	Lab ID
Pjms. 1960-77	Heynes	Child mittens (band)	925-1030 calCE	1059±28 BP	Vilnius Radiocarbon (FTMC-ZC35-3)
Pjms. 1960-77	Heynes	Child mittens (mitten)	925-1030 calCE	1060±28 BP	Vilnius Radiocarbon (FTMC-ZC35-2)
Pjms. 1940	Garðar	Vaðmál mitten	1310-1388 calCE	695±27 BP	Vilnius Radiocarbon (FTMC-ZC35-1)
Pjms. 3405	Arnheiðarstaðir	Nalbinding	1480-1640 calCE	330±30 BP	Beta Analytic (Beta-605821)

Table 3. The AMS-dating of the mittens

that the braided cord was used to bind the mittens to the wearer’s wrists, similar to a pair of Icelandic men’s trousers with braided bands which were used to bind them at the ankles (National Museum of Iceland, Collection Registry nr. Pjms. 1163).

For the AMS radiocarbon dating analysis (Vilnius Radiocarbon, Certificate no. 2022-05-10-FTMC-ZC35, no. 2 and 3), samples were taken from one of the mittens and the braided cord. The sample from the mitten was prepared from six loose threads (each 1.5 cm in length and 14 mg in all) that were cut from two locations on mitten A. The sample provided an AMS date of 925–1030 CE (table 3 and fig. 4a). The sample from the cord (21 mg and 2.3 cm in length) was cut from a single fibre bundle close to the attachment site between the cord and the mitten. This sample resulted in an AMS date of 925–1030 CE (fig. 4b). Both samples provided the same date, confirming the Viking Age origin of the mittens. Children’s mittens are indeed rare discoveries in Scandinavian archaeological contexts and the fact that this pair of mittens dates to the Viking Age makes the find unique.

### The Garðar mitten (Pjms. 1940)

In 1881, a single mitten was found at Garðar near Akranes in western Iceland (fig. 5). This area was known as “Jörundarholt” in the Settlement period and has been inhabited since its founding. At the site,

the ruins of houses built upon earlier structures were discovered in a farm mound and the mitten was found at ground level, under these ruins, about 3.5 metres deep (Pálsson 1895, 34-35).

It is a left-hand mitten, constructed of three pieces of 2/2 twill wool fabric, which like the child mittens from Heynes could also be termed *vaðmál* (table 2). The mitten measures 30 x 19 cm and the fabric is z/s spun with a hard z-twisted warp and a softly s-twisted weft. The mitten is constructed from a piece of textile, which was cut in a curved M-shape and folded lengthwise (fig. 6). It was sewn together at the little finger side and has a curved seam matching the outline of the hand. Near the cuff end on the little finger side, a small triangular gusset was inserted, enabling the cuff to become slightly flared on this side. As there is no hem edge preserved along the cuff edge, the mitten may have been longer (Pálsson 1895, 35). A hole was cut for the thumb piece, which was sewn on from the inside. The Icelandic textile researcher Elsa Guðjónsson noted in 1992 that this mitten had some 2–4 mm long loops made of lightly z-twisted wool that were tightly sewn into the fabric and trimmed to form a hairy surface or tight pile (Guðjónsson 1992, 19). The presence of this feature is not evident today, but it is clear that the fibres inside the mitten have formed a smooth woolly surface (fig. 7).



Fig. 5. The single mitten from Garðar in Iceland. a – Palmar side. b – Back side (Image: Ívar Brynjólfsson)

A sample for radiocarbon dating measuring 2 cm in length and 21 mg in weight was cut from the damaged area on the palmar side of the mitten. The sample provided an AMS date of 1310–1388 CE (Vilnius Radiocarbon, Certificate no. 2022-05-10-FTMC-ZC35, no. 1) (table 3 and fig. 8).

**The Arnheiðarstaðir nalbinding mitten (Þjms. 3405)**

A single, left-hand nalbinding mitten was found deep in the earth during construction in 1889 at the site of Arnheiðarstaðir in Fljótisdalur in eastern Iceland (fig. 9). The mitten measures 27 x 14 cm and it is rounded at the fingertips and has a narrow wrist and flared cuff.

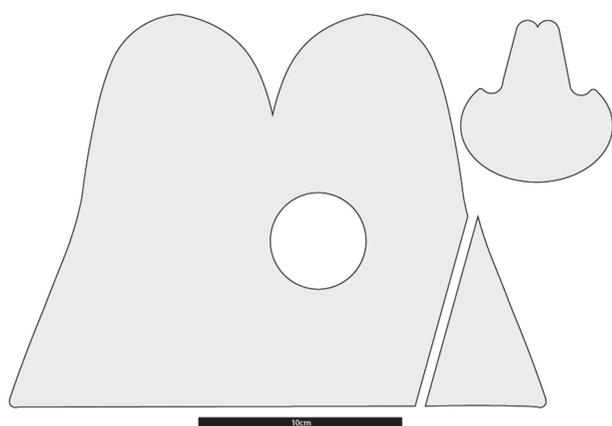


Fig. 6: Schematic construction pattern of the mitten from Garðar in Iceland (Drawing: Charlotte Rimstad/Mads Lou Bendtsen)



Fig. 7: The inside of the Garðar mitten has a filled surface, but no obvious loops or pile (Image: Freyja H. Ó. Sesseljudóttir)

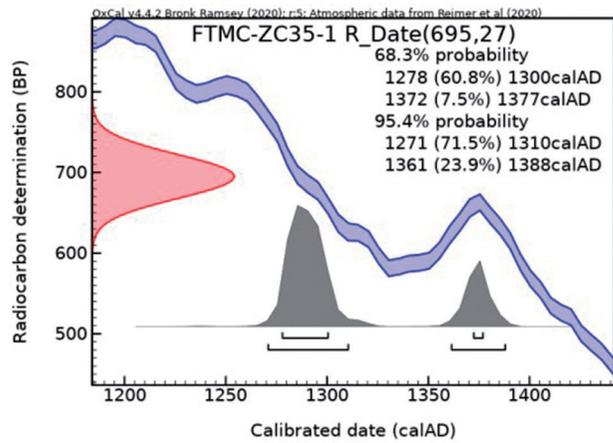


Fig. 8: AMS Radiocarbon results derived from the sampled mitten (Pjms. 1940), providing a date of 1310–1388 CE

The thumb is quite large, 10 x 7 cm, suggesting that it was either worn by a large hand or meant to be worn on top of another kind of handwear. The nalbinding mitten is made of a Z2s plied yarn, which is spun unevenly ranging from 1.4 mm to 1.8 mm in diameter. One of the two threads in the ply has a darker colour than the other, but no dye or wool fibre analyses have been carried out yet (see table 2). When analysing the mitten in 1950, the Danish textile researcher

Margrethe Hald identified the technique as “vantesom or nalebinding” and defined the stitch as Type IIa (1950, 308; 1980, 304; 1951). Today this stitch is more commonly known as the Oslo stitch (Classen-Büttner 2015, 47) (fig. 10). The nalbinding technique requires a needle and a single thread of limited length which can be connected using different stitches. The technique resembles sewing or knotting techniques, where the whole thread is pulled through the previous loops. For radiocarbon dating, a sample weighing 15 mg and measuring 1 cm in length was cut from a damaged area on the side of the mitten, where a loose end of the plied wool threads was present. The sample provided an AMS date range of 1480–1640 CE (Beta Analytic: Beta-605821) (table 3 and fig. 11).

#### A comparison of other archaeological mittens

The first archaeological handwear finds from northern Europe are dated to around 700–800 CE and come from the Netherlands and Germany (Willemsen 2015a, 2-4). However, handwear was known and used long before that, as was mentioned by classical writers and depicted on early art from southern Europe (Willemsen 2015a, 4). Written sources confirm that handwear was known in the north at least since the eighth century, as the monster Grendel’s glove is referenced in the poem



Fig. 9: The nalbound mitten from Arnheiðarstaðir in Iceland (Pjms. 3405) a – Palmar side. b – Back side (Image: Ívar Brynjólfsson)

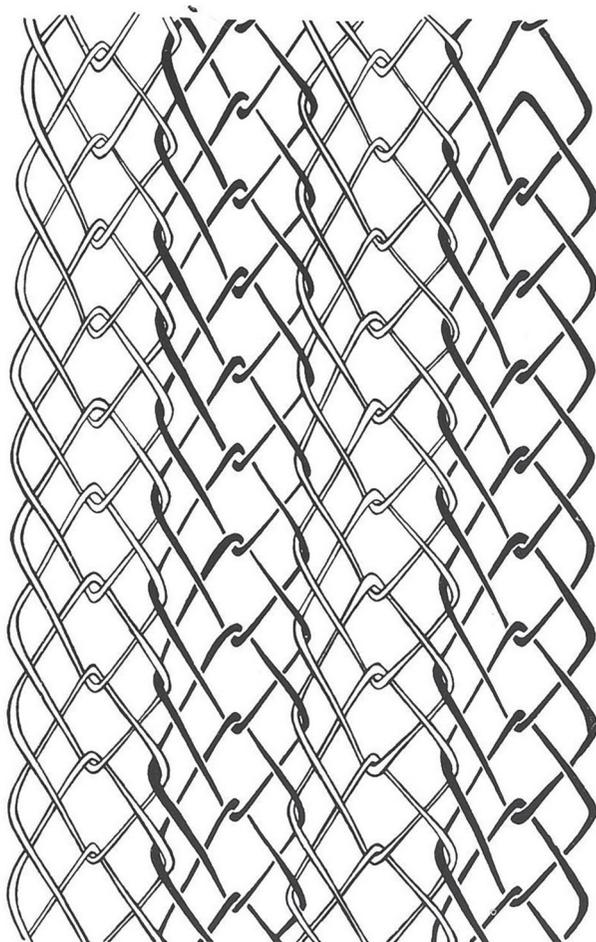


Fig. 10: Schematic drawing of the Oslo stitch in the Arnheiðarstaðir mitten (After Margrethe Hald 1980, fig. 353)

of Beowulf (Beowulf 2085–2100 in Osborn 1983; Lerer 1984). Also mentioned in northern mythology, as noted by the Icelandic writer Snorri Sturluson, the god Thor requires an iron glove called *Járngreipr* to use the hammer *Mjöllnir*. In another passage it is mentioned that Thor, on his way to *Útgarða-Loki*, sleeps in the giant *Skrýmir's* glove (*Gylfaginning*, verse 20; Jónsson 1929, 44). Handwear is also mentioned in an Icelandic context in *Saga af Þorsteini bæjarmagni*, in which a child puts on handwear before going to play (Egilsson and Guðmundsson 1827, 176). The handwear mentioned in that passage is called *bandvettlingar*, an old Icelandic word that has been associated with mittens made in nalbinding (Eldjárn 1994). Prehistoric and historic archaeological examples of skin and textile handwear indicate that woven cloth and nalbinding were mostly used in the Viking Age and Medieval times, while knitted gloves and mittens became dominant in the 16th and 17th centuries (Ringgaard 2010; Vajanto 2014; Willemsen 2015a; Rimstad 2017b).

#### Woven fabric mittens

Few contemporary comparisons to the woven fabric mittens from Heynes and Garðar in Iceland have been found in the Nordic countries. The first example to mention is a woven fabric mitten, dated to 780–890 CE, that was recently found preserved in the now melting glacier (C57874/24) in the area of Lendbreen in Norway (Vedeler pers. com) (fig. 12). It is a left-hand mitten, measuring approximately 18 x 11 cm, and it is made of 2/2 twill, with a thin z-twisted warp and a much thicker and less hard s-twisted weft. It is constructed of one large textile piece for the palmar side and three smaller pieces for the backside, sewn together with overcast stitches in S2z plied linen thread. The thumb is shaped from a separate, but similar piece of fabric. It is likely that the mitten was composed of pieces from a larger, reused garment. From Sct. Pederstræde in Viborg in Denmark, a right-hand mitten made of a 2/2 wool twill fabric, dated to 1050–1200 (fig. 13) resembles the child's mittens from Heynes. Similarly, a medieval right-hand mitten of 2/2 twill from Lödöse in Sweden, shows comparably tightly twisted warp and loosely twisted weft threads (Oksen 2014, 23). Lastly, in four burials excavated from Uvdal Church in Norway, dated to the 12th or 13th century, red mittens of twill-woven fabric were found on the hands of the bodies (Vedeler 2007, 118–131).

It is striking, although not unusual, that all the mittens are sewn from twill. Twill fabrics, such as various qualities of *vaðmál*, were used for numerous purposes, for clothing, bedwear, and sails (Andersson and Granlund 1980, XIX, 412) and twill textiles are known to be more dense, flexible and stretchier than tabby textiles, for example (Andersson Strand et al. 2017, 61). These are qualities perfectly fit for handwear, which must continuously follow the movements of the hand. *Vaðmál* fabric is likewise mentioned in the accounts

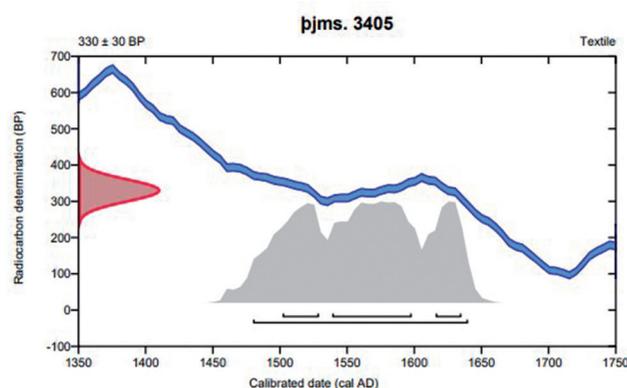


Fig. 11: AMS Radiocarbon results derived from the sampled mitten (Pjms. 3405), providing a date range of 1480–1640 CE

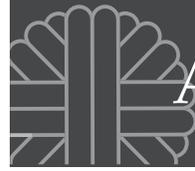


Fig. 12: Mitten in 2/2 twill from Lendbreen in Norway (C7874/24) dated to 780-890 CE. (Image: Maria Jensen, KHM, Oslo)



Fig. 13: Mitten from Sct. Pederstræde in Viborg in Denmark, dated to 1050–1200 CE (Image: Viborg Museum)



Fig. 14: Mitten, checked tabby fabric from Kongens Nytorv in Copenhagen, Denmark. Early Modern period (Image: Charlotte Rimstad)



Fig. 15: The nalbound mitten from Oslo, Norway (Image: Maria Jensen, KHM, Oslo)



Fig. 16: The nalbound mitten from Ribe in Denmark (Image: Sydvestjyske Museer)



Fig. 17: The nalbound mitten from Åsle in Sweden (Image: Ola Myrin, Statens Historiska Museer, Stockholm)



Fig. 18: A nalbound mitten from Rådhuspladsen (D48/1985) in Copenhagen in Denmark (Image: Charlotte Rimstad)

of Bergen Castle from the Late Medieval period as suitable for mittens, especially for people working in the forest (Andersson and Granlund 1980, XIX, 411, 498). However, as seen in an Early Modern checked mitten from Kgs. Nytorv in Copenhagen in Denmark (D46/1985) (fig. 14), examples of tabby-woven mittens do exist, showing that mittens could in fact be made of whatever fabric was available. Moreover, the different thumb solutions, with thumbs of one or two pieces inserted in slits, indicate that there were apparently no fixed rules about how to construct a mitten, such as is seen with leather gloves and mittens in later periods (Cumming 1982, 16).

All the above-mentioned comparative mittens were made for adult hands, and children's mittens are extremely rare. A 15th century knitted mitten from the London Museum and another one from Norwich Castle Museum & Art Gallery are among the few known examples (Hugget et al. 2013).

#### *Mittens in nalbinding*

At present, the mitten from Arnheiðarstaðir is the only nalbinding mitten found in Iceland from this time period. While the nalbinding technique itself is ancient, with the first example coming from the

Mesolithic settlement Tybrind Vig in Denmark, dated to c. 4200 BCE (Bender Jørgensen 1990, 1–4; Classen-Büttner 2015, 30–31; Mannering 2018), the oldest preserved nalbinding mittens from Scandinavia only date back to the Early Medieval period. An early example could be the find from Eura Luistari in Finland, dated to the 11th century, though its function as a mitten was recently questioned and it may rather be some sort of pouch (Vajanto 2003, 29–30; Vajanto 2014). The technique itself was also used in the Viking Age, for instance in the nalbound gold and silver parts in the pendants from Bjerringhøj, Denmark, known as the Mammen stitch (Hansen 1991; Mannering and Rimstad 2023, 59–61) or in the sock from York in York stitch, dated to 970 CE (Walton 1989, 341–245). But no mittens in nalbinding date to this period so far.

A mitten found in 1926 in the Sørenga area in Oslo in Norway (C28155) was AMS radiocarbon dated to 1025–1125 CE (Søvsø and Heel 2015, 60; Classen-Büttner 2015, 45; pers. com. Vedeler 2023) (fig. 15). The so-called Oslo stitch or the UO/UOO stitch, was named after this mitten. However, later analyses have shown that the Oslo mitten is in fact not produced in this stitch, but rather in the Ribe stitch, described below. It is a small detail but considering that the stitch was named after the find, it might be worth re-investigating the original find.

A medieval mitten from Lund in Sweden was also made in nalbinding (Hald 1945). Another nalbound mitten found in Grønnegade in Ribe in Denmark, dated to 1150–1250 CE, was made in the UOOO/UOOO stitch, thus named the Ribe stitch, though sometimes also referred to as the Finnish stitch (Søvsø and Heel 2015) (fig. 16). As opposed to the Arnheiðarstaðir mitten, the above-mentioned older mittens do not have narrow wrists and flared cuffs, but apart from that, these mittens are quite similar in terms of shape. A nalbound mitten from the aforementioned Lödöse in Sweden is dated to the 13th century and made in two different stitches, one being the Åsle stitch and the other unidentified (Öhrling and Josefsson 2024, 199). It is hard to pinpoint the exact provenance of the medieval nalbound mittens. Fragments from Gdansk in Poland, Riga in Latvia and Schleswig in Germany show that this was a rather common technique used for mittens in northern Europe in this period (Classen-Büttner 2003, 47). Perhaps, future strontium isotope analyses of the wool could shed further light on the provenance of the different medieval mittens.

The mitten from Åsle bog in Sweden (fig. 17) was long thought to be the oldest nalbinding object in Scandinavia, as it was initially dated to the first centuries CE (Hald 1950, 305) but a recent radiocarbon

analysis revealed that it is much younger, dating to 1510–1640 CE (Nockert and Possnert 2002), which is fairly similar to the Arnheiðarstaðir mitten. The two mittens are similar, but the Åsle mitten is made in stitch type IIIc, also known as the Åsle stitch (Hald 1950, 308; Classen-Büttner 2003, 51). Nalbinding mittens have also been found in several places in Copenhagen in Denmark, and while many of them unfortunately lack precise dates, some have been recovered from 17th century layers especially. A nalbinding mitten from Rådhuspladsen in Copenhagen in Denmark (D48/1985), made in the Oslo stitch, differs from the others in that it lacks a finger section, while still having a large thumb (fig. 18) (Rimstad 2017a, 237). It must have been used for a special purpose requiring exposed fingers or as an outer mitten. As the mitten still has remnants of tar on it, it may have been used in the maritime sectors of society.

Indeed, the question of why some mittens in the 16th and 17th century were made with nalbinding, even though knitting was invented by this time, still remains. Rather than being chronological, the explanation seems to be functional, as nalbinding mittens were more durable and the stitches would not unravel as they do in knitwear (Søvsø and Heel 2015, 56). The often large size and big thumbs imply that many of the nalbinding mittens would have been worn over other kinds of handwear as regular working mittens. They could, however, also have been used as linings in leather mittens, such as was seen in a find from the late 17th century Dutch shipwreck *Rede van Texel* (Willemsen 2015b, 55). This is emphasised by the fact that the nalbinding mittens rarely have any decorations, such as is often seen on knitted mittens and gloves from the same time periods (Rimstad 2017a, 237). Guðjónsson mentions that nalbinding mittens were especially well-suited for manual labour, compared to knitted ones, because of their sturdiness (1992, 28).

Archaeological fragments of nalbinding textiles were also discovered on Viðey, an island off the coast of Reykjavík in Iceland, occupied since the Settlement period/Viking Age. While they have not yet been radiocarbon dated, archaeological research indicates that these fragments are from the 15th or 16th century (Gunnarsson 1988). In Iceland, the nalbinding technique was likewise used to produce milk sieves from cow tail hair, at least in the 19th century, and in Finland, horsehair was used for the same purpose (Eldjárn 1960; Kaukonen 1960, 46–49). Furthermore, the technique seems to have adopted a more decorative purpose in the 18th and 19th centuries when nalbinding mittens were elaborately



embroidered with geometrical or floral patterns as can be seen in the collection of the Nordiska Museet in Sweden.

### Conclusion

The different dating results of the three Icelandic mittens underline a continuity in use of handwear from the Viking Age and into Early Modern times in Iceland. Future analyses of the wool fibres and potential dyestuff of the mittens are intended, which will increase knowledge about how the different kinds of handwear were produced.

The comparative material shows that the Icelandic mittens fit in very well with the general handwear development in other Nordic countries. It seems that most woven fabric mittens were likely made from left-over fabric from the production of larger garments or other items of *vaðmál* and this twill weave had both the tightness and flexibility required for handwear. The thumb was covered in various ways, probably depending on the fabric available and the skills of the craftsperson.

Nalbinding mittens may have existed in the Viking Age, as the technique was surely known, though no identified mitten finds come from this period. It is not until the 12th century that more convincing examples of nalbound mittens are found in northern Europe. The new AMS-date likewise proved the Icelandic mitten (Pjms. 3405) to be from the Late Medieval or Early Modern Period. It is suggested that mittens of this specific technique were especially suitable for manual labour.

As opposed to gloves – and especially leather gloves – which became a significant symbol of status and dignity in the 17th and 18th centuries, mittens were seemingly more related to solving practical issues, such as protecting the hands from cold, pain or heat.

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# Criteria for matching fragmented archaeological textiles: a survey

## Abstract

Archaeological textiles are a valuable source for understanding past cultures. However, textiles are vulnerable to decomposition and often found in a fragmentary state. Textile experts rely on their eyes and experience for manually matching similar fragments to reconstruct the original item. This requires much time and effort, as well as physical interaction with fragile artifacts. Computer-assisted virtual reconstruction has been recently proposed. Computer scientists suggested that the algorithms could mimic the criteria used by human experts. These criteria are rarely obvious or well-documented. To facilitate future interdisciplinary research efforts, a survey among archaeologists and conservators was conducted. This work explores what criteria are used by experts for matching fragments in the reconstruction process, which in turn may inspire the development of computational algorithms. Furthermore, the study evaluates the awareness among archaeologists and conservators of existing opportunities for computer-assisted reconstruction, their technological requirements and overall openness to such novel interdisciplinary solutions.

**Keywords:** textile, fragment, reconstruction, weave, computational, automatisisation, survey

## Introduction

Textiles have long played a vital role in human life (Mannering and Gleba 2012, Schneider and Weiner 1989). They have been used by humans even before the emergence of pottery and metallurgy (Barber 1991). Analysis of archaeological textile artefacts can, therefore, provide invaluable assistance in understanding past cultures. Since textiles are highly vulnerable to decomposition, they are often highly fragmented and degraded when found by archaeologists. Textiles can be produced from organic plant- or animal-based materials as well as inorganic materials (Shams 1987; Lukesova 2021; Peter 2022) that interact differently with different environmental conditions and degrade at different rates (Tímár-Balázs and Eastop 1998). Hence, when recovered, different parts of composite textiles might be preserved to different extents.

Scattered fragments need to be matched and reassembled to recover the original textile artefact, its appearance and motifs. A vivid illustration of such a

case is the Viking Age Oseberg textiles from Norway shown in fig. 1 (Vedeler 2019). The reconstruction is usually done manually by archaeologists and conservators who rely on their eyes and experience. This process resembles solving a jigsaw puzzle – a popular brain-teaser. However, unlike jigsaw puzzles, archaeological textiles are usually highly fragile and physical interaction and manipulation need to be kept to a minimum for conservation purposes. Furthermore, archaeological textiles can be damaged or faded with missing or deformed parts due to decomposition and ageing, as well as modified by post-excavation treatments. This further complicates the reconstruction, which can be very time-consuming, tedious, and exhausting for human experts as well as leaving many unanswered questions.

The emergence of machine learning and computer vision led computer scientists to propose virtual computational alternatives for the reconstruction of archaeological textiles (Gulbrandsen 2023; Gigilashvili et al. 2023a; Gigilashvili et al. 2024). Gigilashvili et al.



(2023b) conducted a thorough literature review of existing computational techniques for puzzle solving and archaeological artefact reconstructions. They concluded that modern machine learning models are not robust enough to offer fully automatic virtual reconstruction for archaeological textiles primarily due to the amount of missing information and the lack of proper datasets to train the models. However, the authors argue that computational techniques could offer semi-automatic solutions, where a machine could assist human experts and facilitate and expedite the reconstruction process as well as protect the objects from excessive and repetitive manipulation. Since general machine learning models do not demonstrate satisfactory performance, different authors argue (Kodrič Kesovia et al. 2021; Gigilashvili et al. 2023a; Gigilashvili et al. 2023b; Gulbrandsen 2023) that machines should mimic the approach taken by human experts. In other words, the criteria used by human experts for finding matching fragments can be an inspiration for computational algorithms. For instance, the Viking Age Oseberg textiles (Vedeler 2019) were the subject of multiple computational reconstruction attempts (Gulbrandsen 2023, Gigilashvili 2023a; Gigilashvili et al. 2024). The authors suggest that the

characterisation of the weaving technique and locally counting the threads per cm from close-up images, such as shown in fig. 2, can improve the performance of computational approaches.

The features that archaeologists and conservators measure using traditional tools and experience, and on which they rely for their judgments, can be mimicked by machines and hence, inspire advancements in computational techniques. In other words, if we automatise the measurement, analysis, and comparison of the features that are currently measured, analysed, and compared by physical observation and manual work, computers can provide valuable assistance to human experts and substantially decrease the time and effort needed for manual reconstruction of archaeological textiles.

Even though human experts rely on their experience, the exact criteria used for reconstruction are rarely explicitly documented and communicated. To investigate these criteria, a survey was conducted among textile archaeologists and conservators in November 2022. The survey had multiple objectives: first, to understand what criteria are used by archaeologists and conservators when they assess whether multiple fragments of archaeological textiles



Fig. 1: The Oseberg textiles contain fragments with interesting motifs from the Viking Age. However, the fragmentary state of the textiles makes it difficult to recover the stories that they are telling. This collection has previously been a case study for virtual reconstruction efforts in computer science research (Gulbrandsen 2023; Gigilashvili et al. 2023a; Gigilashvili et al. 2024) (Image: George Alexis Pantos)

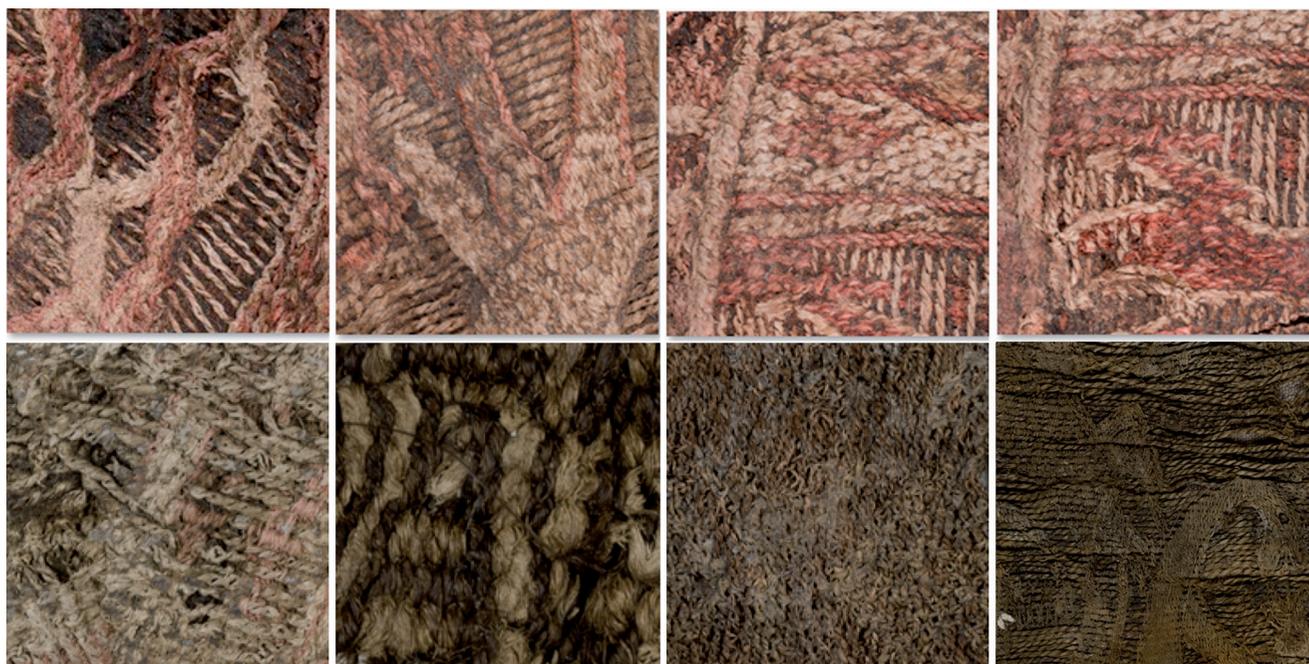


Fig. 2: Close-up of Oseberg textiles. Computational techniques can be used to automatise the measurement of technical characteristics, which can be used for further virtual reconstruction. Reproduced from Gigilashvili et al. 2023a (Image: George Alexis Pantos)

match or belong to the same original item; secondly, to investigate whether the archaeologists and conservators are aware of the existing computational solutions offered by the latest computer science developments, how much they currently rely on them, and what is the state-of-the-art; and thirdly, to evaluate their openness to relying on machine assistance and to understand where, and in what areas, computer assistance is required most.

The results of this survey will help to identify the knowledge gaps where interdisciplinary effort is essential and will foster more cross-disciplinary collaboration between archaeological textile and computer science communities in general.

The article is organised as follows: in the next section, the research methodology is presented. Afterwards, the main findings of the survey are summarised, followed by the discussion and conclusions.

### Methodology

This section summarises the research methodology and describes the survey preparation and data collection process.

#### *Preparation of the survey*

The aim of the survey was to get input from the different communities that deal with archaeological textiles in different contexts. In order to maximise the clarity of the communication, the draft version of the

survey was sent to 13 leading experts from archaeology, art history, and conservation. The objective of the survey was explained to them, and they were asked to provide feedback on the composition of the survey: in particular, to comment on whether the wording and formulation of the questions were clear and understandable, and whether the options in multiple-choice questions were adequate. Furthermore, they could suggest additional questions that they believed would serve the overall purpose of the survey. The draft version was revised based on the feedback of these 13 experts from different communities.

#### *The structure and execution of the final survey*

The final version of the survey consisted of 20 questions in total that came in two parts, with 7 and 13 questions, respectively: the first part collected demographic information about the participants' background: such as age, practical training, field of expertise, years of professional experience, employment situation, and the context in which they mainly reconstructed heritage textiles. The following clarification was given before the first part: "demographic information on the respondent: the study is anonymous, and the demographic information is collected for statistical purposes only. Only the aggregate statistical data will be analysed and no individual responses that could in any way identify the individual will be ever made public."



The second part of the survey consisted of 13 questions on heritage textile reconstruction and the perceived role of computational solutions. The questions came in several forms: some required free form answers, while others were multiple-choice with or without the possibility to select more than one option. The following instruction was displayed before this part: “the main part of the survey: if you are uncertain about any question, please answer to the best of your knowledge. If you want to comment further on multiple-choice questions, please, in addition to your answers, also tick ‘Other’ and use the space in the ‘Other’ option to explain.”

Several questions came with additional explanations to clarify context. The exact formulation of all questions, respective explanations provided, and the multiple-choice answer options (if any) can be found in the appendix. For conciseness, below are only the questions asked in the main part (questions 8 to 20):

- 8) The following criteria are often used to define a historical/archaeological woven textile: Binding/weave/technique, thread count (warp/weft), spin/twist direction (warp/weft), material/fibre, and colour. What other features might you add? [free form answer]
- 9) How would you know whether fragments of archaeological textiles belong to the same initial item? [multiple-choice with more than one answer possible]
- 10) Please rank the answers/criteria that you selected in the previous question. Which one would be the most important to tell whether the fragments belong to the same item or not? Which one will be the second most important? etc. Use the space in this question to arrange/rank them by priority; 1 means the most significant and informative; 2 - second most significant and informative, and so on... [free form answer]
- 11) Is direct physical contact with the artefact necessary for technical analysis of archaeological textile fragments? [multiple-choice with one answer]
- 12) Where access to textile artefacts is limited, to what extent can a full textile analysis be carried out based on digital photographs? Please briefly explain your choice in “Other”. [multiple-choice with more than one answer possible]
- 13) How reliable would you consider an analysis gained through digital photography? [multiple choice with one answer]
- 14) How much of the process of archaeological textile analysis is manual labour, i.e. done by eye and experience (physical observation and manual

work) without the help of machinery? [multiple choice with one answer]

- 15) Please explain exactly which steps in the technical analysis of archaeological textiles involve manual labour with direct human involvement? [free form answer]
- 16) How many hours of work would it take you in total to describe, characterise and group 100 fragments? (see the explanation below) Please briefly explain your choice in “Other”. [multiple-choice with more than one answer possible]
- 17) Do you usually use computer assistance, or to some extent rely on computer output? (e.g. automatic measurement of thread diameter or any other feature in a photograph, digitally puzzling fragments on a screen etc.). Please comment in “Other” if you like. [multiple choice with more than one answer possible]
- 18) Currently, how much of the technical analysis of archaeological textiles and puzzle solving mentioned in question 16 can be done in an automatic manner by computational methods? [free form answer]
- 19) What are your computational needs? Which computational tools could, if implemented, facilitate and progress textile research? [free form answer]
- 20) How do you think a computer scientist could contribute to textile research: for example, how would you imagine a perfect computer assistance in virtual reconstruction/classification/puzzling developed by computer scientists? [free form answer]

### **Data collection**

An email invitation to voluntarily participate in the survey was sent to several hundred professionals involved in EU’s Cost Action #19131 – *Europe Through Textiles: network for an integrated and interdisciplinary humanities (EuroWeb)* in November 2022.

### **Findings**

This section summarises the quantitative and qualitative results of the survey.

### **Respondent demography**

In total, 26 experts completed the survey. On average, it took 28 minutes to complete both parts. The responses came from professionals from a broad range of backgrounds (the responses may not total 26 since respondents could choose multiple answers): the majority (18 experts) work in archaeology and conservation (5 experts), while we also had input



from textile technology, as well as art and history professionals. The majority work in academia (18) and/or cultural institutions, such as a museum (6). We had a couple of responses from industry, art and design, and governmental institutions other than academia. A total of 22 of the respondents were employed professionals, two of them were PhD students, while five were also identified as a freelancer and/or an independent researcher. The majority of the respondents belonged to the age group from 40 to 49 years, and there was input from age groups from 20 to 29 up to 60 to 69, with substantial experience in the textile field: four people with 40 to 49 years of experience, 7 with 20 to 29 years, 8 with 10 to 19 years, and the remaining 7 with less than 10 years. The majority received practical training in weaving and/or archaeology, and most of them reconstruct and interpret heritage textiles in the context of archaeology (20), costumes (9), or flat textiles and conservation (3 each). No significant differences were observed in the main part of the survey between the respondents from different demographic groups. Therefore, only the aggregated data is reported below.

### The criteria for textile analysis

One of the fundamental objectives of the survey was to identify the features that the experts use to characterise historical or archaeological textiles and to determine whether the fragments belong to the same initial item. In addition to the criteria proposed in the first question of the second part, multiple respondents (at least three) identified several important criteria independently from one another. These criteria are conservation state and mineralisation, context of discovery (where the fragments were found), decorations, style and presence of selvedge (the longitudinal edge of a woven textile following the warp direction) or lack thereof, thread diameter, fibre diameter and length. Question 9 provides clearer quantitative insight into this question. The results are illustrated in fig. 3. As the figure shows, the criteria selected by the largest number of experts are weave technique (24), fibre material (22), thread count and yarn/thread twist/spin (20 each), type of pattern/motif (17), and selvedge (15). Six respondents proposed additional criteria, which can be grouped into two types: context of discovery (location where it was found and chronology) and colour or dyes.

Finally, the respondents were given an opportunity to rank the criteria by importance. As this is a free form ranking, two types of metrics are reported to measure the importance of a given criterion: how many respondents mentioned a given criterion in their ranking; and what was the average rank. The

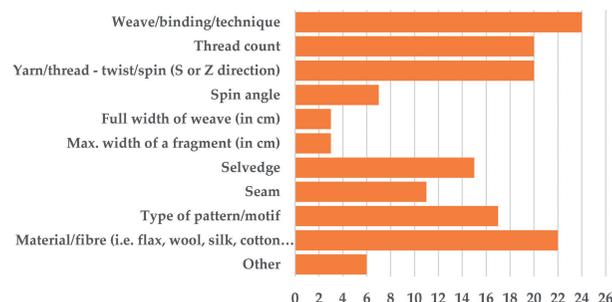


Fig. 3: The results of a survey. The graph shows the number of respondents who rely on a given feature to know whether two textile fragments belong to the same initial item (Image: Davit Gigilashvili)

results for those features that were mentioned by at least 6 respondents are given in table 1. The results of the ranking are consistent with that of the previous questions: technique and the textile material are considered the most significant criteria, while yarn/thread twist/spin, type of pattern/motif, thread count, selvedge, and seam are also pointed out by many. Several respondents mentioned that all criteria are important, while one mentioned that all criteria must be equal to conclude that the fragments belong to the same item. Two respondents pointed out that the importance of criteria depends on the fragments and specifically, on their state of preservation, as some of those may or may not be detectable from the fragment (e.g. motifs may or may not be visible). The motif itself as a criterion can be vague, as one respondent commented that a similar motif in dimensions and spatial features is highly unlikely to belong to different items, while the same is not true for typological similarities in motifs. The same respondent pointed

Feature	Times Mentioned	Average Rank
Weave/binding/technique	20	2.00
Material/fibre (i.e. flax, wool, silk, cotton etc.)	19	2.16
Yarn/thread - twist/spin (S or Z direction)	12	2.83
Type of pattern/motif	13	2.92
Selvedge	8	3.50
Thread count	15	3.53
Seam	6	4.83

Table 1: The features mentioned by at least 6 respondents in a free form ranking. The second column shows how many respondents included a given feature in their ranking, while the third column shows their average rank (Table: Davit Gigilashvili)

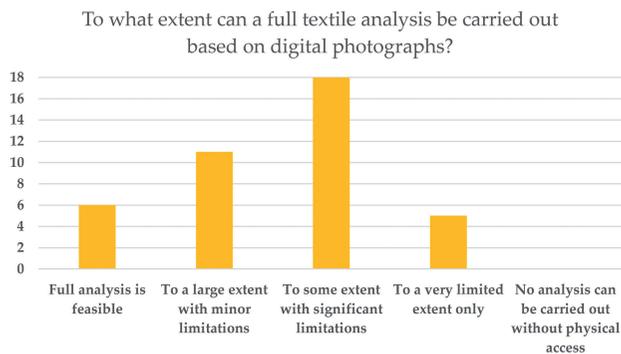


Fig. 4: The graph shows to what extent can a full textile analysis be carried out based on digital photographs, according to the respondents (Image: Davit Gigilashvili)

out that the importance of weave also depends on the context, as exclusive pieces are more likely to be assembled from different craftsmen and techniques, while pieces of daily use tend to be made by a single person and have one type of technique.

#### Photographs as a substitute for physical interaction

Another question is whether the experts consider professional high-quality museum photographs to be adequate substitutes for physical interaction. 17 respondents said that direct physical contact with the artefact is necessary for technical analysis of archaeological textile fragments, while nine said that it is not. Fig. 4 summarises to what extent an analysis can be conducted on digital photographs, according to our respondents, and fig. 5 shows how reliable it is found to be. Although the majority of them see some limitations in using photographs instead of direct interaction, the plots are skewed and photography is seen as more positive and reliable than negative and unreliable. The respondents could explain their responses, where they listed the limitations that they see in using photographs. These limitations can be classified into three groups: impossible to carry out chemical (for example, dyes, fibre materials) analyses from the photographs; image quality and insufficient spatial resolution (for example, fibres need to be analysed with a microscope, not a photograph); and access to the photographs (difficulty to obtain permission to photograph objects due to museum policies).

#### Current state-of-the-art

The third question that was investigated with this survey is how much of the analysis is currently done manually and how much time and effort it takes. Fig. 6 shows that most of the textile analysis is still being done manually by humans without automated machinery.

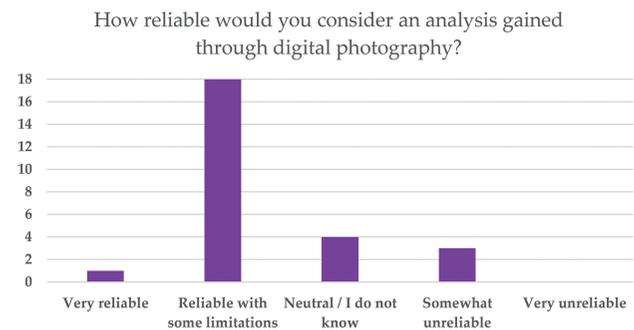


Fig. 5: The graph shows how reliable this analysis is considered when using photographs for textile analysis. Although some limitations are seen by the majority of the observers, their opinions are more on the positive side (Image: Davit Gigilashvili)

The estimated number of hours for analysing 100 fragments varied considerably, as shown in fig. 7. The respondents explained that this varies from case to case and depends on several important factors: such as the state of preservation, type of fragments, how many fragments are missing, and how much of the context is known. However, the overwhelming majority said that it would take more than one day of work. They were also asked to specify what kind of work requires manual labour. They responded that they extensively rely on machinery for magnification (microscopes); however, the measurements and analysis (counting threads, looking for selvages, identifying twist and spin directions, describing decors, and puzzling) are done manually. Furthermore, some respondents refer to manual inspection as a method to check the flexibility of the fabric, identify the fabric material, and observe the fragments from different viewpoints. Sample preparation and documentation (cleaning, documenting the context, photographing) are also done manually. Several respondents explicitly mentioned the Dino-Lite microscope and its proprietary software. Dino-Lite microscopes are part of a series of small digital USB tools that are popular for their cost-efficiency and practicality in terms of size and weight. They do not offer any functions for automated measurements. However, manual measurements of magnified images are possible. Digital microscopes can operate as simple optical microscopes with built-in LED light source and without eyepieces where an image is observed on a monitor (Lukesova 2022).

#### The need for interdisciplinary effort

Finally, the objective of the survey was to identify the knowledge gaps with potential room for interdisciplinary collaboration between textile and computing communities. Ten respondents answered that they do not use any kind of computer assistance.

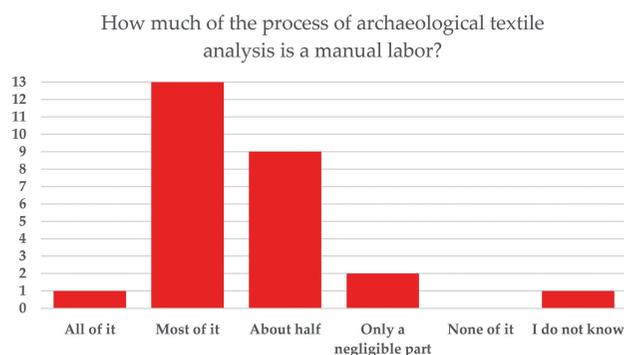


Fig. 6: The graph shows how much of the textile analysis needs manual labour, i.e. done by eye and experience rather than by automated machinery, according to the respondents (Image: Davit Gigilashvili)

Out of those who said that they did use computer assistance, only four explained their choice. Two of them mentioned that they use a computer to digitally puzzle the pieces by moving the fragments on the screen manually; and two mentioned Dino-Lite for thread description and basic measurements. Half of the respondents do not know how much can be achieved by computer assistance due to limited experience; nine seem positive and believe that some measurements, such as thread counting and weaving pattern identification, as well as puzzle solving, could be achieved with a computer, while four are sceptical either due to the complexity of the task or negative experience in the past. The computational needs that could facilitate and progress textile research are divided into three major groups: automating measurements (thread counting, thread diameter and length measurement, weave analysis, spin angle estimation, selvedge/hem detection, and decor detection) and generating statistics based on these measures; visualisation (automatic sketching, drawing planes of weave, zooming capabilities, ability

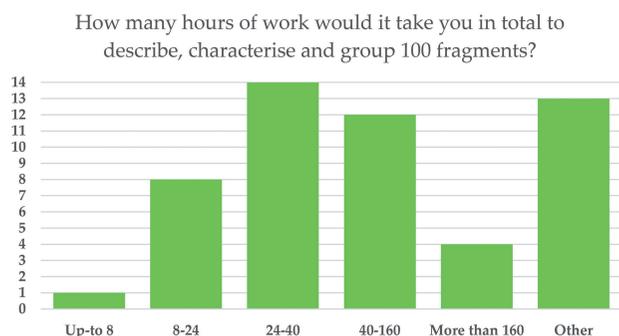


Fig. 7: The graph shows the estimated number of hours needed for analysing 100 fragments according to the respondents (Image: Davit Gigilashvili)

to move the fragments around, adjustable opacity, stereoscopy); and reconstruction (puzzle solving, 3D shape reconstruction, photogrammetry, clustering based on material and weave). A total of 23 out of 26 respondents are positive about collaboration with computer scientists and believe that solutions for the above-mentioned computational needs will be beneficial, while the remaining three are uncertain and could not answer the question.

## Discussion

The survey conducted among archaeologists and conservators revealed several interesting trends. This section discusses the main takeaways from respondents' feedback and proposes a framework for future reconstructions.

It is apparent from the responses that analysis and characterisation of textiles to date relies primarily on the eye and experience of the experts, while the use of machinery is limited to magnification and visualisation tools with little or no automation. The majority of the experts see the need for computational solutions and are open to interdisciplinary collaboration. The survey revealed the primary features or criteria that the experts use for grouping fragmented textiles together and for identifying which fragments should belong to the same original item. Weave/binding technique, fibre material, type of motifs (if visible), thread count, yarn/thread twist/spin, selvedge type, and seam have been named among the most significant factors, along with the discovery context and chronology. Measurement and description of these features currently need long and tedious manual labour; hence, automatisations of this process by specially tailored computer algorithms can save multiple days or even weeks of work and protect vulnerable archaeological fragments from excessive manipulation if high-resolution professional photographs are available. The authors argue that taking such photographs contributes to good documentation of archaeological finds and is less harmful than subsequent and repetitive manipulation. These results had interesting implications for the open reconstruction problem of the above-mentioned Oseberg textiles. Gigilashvili et al. (2024) tested several computational techniques to identify matching fragments from the Oseberg textiles and cluster them by similarity. They asked textile experts to do the similar task manually and compared their responses with the automatic solutions. Interestingly, the experts used nearly identical criteria to those reported by the respondents of this survey (thread count, type of motifs, spin/twist etc.). This illustrates that the accuracy of the computational solutions is benchmarked against

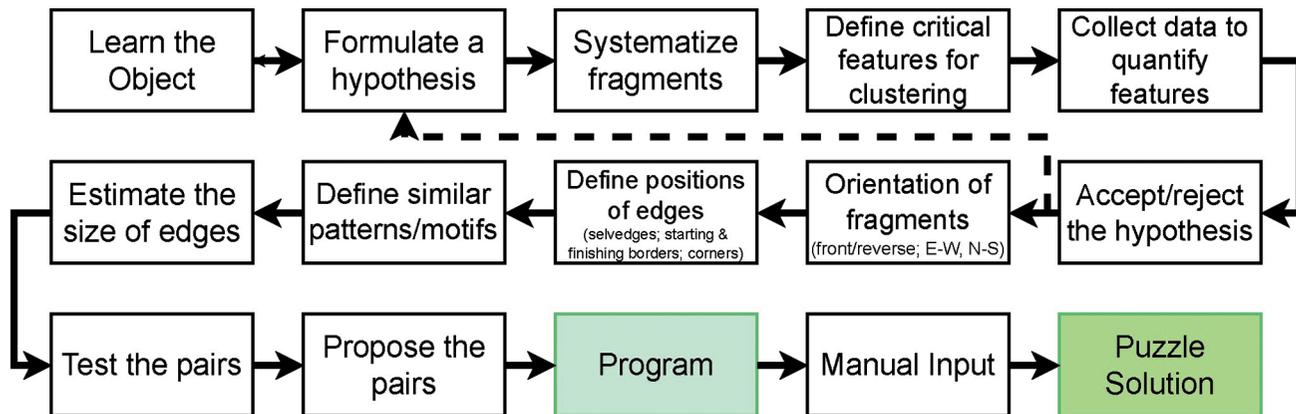


Fig. 8: The proposed semi-automatic workflow based on the literature review and survey of the experts, which can be followed in the puzzle solving process (Image: Davit Gigilashvili and Hana Lukesova)

the pseudo ground truth defined by the criteria that were reported in this article. Zain Fadillah et al. (2024) recently published the preliminary results of automatic thread counting for the Oseberg textiles. Their results showed an algorithm that enabled automated thread counting of warp in an area where weft was missing. Further work on the automation of thread counting can lead to promising results since it can be faster than manual measurements. Furthermore, the authors conducted clustering using the automatically extracted warp and weft thread counts alone, and the results for twelve out of 27 fragments were aligned with the experts' opinions. The development of automatic solutions for the additional criteria, such as weave analysis, spin estimation and motif recognition, will increase clustering accuracy and greatly benefit the reconstruction of Oseberg and other heritage textiles. Nevertheless, the experts see several significant limitations in using photographs against physical interaction, such as: impossibility of chemical dyestuff and material analysis, as well as lack of motion and 3D structural information. As a workaround, a recent literature review (Gigilashvili et al. 2023b) proposes using more sophisticated imaging techniques, such as hyperspectral imaging (HSI) and reflectance transformation imaging (RTI), which could provide additional information on material composition and surface characteristics, respectively. Finally, considering the knowledge status on computational solutions from the literature (Gigilashvili et al. 2023b) and the results of the survey that was conducted with archaeologists and conservators and reported in this article, the authors propose the following workflow for computer-assisted arrangement of flat archaeological woven textile puzzles as shown in fig. 8.

At the first stage, a human expert needs to *learn the object*, inspect it, and *formulate a hypothesis* about its belonging and place in the puzzle. Afterwards, they need to *systematize the fragments* based on the formulated hypotheses, i.e. identify the groups that are likely to belong to the same original item, as well as those that contain little to no useful information due to extreme degree of degradation. Afterwards, they should *define critical features for clustering* similar fragments. The features will be used to identify which fragments belong to the same cluster. After they define the set of features they want to measure, they *actually collect data to quantify features*. For example, if they define thread count (number of threads per cm) as a critical feature that has to be used in clustering and matching, at the data collection stage, they should actually count the number of threads per cm in warp and weft directions for each fragment. Data collection can involve manual measurements, automated computational solutions, or a mixture of both. The measured features are fed to the clustering algorithm, and the machine clusters fragments based on these features. The clustering results are compared against the hypotheses that were formulated at an earlier stage, and the experts either *accept or reject particular hypotheses*. Depending on the result, they may need to re-think and re-formulate the hypotheses (fig. 8), or if enough quantitative evidence is available, they can proceed to the next step. They virtually separate the fragments that belong to the same original item from the rest and start *orienting these fragments* in space. At this stage, they can identify how the fragments are oriented in space based on motifs, warp and weft directions, and other factors such as front and reverse side. The next step toward solving the puzzle is to define positions of edges – in other words, to identify



fragments that are likely to be the edges (starting and finishing borders, selvages, corners) and place them respectively to have an outline of the puzzle. This approach is also commonly taken when solving regular jigsaw puzzles. Afterwards, they can start identification of neighbouring fragments and start pairing them. For this, experts need to define similar motifs – for example, if two fragments contain parts of a red horse, they are likely to be part of the same horse and thus, to be adjacent fragments in the final arrangement. At this stage, they should estimate the minimal size of edges to estimate the overall size of the original and outline the space where the rest of the pairs should be placed to ensure that the proposed pairs fall within the edges. Next, they test different orientations and fitting options to test whether the pairs are actually adjacent. Whether or not they fit (based on outline, colour, motifs, technique etc.), the human expert makes a decision and proposes the pairs. This information can be used for developing a novel computer programme or can be simply used as an input to the software that is already available, such as *Gulbrandsen's Artifact Assembly* (Gulbrandsen 2023), where the puzzle will be finalised based on manual input, where the human expert re-arranges the pairs in a trial-and-error manner and validates the result.

### Conclusion

This work reports the results of a survey that was conducted with 26 archaeologists and textile conservators. While the cutting-edge computational techniques enable solutions to many complex problems, to date, automatic archaeological textile reconstruction remains beyond reach. Archaeological textiles are currently reconstructed manually. The parameters that are used by humans for identifying matching pieces, such as thread count or yarn twist and spin, can be measured automatically by machines in the future and taken as input to the clustering algorithms to identify similar fragments in a semi-automatic manner. The survey revealed that the awareness of new horizons that computer science and machine learning have to offer is relatively low in archaeology and conservation communities. However, the community points out the need for computer-assisted solutions and expresses openness to them, which paves the way for the rigorous interdisciplinary research effort in the future.

### Acknowledgements

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Through Textiles: network for an integrated and interdisciplinary humanities). We want to thank all anonymous respondents for their valuable time and effort. The work on this paper was partially funded by the Research Council of Norway: the project no. 316268, *Virtual reconstruction, interpretation and preservation of the textile artifacts from the Oseberg find*.

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## Appendix: The questionnaire used in the survey

### Demographic Information on the Respondent

The study is anonymous, and the demographic information is collected for statistics purposes only. Only the aggregate statistical data will be analysed and no individual responses that could in any way identify the individual will be ever made public.

#### 1. How long have you been active in the textile field?

- Less than 10 years
- 10-19 years
- 20-29 years
- 30-39 years
- 40-49 years
- 50+ years

#### 2. In which context did you get your practical training?

- Textile design
- Textile art
- Weaving
- Embroidery
- Sewing
- Other (please, specify if possible)

#### 3. What is your age?

- 18-19
- 20-29
- 30-39
- 40-49
- 50-59
- 60-69
- 70-79
- 80+

#### 4. What is your working situation?

- Student (Bc, MgA)
- Student (PhD)
- Employed professional
- Freelancer

- Independent researcher
- Retired
- Other (please specify)

#### 5. What is your field?

- Archaeology
- Art History
- Conservation
- Other (please specify)

#### 6. Where are you working?

- Academia
- Cultural institution (as museum)
- Industry
- Art & Design
- Other (please specify):

#### 7. In which context do you mainly reconstruct heritage textiles?

- Costumes
- Flat textiles
- Archaeology
- Conservation
- Art History
- Other (please specify)

#### The main part of the survey

If you are uncertain about any question, please answer to the best of your knowledge. If you want to comment further on multiple-choice questions, please, in addition to your answers, also tick “Other” and use the space in the “Other” option to explain.

**8. Question:** The following criteria are often used to define a historical/archaeological woven textile: Binding/weave, thread count (warp/weft), spin/twist direction (warp/weft), material/fibre, and colour. What other features might you add?



**9. Question:** How would you know whether fragments of archaeological textiles belong to the same initial item?

*Explanation:* Imagine the following context: multiple fragments have been found at different parts of a single grave. How do you distinguish which ones belong to the same initial item (i.e. have been part of the same while) and which ones come from different items? Please select and/or list at least 5 criteria that you consider most important. The criteria/features can be as below (select from the list of specify in Others, in total 5 or more answers needed).

- Weave/binding/technique
- Thread count
- Yarn/thread - twist/spin (S or Z direction)
- Spin angle
- Full width of weave (in cm)
- Max. width of a fragment (in cm)
- Selvage
- Seam
- Type of pattern/motif
- Material/fibre (i.e. flax, wool, silk, cotton etc.)
- Others (please specify):

**10. Question:** Please rank the answers/criteria that you selected in the previous question. Which one would be the most important to tell whether the fragments belong to the same item or not? Which one will be the second most important? etc. Use the space in this question to arrange/rank them by priority; 1 means the most significant and informative; 2 - second most significant and informative, and so on...

**11. Question:** Is direct physical contact with the artefact necessary for technical analysis of archaeological textile fragments?

- Yes
- No

**12. Question:** Where access to textile artefacts is limited, to what extent can a full textile analysis be carried out based on digital photographs? Please briefly explain your choice in "Other".

*Explanation:* We ask this because replacing physical fragment with digital images can have several important benefits: firstly, limiting contact avoids potential damage to highly fragile artefacts; second, direct physical examination can require costly and time-consuming travel, while digital images are readily accessible to a far broader community across the globe; third, a computer processes and analyses

digital images in complex ways, which, to some extent, simplify manual labour.

- Full analysis is feasible
- To a large extent with minor limitations
- To some extent with significant limitations
- To a very limited extent only
- No analysis can be carried out without physical access
- Other (please explain your choice)

**13. Question:** How reliable would you consider an analysis gained through digital photography?

- Very reliable
- Reliable with some limitations
- Neutral / I do not know
- Somewhat unreliable
- Very unreliable

**14. Question:** How much of the process of archaeological textile analysis is a manual labour, i. e. done by eye and experience (physical observation and manual work) without the help of machinery?

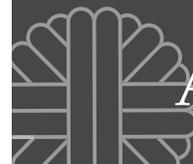
- All of it
- Most of it
- About the half of all the work
- Only a negligible part
- None of it
- I do not know

**15. Question:** Please explain, exactly which steps in technical analysis of archaeological textiles involve manual labour with direct human involvement?

**16. Question:** How many hours of work would it take you in total to describe, characterise and group 100 fragments? (see the explanation below) Please briefly explain your choice in "Other".

*Explanation:* Imagine the following scenario: you have tens of archaeological textile fragments, and your task is to identify: a) which fragments are likely to belong to the same item; b) recover how they have been arranged spatially. So in simple terms, you have pieces of a several puzzles, which you have first grouped by their origin in order to then solve the puzzle and recover the original item as much as possible (many pieces are missing though). How fast can you do this?

- Up-to 8 hours
- 8-24 hours
- 24-40 hours
- 40-160 hours
- More than 160 hours
- Other (please explain your choice)



**17. Question:** Do you usually use computer assistance, or to some extent rely on computer output? (e.g. automatic measurement of thread diameter or any other feature in a photograph, digitally puzzling fragments on a screen etc.) Please comment in “Other” if you like.

*Explanation:* When you do technical analysis of archaeological textiles similar to the puzzle-solving scenario in Question 16: How much of the job to solve the problem is currently done by a computer? Exactly what parts are performed by a computer (if any)?

- Yes
- No
- Other

**18. Question:** Currently, how much of the technical analysis of archaeological textiles and puzzle solving mentioned in Question 16 can be done in an automatic manner by computational methods?

*Explanation:* Regardless of what you answered to Question 17, i.e. whether you use computer assistance or not, to the best of your knowledge, how much of the process can be performed by a computer? Are you familiar or have you heard of any computer-based solutions (whether or not you have used them yourself)?

**19. Question:** What are your computational needs? Which computational tools could, if implemented, facilitate and progress textile research?

*Explanation:* No matter whether the solution exists or not, imagine the process described in Question 16. What elements of the job do you think would be improved if performed by a computer instead of a human, and in which of those would computer involvement have the biggest impact?

**20. Question:** How do you think a computer scientist could contribute to textile research: for example, how would you imagine a perfect computer assistance in virtual reconstruction/classification/puzzling developed by computer scientists?

*Explanation:* Anything related to the analysis and interpretation of the archaeological textiles that has not been mentioned above and you think would be interesting and valuable to collaborate on with the computer science community. Any suggestions for a computer scientist. For instance, imagine you get a nearly perfect computer program that helps you with the task described in Question 16. Could you describe this program? How does it operate? What features does it have? How does it help you?



Rachele Pierini

# Trans-PLANT and MAST: two interwoven projects

## Introduction

*Transformational uses of dye plants in Linear B tablets. New approaches to cultural identity and technologies in the Bronze Age Aegean*, with the acronym Trans-PLANT, is a Marie Skłodowska-Curie project founded by the European Union under the Horizon 2020 scheme and hosted at CTR, Saxo Institute (University of Copenhagen, Denmark) since August 2021. The scientific aim of Trans-PLANT is to use Mycenaean dye plants as a prism through which to explore Bronze Age Aegean protohistoric societies and unravel the wealth of information that is hidden within Bronze Age Aegean scripts and material culture. Trans-PLANT also has the ambitious goal of bringing Aegean studies beyond their specialised niche by integrating the results into the current scientific debate. Instrumental to this end are the Trans-PLANT outreach activities and the MAST project (Meetings on Aegean Studies), which has joined forces with Trans-PLANT in a dissemination mission. As a result, the Trans-PLANT outreach programme targets the general audience, and the MAST contents, with a more technical focus (seminars, papers, discussions, images, etc), are published open-access in the peer-reviewed and rapid publication journal *Classical Continuum*. This contribution aims to present selected Trans-PLANT activities as well as introduce MAST and invite even more participants to join it in the future.

## The Aegean “linear” scripts: Linear A and Linear B

While excavating the ruins of Knossos in Crete in 1900 CE, Arthur Evans uncovered clay tablets bearing evidence of writing systems thus far unknown. By observing the tablets and the shape of the inscribed signs, Evans realised that two related but overall different writing systems were at play. He also

determined that chronology played a major role in explaining those differences and that the two writing systems were syllabic scripts with a strong logographic component. In this context, in which both scripts were undeciphered, Evans coined the names of these writing systems, with his nomenclature making reference exclusively to the scripts and the shape of the signs. As such, Evans qualified the two scripts as “linear” since their signs were contrasted with the decorative and calligraphic signs of another script used in the same geographic area in the second millennium BCE. Next, he established an opposition between the two “linear” scripts, arguing that one was older and the other more recent. Accordingly, Evans named “Linear A” the former and “Linear B” the latter. Fast forward to today (fig. 1), Linear B (circa 1450 to 1200 BCE), attested on the island of Crete and the Greek mainland, is the only Aegean script to have been deciphered and records the earliest form of the Greek language known (Mycenaean); Linear A (circa 1750 to 1450 BCE), attested on the island of Crete and the Aegean area, encodes a language (Minoan) that is still poorly understood.

## Trans-PLANT

The Trans-PLANT project has the ambitious goal of raising awareness of the wealth of information that is hidden within Aegean scripts and Bronze Age material culture by using the written sources on Mycenaean dye plants (Linear B tablets) as a prism through which to explore protohistoric societies. By focusing on dye plants and their transformation into fashion goods, Trans-PLANT aims to demonstrate how the knowledge coming from transformational uses of dyes transcends the visual perception of the resulting product and addresses the cultural message it conveys. The project explores the

interrelations between linguistics, history of science, and experimental archaeology to analyse dye plants, the technologies transforming them, and dyed goods such as textiles. In particular, the Trans-PLANT project focuses on dye terminology as well as technical knowledge and cultural identities. The analysis of dye terminology examines dye plants

in Linear B texts and uses this as a model of linguistic interaction to define transculturation by combining Indo-European linguistics and Aegean epigraphy with research on ancient technologies, cross-crafts, cross-cultural textiles, and experimental archaeology. The section on technical knowledge and cultural identities is made of two parts. The first part

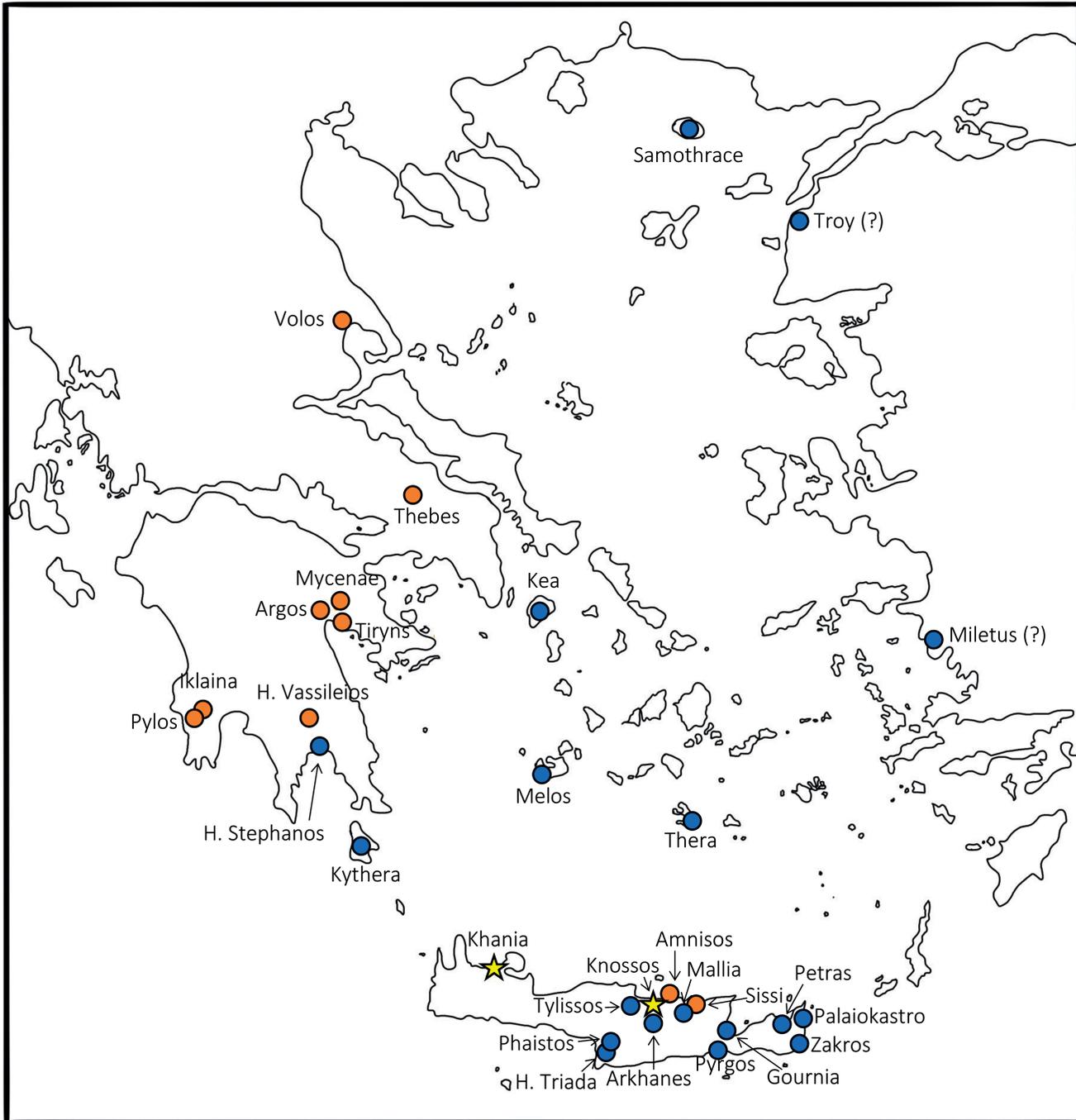


Fig. 1: Main Minoan and Mycenaean sites in the Aegean area. Minoans — Linear A (1750–1450 BCE); Mycenaean — Linear B (1450–1200 BCE) (Drawing: Ester Salgarella)



investigates cross-craft and cross-cultural interactions by combining the reconstruction of the Mycenaean *chaîne opératoire* of dyeing textiles with the cultural dimension of these goods in Mycenaean and Minoan society. The second part analyses roles and functions of particular colours in dyed textiles to show the dimension of coloured goods as a cultural media communicating identity, status, power, and gender.

In addition, Trans-PLANT is committed to a rich programme of outreach activities. This part of the project aims to promote accessible, but research-based, approaches to classics and the Bronze Age Aegean by engaging in mainstream topics to show the richness of the classical substratum in daily life. It has been communicated via texts, oral presentations, digital presentations, images, small films, and the Trans-PLANT logo.

#### *The Trans-PLANT outreach activity*

The Trans-PLANT outreach programme aims to raise awareness among the general public on the concepts at the core of the project: translation, transformation, and transculturation. In addition to a number of in-person events, the written production encompasses ten pieces that have been published in *Simbiosi: un nuovo rapporto tra uomo e natura*, a periodical focusing on ecosystems and more sustainable approaches to natural resources. They show specific examples of plants' transformations (both in mythology and through technologies) and their cultural impact in the ancient world and how they were transmitted to present day. The following three pieces showcase the approach of the Trans-PLANT project.

By focusing on the bear in ancient Greece, *Zafferano, sacerdotessa e stelle: l'orso in Grecia antica* examines the word for "bear" in a number of ancient and modern Indo-European languages and explores the ritual and gendered uses of crocus and saffron-dyed textiles in second and first millennium BCE.

With an overview of the willow in ancient medicine, ancient wheel construction, opera, and modern poetry, *La canzone del salice: breve storia di remedia medicinalia effervescenti, ruote micenee, cetre e arpe* traces the use of the willow from Assyrians and Babylonians to nowadays. It also focuses on Mycenaean tablets and their attestation of willow as a construction material for chariot wheels in the second millennium BCE.

*Tagliare per rinascere, ovvero Saturno e i limoni* focuses on Saturn as an agricultural god in ancient Greece and the legacy of the rituals connected with the festivity in his honour in contemporary traditions.

#### *The Trans-PLANT logo (fig. 2)*

The choice of the green colour is due precisely to the natural colour of (most of) the plants. The circle symbolises the transformation, not only because the circular shape has no beginning or end but also because the beginning and the end coincide in it. Two triangles on the external part stress the movement and the circularity of the transformational activities. A bigger triangle is inscribed within the circle and refers to the internal characteristics that are necessary for an external and visible outcome. Surmounting the internal triangle there is a stylised, linear version of the logogram for the crocus as it appears in Linear B tablets and Minoan frescoes (fig. 3a and fig. 3b).



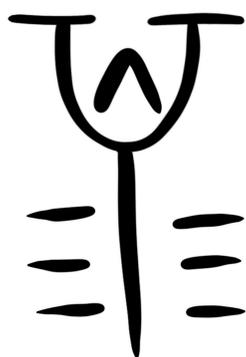
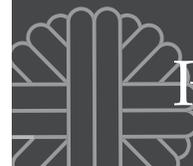
Fig. 2: The Trans-PLANT logo (Image: Rachele Pierini)

#### **MASt**

MASt (*Meetings on Aegean Studies*) is tightly interwoven with textile research in a number of areas, including the MASt board and editorial team, the MASt logo, and the MASt seminar topics.

MASt was co-founded in 2019 by Gregory Nagy, Tom Palaima, and Rachele Pierini. Started as a collegial seminar, MASt quickly grew into a worldwide network in just three months. Today, the MASt network involves 20 plus institutions in more than 15 time zones (from California, US, to Australia) and maintains the friendly and collaborative atmosphere of the earliest encounters. Furthermore, the MASt team includes a project leader (Pierini), an editor-in-chief (Pierini), an associate editor (Palaima), an editorial board (Elena Džukeska, Joseph Maran, Leonard Muellner, Gregory Nagy, Marie-Louise Nosch, Thomas Olander, Birgit Olsen, Helena Tomas, Agata Ulanowska, Roger Woodard), a secretary (Giulia Muti), editorial assistants (Harriet Cliften, Linda Rocchi, Katarzyna Żebrowska), a student assistant (Matilda Agdler), and a digital media consultant (Riccardo Finamore).

The MASt project is designed to boost specialised discussions on Bronze Age Aegean topics and enhance the connection between prehistorians and classicists and between the ancient world and today's society. The MASt logo conveys these messages and



a



b

Fig. 3: a – The crocus logogram as drawn in the reference table for linear B logograms, decided in the Salamanca Colloquium (Ruipérez 1972); b – Minoan representation of saffron on the Minoan fresco from Akrotiri (Xeste 3, Room 3, 1st floor) *Saffron gatherers*, 17th century BCE. Now in the Prehistoric Museum of Thira, Fira, Santorini (a – Drawing: Ester Salgarella after *Docs*<sup>3</sup>; b – Image: Elsa Yvanez)

values, and the project's initiators designed a twofold strategy (that is, specialist seminars and open-access publications) to achieve MAST's ambitious goals.

MASt offers quarterly online seminars in which two speakers present the latest results of their research on Bronze Age Aegean topics in 20-minute talks. A 30-minute debate follows each presentation. In this timeframe, the participants, who all have substantial expertise in Bronze Age Aegean matters, engage in discussion with the speakers and provide extensive feedback. Within a few months of the specialist seminar, the MAST team publishes the peer-reviewed papers along with substantial summaries of the discussion in the journal *Classical Continuum*, an online open-access periodical founded by Harvard University.

#### *The MAST logo* (fig. 4)

The mast of a ship is a sturdy, vertical structure that supports its sails, flags, and antennae. MAST supports Aegean sails since the Bronze Age Aegean is the project's scientific focus; supports all perspectives, backgrounds, and identity flags; supports new approaches to classics by pioneering wireless and online meeting as well as free and open-access content. It has done all three since 2019.

The mast is located near the centre of a vessel and helps to balance the boat and keep it stable while it is underway. Additionally, the Greek word for "mast" (*histós*) also means "beam of the loom" since it stems from an Indo-European root indicating "to make stand, set up". With its increasingly larger network, array of specialised areas and approaches, and intergenerational participation, MAST is designed to provide a safe space to set up new ideas for discussion and growth and aims to constitute a reference point for anyone passionately interested in navigating the challenging and open waters of the Aegean world, be they already on board or about to embark on a journey.

Boats were essential tools for the Aegeans to explore, navigate, connect distant places, run businesses, discover new countries and cultures, bring people and societies together, and communicate. The MAST boat is a symbol of connection, discovery, progress, mobility, and communication. It represents the project's values of passionate commitment, cooperation, growth, and openness and the project's goals of expansion, community-building, interdisciplinarity, multilingualism and multiculturalism, connectedness, and public engagement.



Fig. 4: The MAST logo (Image: Rachele Pierini)

The shape of the second letter in MAST is based on the sign for *a* in Linear A and Linear B—it is the same since Linear B inherited it from Linear A and thus is commonly referred to as the AB sign (fig. 5). Specific features of the Linear B sign have been emphasised to obtain a sign that is close to a capital A of the Latin alphabet. By undergoing this change, this letter represents MAST's goal to unravel the connectedness between the ancient and today's worlds while focusing primarily on what is unique in the past and present and what is shared, what is still the same and what is different, what can be maintained and what has to be rethought to enter the future.

The MAST colours are the natural colours of the beautiful Aegean Sea - the colours that the Aegeans could, and still can, enjoy. The elements in the green water colour represent Aegean key features (the boat and the vertical stroke in the Linear B sign for *a*) and the elements in the blue colour represent the contemporary approach to the Bronze Age Aegean through dedicated meetings and studies. The inner circle in green water represents the MAST focus on the past societies of the Aegean area and the outer circle in blue represents the MAST commitment to bring the second millennium BCE into the third millennium CE.

### **MASt and textile research**

The summer 2020 MAST seminar (the first to be published as a MAST report) hosted a paper by pioneer textile researcher Elizabeth Barber *The weaving process in ancient and today's textile industry and some notes on Mycenaean and alphabetic Greek textile lexicon* (Barber 2020).

In the fall 2020 MAST seminar, Anne Chapin delivered a presentation about the visual impact of textile patterns



Fig. 5: The AB sign for *a* as it appears on the Hagia Triada tablet HT 126a (Image: SigLA)

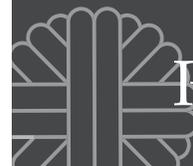
in Aegean Bronze Age painting, focusing on the exploitation of artistic elements and design principles of Aegean artists. Hedvig Landenius Enegren and Rachele Pierini also offered a comparison between second millennium BCE and third millennium CE practices for washing textiles with ashes. The comparison has been subsequently published as an appendix to the Fall 2020 MAST report (Landenius Enegren 2020; Pierini 2020).

The winter 2021 MAST seminar hosted the first part of the presentation of the book by Morris Silver *The Purpled World: Marketing Haute Couture in the Aegean Bronze Age* (Pierini and Palaima 2021a), whereas the second and last part of this presentation appears in the spring 2021 MAST report (Silver 2021).

In the summer 2021 MAST seminar, postdoctoral researcher Chiara Spinazzi-Lucchese and terminological expert Susanne Lervard (both from the Centre for Textile Research in Copenhagen) contributed to the discussion on the papyrus flower (Pierini and Palaima 2021b). The fall 2021 MAST seminar hosted Hedvig Landenius Enegren's research on the non-flammable fibre asbestos in ancient textile manufacture (Landenius Enegren 2021).

The winter 2022 seminar hosted a paper by Agata Ulanowska which presented the COST Action project, EuroWeb (Ulanowska 2021).

Textiles are extensively represented in the MAST team, too. In addition to co-founder and editor-in-chief Pierini, the board includes Centre for Textile Research initiator and former director Marie-Louise Nosch and EuroWeb leader Agata Ulanowska. Secretary Giulia Muti is an archaeologist specialising in Bronze Age Cypriot textile production and editorial assistant, Katarzyna Żebrowska, is an archaeologist of the



Aegean region, specialising in the functionality of textile tools.

## Acknowledgements

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Susanna Harris

# Uncovering Scotland's earliest textiles

## Introduction

In August 2024, a one-year Personal Research Fellowship *Uncovering Scotland's Earliest Textiles* started for Susanna Harris at the University of Glasgow. It is funded by The Royal Society of Edinburgh (fig. 1). The project will use scientific and archaeological approaches to reveal new evidence for the start of Scotland's iconic textile industry.

The earliest textiles in Scotland belong to a period called the Bronze Age dated 2400 BCE to 700 BCE. Since its conception in the early 19th century, the story of the Bronze Age has been dominated by the societal effects of early metals. However, the Bronze Age is also a time of innovation in textiles and the societal impacts they engendered.



Fig. 1: The Royal Society of Edinburgh's Personal Research Fellowship *Uncovering Scotland's Earliest Textiles* was awarded to Susanna Harris, who is shown here holding replica spindles with ceramic whorls (Image: University of Glasgow)

In Scotland and across Europe, the early Bronze Age is characterised by a fascination with plant fibre yarns to make textiles, used to decorate fine ceramic vessels (fig. 2) (corded ware, see Grömer and Kern 2010) and to make a fabric called twining. The earliest twined fabric in Britain is found in stone cist burials in Scotland, an advanced centre of innovation at the time. Across Britain, the earliest presence of wool fibre and textiles is in Scotland. Originating from southwest Asia, sheep's wool was developed for textile fibre through systematic breeding of hairy sheep to become woolly sheep (Bender Jørgensen and Rast-Eicher 2016). The dynamic change to wool is called the first textile revolution (Sabatini and Bergerbrant 2020). At the same time, people were trying other novel fibres from new resources, such as horse hair. Advances in textiles led to changes in dress and appearance, while domesticated fibres, such as flax and sheep's wool (fig. 3), enabled local resources to be made into desirable, tradeable products with exchange value beyond their raw materials.

These shifts were not solely material, they also brought environmental, ideological, societal and political change across the Eurasian continent. As clothing, textiles changed the substance of human appearance (Grömer 2016). Textiles had the potential to create prosperity and to exchange and amass wealth in the same way as their bronze metal counterparts did - as is also true for the medieval and post-medieval textile trade in Scotland. This has been overlooked in the interpretation of Bronze Age Britain.

The Bronze Age textiles of Scotland have not been comprehensively analysed and published since Audrey Henshall's articles in the 1950s (Henshall 1950; 1951). This research is timely because recent discoveries of textiles have transformed the understanding of Bronze Age textiles in Britain. Remarkable discoveries at Must Farm and Whitehorse Hill Cist, England (Harris and

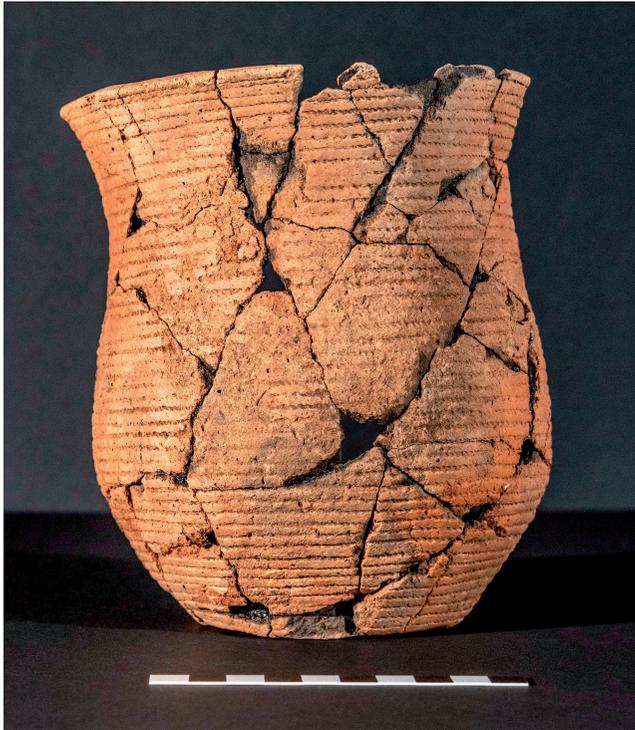


Fig. 2: Cord impressions on a beaker vessel (inventory number KHM 2016.1089) from Upper Largie, Kilmartin (Image: © Kilmartin Museum Company Ltd)

Gleba 2024; Harris and Jones 2017) have been game changers for the interpretation of the Bronze Age by enhancing the visibility of textiles.

By applying a pioneering suite of methods, this research will investigate Scotland's earliest textiles in their geographical and chronological setting. The results will be communicated through single and joint authored academic publications and public facing channels.

#### Acknowledgements

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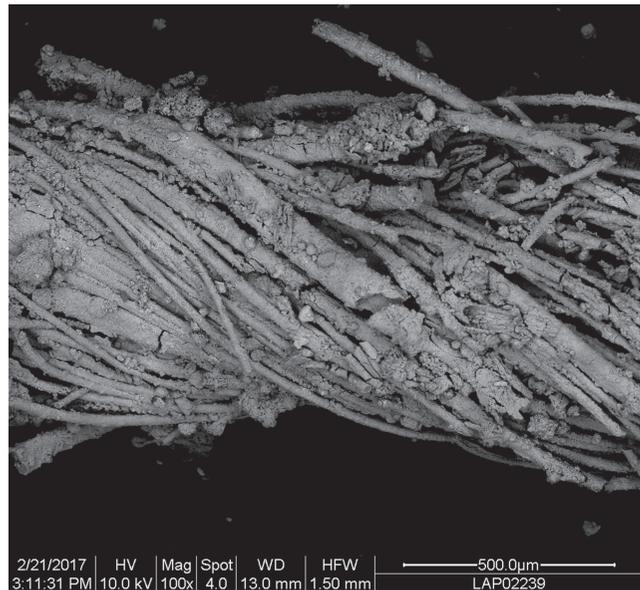


Fig. 3: Scanning electron micrograph (SEM) of Bronze Age wool fibres (Image: S. Harris)



Kayleigh Saunderson, Karina Grömer and Daniel Brandner

# Tablet weaves and more: textile news from Hallstatt

## Introduction

Hallstatt, located in the Salzkammergut in Upper Austria, with its salt mines and cemetery represents one of the most significant prehistoric sites of Central Europe, coining the term “Hallstatt period” (circa 800 to 450 BCE = Early Iron Age). This status is largely due to the exceptional preservation of organic finds in the mines, which have greatly contributed to our knowledge of textiles from the Bronze Age and Early Iron Age. Many of these textiles were documented by Hans Jürgen Hundt in the mid-20th century (e.g. Hundt 1959; 1960; 1967). Extensive research on the textiles from the salt mines was then carried out by Karina Grömer and Helga Rösler-Mautendorfer, together with specialists on dyestuffs, wool analyses, and C14 dating. All textile finds excavated in the salt mine of Hallstatt, up to 2010, have been published with an extensive and detailed catalogue in 2013 (Grömer et al. 2013), together with scientific discussions. This revealed the vast technological changes and creativity from the Bronze Age to the Iron Age (Grömer 2016, fig. 140). The Iron Age textiles exhibit a plethora of colours, patterns (twill variants, spin patterns, chequered patterns), remarkably fine threads, and patterned ribbons. Up to the publication of Grömer et al. 2013, 306 textile complexes, consisting of more than 500 single pieces of textiles had been analysed. However, excavations in the salt mines (fig. 1 and 2) have been carried out every year since then, bringing to light yet more textiles.

Here we present a small insight into two recent finds of tablet woven bands from the Hallstatt salt mines, which have interesting, but quite different, connections to previous finds.

## Tablet weaves of Hallstatt

Tablet weaving, though likely evidenced already in the Bronze Age salt mines (Grömer et al. 2013,

87; though a twining technique cannot be excluded with certainty), can be considered a “speciality” of the Early Iron Age, with complex patterns and motifs woven on these narrow bands. In Hallstatt, as opposed to, for example, the Early Iron Age examples from Hochdorf (Banck-Burgess 1999, 71), all tablet weaves are woven separately and then either sewn onto the edges of larger fabrics or used discretely. As sewn-on borders they could serve a practical purpose – “stiffening” the edges as well as protecting them from damage thanks to the sturdy, dense structure of tablet woven bands. However, the main purpose of the bands from Hallstatt was decorative, as evidenced by the many intricate patterns and colours used. Interestingly, large woven fabrics from Hallstatt never use more than one colour in their patterns, but ribbons (both tablet-woven and repp bands) can exhibit more (Grömer



Fig. 1: Excavation process in the prehistoric salt mine in Hallstatt (Image: Natural History Museum Vienna and Salinen Austria)

et al. 2013; Saunderson 2020). As of 2024, 12 tablet weaves have been found (HallTex 43B, 123A, 136-1, 152A, 186, 287B, 288C, 364, 376, 383, 385B, 390), of which two are presented in the following, with patterns ranging from complex geometric motifs to

simple stripes, using two or four threads per tablet. As these textiles were not found in a particular context in the mines and are all fragmented, it is difficult to determine their exact use. Clothing must definitely be considered. HallTex 123, with its ends sewn

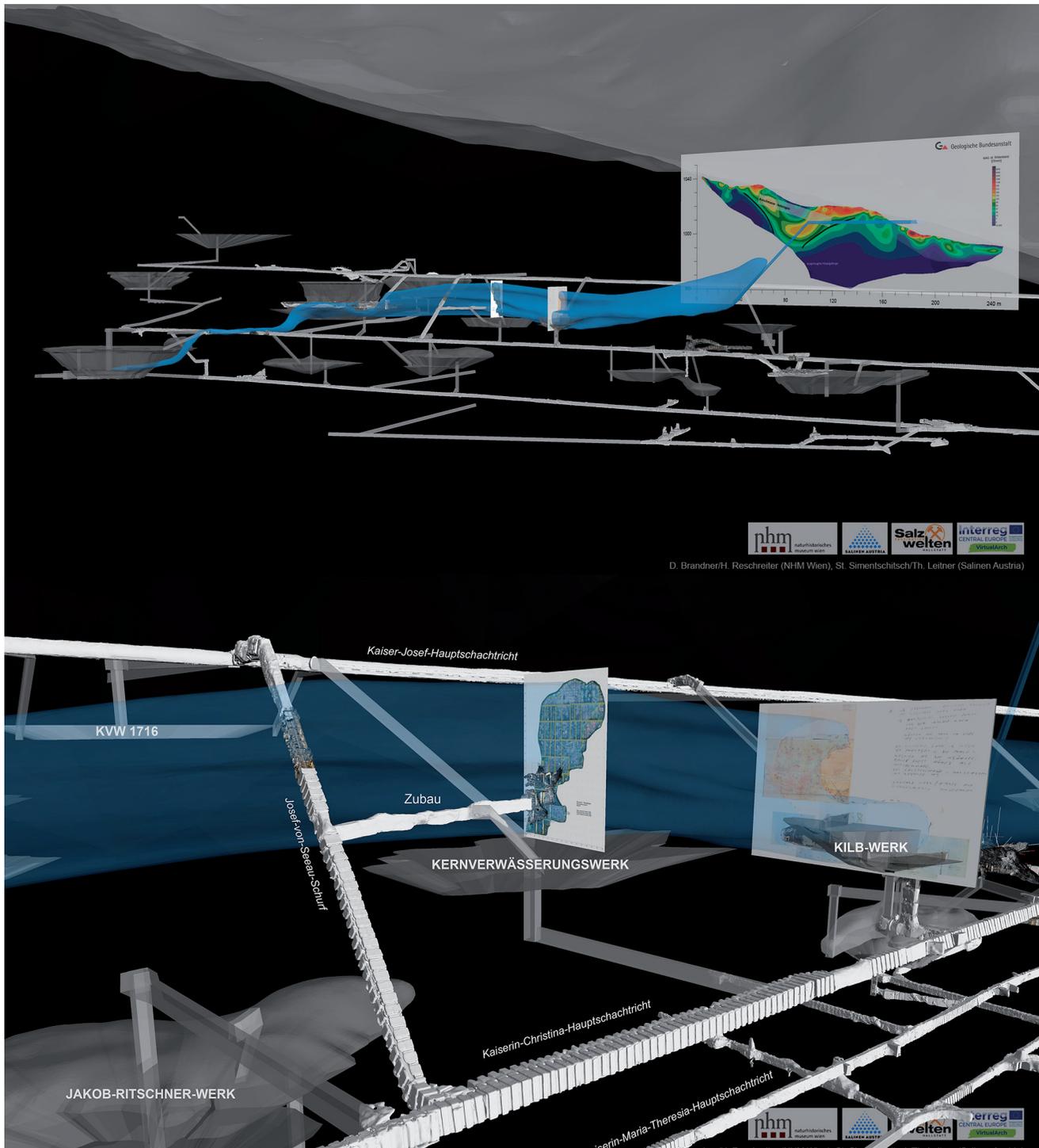


Fig. 2: Reconstructed overview of the different findspots in the Hallstatt salt mine (Image: Daniel Brandner, NHM)



together with a 22 cm circumference and attached to a twill fabric probably represents a sleeve (Grömer et al. 2013, 449–450). Given the decorative use, it can be deemed likely that many of these tablet-woven borders derive from clothing. Separate ribbons, i.e. those that are not sewn or woven onto another fabric, are difficult to interpret. They might have been used as headbands or belts or might have been meaningful objects in and of themselves.

### Recent research at the salt mine Hallstatt

In course of the mining operations of the last 300 years, traces of prehistoric salt mining were discovered in more than 100 places in the mines of Hallstatt, in some cases reaching more than 200 metres below surface. They are mostly parts of large Bronze and Iron Age mining chambers, shafts, and tunnels, in which the rock salt was mined dry. Almost all of them were filled up in prehistoric times by recurring landslides with material from the surface. On the floor of these chambers, we find the mining waste in layers up to 8-metres-high still *in situ*, perfectly preserved over the millennia due to the salty environment and lack of oxygen (fig. 1). This “heathen-rock”, as it is called by the miners, bears a huge number of organic finds, such as burnt down lighting tapers, broken tools, mining equipment, clothing, food remains, and even human excrement. Hence, this material allows insights into prehistoric living- and working conditions in exceptional detail.

Since 1960, the Natural History Museum of Vienna in close cooperation with the mining company Salinen Austria AG, has conducted archaeological research in the prehistoric salt mines of Hallstatt. Starting from the “accidental” findspots, hundreds of metres of excavation tunnels were dug through these filled up prehistoric mining chambers. Thousands of organic finds were discovered and analysed, and specialised techniques were developed to deal with these very special finds. Together with the constant improvement in excavation and documentation

methods, highly precise dendrochronological dates, and interdisciplinary research, this is leading to an ever better understanding of prehistoric salt mining in Hallstatt.

Precise dendrochronological dates of stratified wooden objects (Grabner et. al 2021) from the prehistoric find spots together with geoelectric measurements enable the connection of individual sites in the mine and create a fine chronology of the mining phases. They also give evidence for mining phases that are missing in the archaeological record. A comprehensive 3D-documentation of all accessible sites under ground and the integration of further research data visualises the current state of research and presents the basis for the development of further research questions. For instance, in recent years prospection drillings were carried out, giving insights into previously unknown areas of the salt deposit and proving a large mining chamber dates to the 6th century BCE (Ha D). This phase is scarcely known in the Hallstatt salt mines, most of the well-researched sites date to Ha C. New research tunnels were opened at this site to analyse the prehistoric mining waste, which will lead to a finessed chronology of Iron Age materials in Hallstatt.

In a 10-year project, funded by the Republic of Austria and the federal state of Upper Austria, archaeologists of the NHMW, together with miners of the Salinen Austria AG are restoring and maintaining the access to underground sites. This should enable the access for future generations to this unique part of the UNESCO-World Heritage site. In 2021, restoration works were conducted at a site, which is key in understanding Iron Age salt mining. At the location “Kernverwässerungswerk” (fig. 2) the only undisturbed cross-section through a filled-up mining chamber of the eighth to seventh centuries BCE was excavated between 1989 and 1996, proving the massive size of these structures (Barth and Reschreiter 2019). The prehistoric miners followed a large rock-salt vein (“Kernstrich”) and produced a



Fig. 3: Patterned tablet-woven band HallTex 383 (Image: Benedict Seidl)

HallTex 383	Warp				Weft
	dark green	dark red	yellow	light green	dark red
Single/plied	plied	plied	plied	plied	plied
Twist direction	Z2s	Z2s	Z2s	Z2s	Z2s
Twist angle	30–40°	30–40°	30–40°	30–40°	30°
Thread diameter	0.3–0.4	0.3–0.4	0.3–0.4	0.3–0.4	0.25–0.35
Thread count	13 tablets per 9 mm = 26 threads on each face				11 per 10 mm

Table 1: Technical data of HallTex 383

huge chamber of more than 20 m in height, 15–30 m width and a length of 300 m. It was filled in around 660 BCE, due to a landslide of clay and limestone from the surface layer (Grabner 2021).

In the course of restoring the research tunnels and renewing the timbering, the prehistoric layers, situated on the floor of the mining chamber, were researched once more and new finds came to light, including the two textile pieces discussed below.

**Case study 1: A new patterned tablet-woven ribbon**

HallTex 383 (fig. 3, table 1) was found in the “Kernverwässerungswerk, rottoniges Heidengebirge – level -1” during the maintenance work in 2021 and can be dated to 720–660 BCE. It shows a yellow geometric motif, which is repeated 5 times across the fragment of the band, on a light green and dark red background and with dark red and dark green borders. Both warp and weft are made from plied wool. Its preserved length, with torn ends, is 9.4 cm, and it is 0.85 to 0.95 mm wide. Reconstructing the pattern with all tablets warped in the same direction reveals a relatively simple sequence (fig. 4), repeating every 16th turn.

**A lost piece?**

The width, colours, and thread features of this fragment HallTex 383 (fig. 4b) are the same as those

of HallTex 186 (Grömer et al. 2013, 518–519), found in Kernverwässerungswerk in 1993, of which two fragments are preserved (one of which has a hem). However, the pattern of HallTex 186 (fig. 4c) is different, with a triangle ornament, though it is simple to switch between these two ornaments while weaving (fig. 4a). Given these facts, it is very likely that HallTex 186 and Inv. Nr. 127423 were once part of the same ribbon, but found 28 years later. Switching between different ornaments is also known from Hallstatt’s Inv. Nr. 126520. However, one cannot completely exclude the possibility that these were woven separately, meaning that this could have been a kind of standard setup or series of bands by a particular weaver or workshop. Inv. Nr. 127423 and HallTex 186, as well as Inv. Nr. 126520, do not exhibit traces of being sewn onto another fabric, thus they were probably used separately.

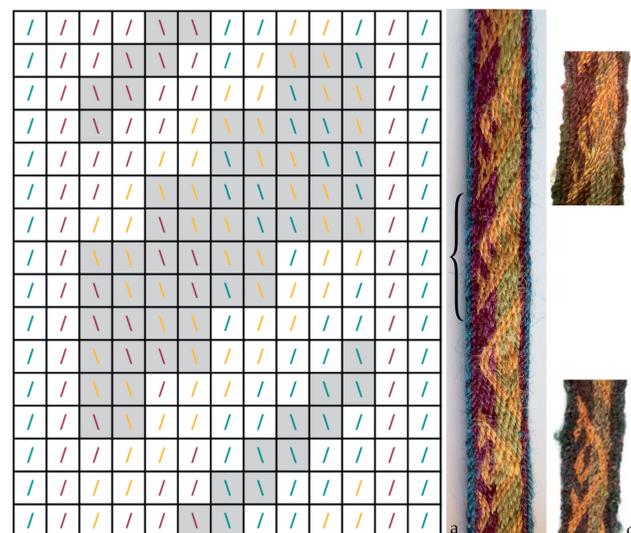
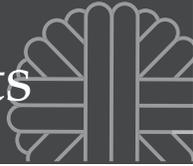


Fig. 4: Reconstructing the band. The weave pattern of HallTex 383 showing the colours and twist directions (/ = Z-twist; \ = S-twist). With all tablets threaded in S-direction, the white boxes can be read as tablets to be turned forwards (i.e. away from the weft) and the grey backwards (i.e. towards the weft). Each row represents one weft. a: Reconstruction of HallTex 383 (top half; with marked section of the shown weave pattern) combined with HallTex 186 (bottom half); b: ornament of original HallTex 383; c: ornament of original HallTex 186 (Image: Kayleigh Saunderson)



## Case study 2: A new simple tablet-woven border

The second tablet-weave, HallTex 385B (fig. 5, table 3), was found in “Kernverwässerungswerk, Vorkammer – level 1, Kerniges Heidengebirge” during the maintenance work in 2021 and also dates between 720

and 660 BCE. It is relatively simple, without ornament, using three tablets warped with four dark red threads each next to two with two bluish green threads each, all continuously turned in the same direction (S/S/S/S/Z). After weaving, the band (Textile B) was sewn onto a



Fig. 5: HallTex 385 with its tablet-woven border. Top: complete textile fragment (Image: Benedict Seidl); left: probably the outside of the piece showing the patterned stitches; right: probably the back side showing the hem and the placement of the stitches (DinoLite Edge digital microscope, 20x-magnification; Images: Kayleigh Saunderson)

HallTex 385A	System 1	System 2
Single/plied	single	single
Twist direction	s/z	s/z
Twist angle	40–50°	40–50°
Thread diameter	0.3–0.4	0.3–0.4
Thread count	24–26	14–15

Table 2: Technical data of HallTex 385A, the tabby base weave  
 Table 3: Technical data of HallTex 385B, the tablet-woven band

HallTex 385B	Warp		Weft
	dark green	dark red	dark red
Single/plied	plied	plied	plied
Twist direction	S2z	S2z	S2z
Twist angle	40°	40–50°	30°
Thread diameter	0.35–0.4	0.35–0.45	0.3–0.4
Thread count	7 tablets per 4 mm = 14 threads per face		7 per 10 mm

385	Seam/hem		Sewing thread				Stitch	
	type	width	colour	material	type	diameter	type	length
S1	hem	3.8 mm	Not visible	-	-	-	not visible	-
S2a	seam	-	blue	wool	plied yarn Z2s	0.3–0.4 mm	back stitch/ dot stitch	1.4 mm
S2b	seam	-	yellow- olive green	wool	plied yarn Z2s	0.3–0.4 mm	back stitch/ dot stitch	1.4 mm

Table 4: Technical data of seams, hems and stitches on HallTex 385

yellowish/olive green spin-patterned (with a sequence of four s and four z single yarns, both in the warp and weft system), tabby-woven fabric (Textile A, technical data see table 2). The seam (table 4) connecting the two textiles was also created in a decorative way – alternating three blue threads and three yellow-olive green threads, with a very short distance on the outside (opposite the hem of Textile A), thus creating “dots” in alternating colours (fig. 5).

Pattern: spin pattern with a sequence of 4s and 4z single yarns alternately, both in the warp and weft system

#### Visual similarities

As opposed to the previously presented ribbon, no other parts of this tablet weave are known. However, there are visual similarities to other textiles, which could suggest a certain fashion in colour combinations and design. One is HallTex 43 (Grömer et al. 2013, 360), also a yellowish textile (but a 2/2 twill) with a sewn-on simple tablet-woven border, which is also greenish blue and dark red. The other is HallTex 163 (Grömer et al. 2013, 492–493), also a yellowish tabby-woven fabric with a sewn-on border, which, however, is a repp band and not tablet-woven. Again, the warp is dark red and bluish green. HallTex 153 (Grömer et

al. 2013, 482–483) is interesting as a comparison for the decorative stitches. Two pieces of this blue tabby with a spin pattern were connected by short stitches, also creating these “dots”, with alternating three yellowish and three brownish-red threads, thus not just acting as a functional seam, but also a decorative element.

#### Current studies on Hallstatt textiles

Since the 2013 publication on the Hallstatt textiles (Grömer et al. 2013) that contains all textiles from the salt mine Hallstatt found until the year 2010, more research has been carried out.

The ongoing excavations brought to light new textile complexes with 110 textiles and 165 loose threads. Their documentation and the recording of all technical details will be undertaken in the coming years.

Moreover, the dendro- and C14 dating of the salt mines (Brandner et al. 2022) have been refined due to the research of the last 10 years, which also impacts our understanding of the textiles and their chronology. In particular, the dates for specific parts of the Iron Age mines, which formerly have been roughly set into the timeframe between 800 and 450/400 BCE, are a huge step forward. Now we know that the Kernverwässerungswerk and the Kilbwerk (fig. 2)



Fig. 6: Research as conducted on the textiles from the saltmine Hallstatt in summer 2024. More than 110 textiles have been analysed, deriving from the excavation campaigns 2010–2023 (Image: Benedict Seidl)

date to the eighth and seventh centuries BCE, whilst the Enderwerk is dated to the sixth and fifth centuries BCE. Attempts to define an inner chronology of the Iron Age textiles from Hallstatt are currently running. Also, the ongoing work of re-dating of the Bronze Age parts of the mine will bring interesting new results that impact our understanding of the developments of textile technology in continental Europe.

Margarita Gleba suggested the re-dating of the linen twill fabrics that have been found in the Bronze Age parts of the salt mine (HallTex 26 and 27, Grömer et al. 2013, 250–252), as the textiles in question did not fit her studies on raw material preparation and splicing techniques in prehistoric periods in Europe. The new C14 dates brought to light that HallTex 26 and 27 are not prehistoric, but Early Modern intrusions (Grömer et al. 2020).

Other studies that involved the textiles from Hallstatt have been carried out for research in restoration/conservation (Almstädter et al. 2021). New cleaning and drying procedures and standard protocols have been worked out for the textiles excavated in the context of hard salt rock.

In 2024, studies on dyestuffs and colours were resumed. In the project, HallTexRed+, the team of dyestuff experts from Vienna and Amsterdam and C14 dating from Fribourg will look at specific red shades.

## Conclusion

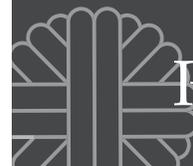
Although a large part of the textiles from the Hallstatt salt mines was published in 2013, new textiles are still brought to light by the excavations every year, continuing to raise new questions in textile research. The recent more precise dating also results in new research questions of typo-chronology in textiles. The two tablet weaves presented here are interesting case studies, showing strong similarities to previously found textiles, with one most likely belonging to a fragment found in 1993 with a slightly different pattern, and the other exhibiting various decorative elements and perhaps a common colour combination.

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Ronja Lau

# Textile archaeological analyses of the finds from the Dürrnberg salt mine

## Introduction

The Iron Age salt mine at Dürrnberg near Hallein, Austria, offers ideal conditions for researching prehistoric textiles because of their preservation in salt. Dürrnberg dates mostly to the early La Tène period and was the economic centre of the region. The analyses of the over 600 colourful textiles from the salt mine and the mineralised fragments from the burials will determine the technical details of the fabric, fibre analysis, chronology and colour analyses. This project is being carried out as part of a doctoral thesis at the Ruhr University, Bochum, and is funded by the German National Academic Foundation (*Studienstiftung des Deutschen Volkes*).

The data generation is based on the microscopic examination of each find and records the following details (CinBA undated): information about warp and weft, yarn or ply, thread twist, thread diameter, twist angle and thread count.

One of the research questions deals with the textile traditions. Local or regional textile traditions in certain areas can usually be recognised by specific factors of these technical fabric details. For the Iron Age in and around Austria, there is already evidence for certain thread twists and patterns in fabrics and they differ from textile traditions in other regions (von Kurzynski 1996, 34; Grömer 2012, 44; Grömer 2014).

An important aspect will be the question of resources in and around the mine, examining where the resources for textile production on the mountain come from. Local textile production requires the use of a wide range of resources, including both plant and animal products.

## Methodology

The basis of textile research has been standardised in recent decades (Grömer 2014, 9–16; Wild 1988). These include methods such as fibre analysis using scanning electron microscopy (SEM), microstratigraphy and wool fineness measurements (Grömer 2015, 90).

The differentiation of plant and animal fibres has so far only been possible with limited insight (Stöllner 2005, 168). As the Dürrnberg salt mine has a large number of linen fabrics, SEM images can lead to a detailed analysis of the fibres and, for the first time, enable questions to be asked about cultivated fibre plants (Banck-Burgess 2012, 38).

Preservation in salt enables further investigations, such as colour analyses using High Performance Liquid Chromatography (HPLC) (Banck-Burgess 2012, 38). The range of colours can be determined using the Natural Colour System (Natural Colour System 2023). Both radiocarbon 14 dating and isotope and material analyses extend and enrich this work. Existing dating provides an initial overview and categorisation of most textiles. Strontium can be used to reconstruct the place of origin and habitat of living organisms. Pilot studies have already analysed recent sheep's wool as well as prehistoric finds from Denmark and Sweden (Frei et al. 2009, 255).

## Findings

The rich spectrum of finds provides an insight into the craftsmanship, aesthetic demands, design concepts and variability in fabrics.

In the 1960s, Hans-Jürgen Hundt (Hundt 1961) and in the mid-1990s, Katharina von Kurzynski were

working on the textiles (von Kurzynski 1996). Von Kurzynski recognised some differences in direct comparison with the prehistoric Hallstatt salt mines (von Kurzynski 1996, 33). The textile research in Hallstatt offered researchers a unique insight into textile production, manufacture and aesthetics in the Early Iron Age (Grömer et al. 2013). Although some of the finds were published for the first time around 20 years ago (Stöllner 2002), every textile and organic fragment still offers detailed possibilities for documentation and analysis according to the current guidelines in textile archaeology. The finds from the recent excavation seasons are now being included in textile research for the first time. In contrast to Early Iron Age (Hallstatt period) Hallstatt, the Dürrnberg dates to the Late Iron Age, the Early La Tène period, and is usually regarded as the replacement of Hallstatt as the economic centre of the region (von Kurzynski 1996, 33). The significance of the finds can therefore be equated with those of Hallstatt.

There are currently 1,186 entries of textiles from 1970 to 2000 from the salt mine. This is the number of individual fragments to date, which belong to around 567 different textiles. The textile finds from 2000 to the current excavations in 2023 are stored in the Bergbaumuseum, Bochum and the salt mine depot. An overview of the quantity of finds is not yet available. During the processing, “new” finds are sometimes discovered that have not yet been documented as separate textiles. The number of finds will therefore continue to grow. It is estimated that there are more than 600 textiles from the salt mine. In addition, around 200 mineralised textile fragments have so far been found in the graves, as identified by the staff of the museum in Hallein.

### Mineralised Textiles

As the salt mine forms a problematic archaeological context for the adequate interpretation of textile finds (above all due to the secondary use of the fabrics), mineralised finds from the graves should be consulted. Mineralised textile remains offer various possibilities. As they are found in the context of a burial, the interpretation of the finds is usually clearer and is related to humans and possible clothing. Furthermore, textiles in burials can reveal other uses that represent the everyday or ritual need for fabric. These include pouches for cremated remains, wrappings for objects or shrouds (Banck-Burgess 1999, 2012; Gleba 2014; Grömer 2015, 99; Rebay-Salisbury, 2016). It is highly likely that the textile details reveal similarities and differences to textiles that may have served another purpose.

The social appearance of the population on the Dürrnberg can be built up piece by piece on the basis of the contexts, features and finds. Potential questions arise, for example, in relation to practice-specific clothing in mining and the supposedly higher quality worn as special funeral clothing. Can these differences be verified on the basis of quality, material and appearance, thus providing a differentiated social insight into a closed population group? However, the difference between the textiles of “poorer” burials and “richer” burials cannot be determined, as textiles from the “poorer” graves are not preserved due to the lack of metal artefacts (Grömer 2016, 267). As the mineralised textile fragments are in direct contact with other archaeological finds, further methods can be applied to examine them specifically. The mapping and depiction of microstratigraphy is already an integral part of the study of mineralised textiles. Terminology and specifications from various institutions (Bayrisches Landesamt für Denkmalpflege 2023, CTR 2020) enable comparable values, representations and statements.

### Preliminary results

The preliminary results already provide a good overview of the existing finds and the possible analysis. For example, the weave types can be correlated with the fibres used. Figure 1 shows the distribution of weaves on wool and linen textiles. Without exception, the linen textiles are woven in tabby. Almost as many tabby wool fabrics can be seen, but they are in strong competition with 2/2 twill fabrics (fig. 2). No other twill variants have yet been identified. In most cases, the tablet weaves listed are woven selvages with just one to three tablets per border.

Around 72% of the textiles analysed so far are made from wool and 26% have been identified as flax. A few



Fig. 1: Weave types by fibres in the textile from the salt mine Dürrnberg



Fig. 2: Textile inventory number 1718, a common brown twill textile with a selvage (Image: Ronja Lau/Keltenmuseum Hallein)

finds even show the use of flax and wool together in a fabric (fig. 3).

Due to the excellent preservation conditions, the colours of the fragments can be described precisely. Natural wool colours such as light brown, medium brown and dark brown make up almost 52% of the total. The other half is dominated by the colour blue, which accounts for approx. 17%. Other colours such

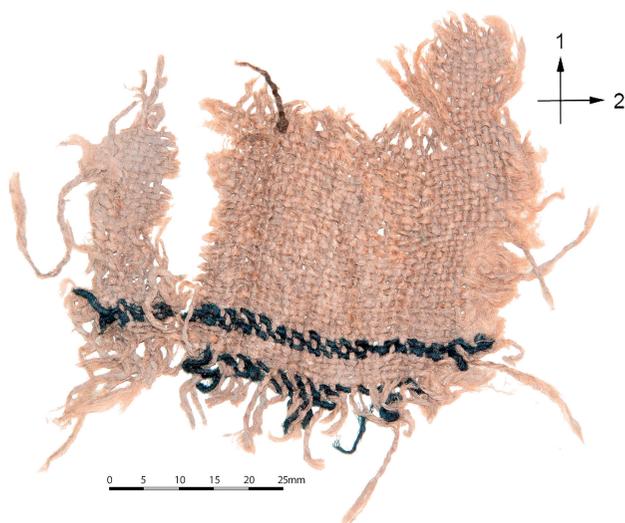


Fig. 3: Textile inventory number 1060, a beige linen textile with dark blue wool threads in a striped pattern (Image: Ronja Lau/Keltenmuseum Hallein)

as red or green are less common. The colour yellow is difficult to detect visually and grey and beige are mostly used to describe linen fabrics. The distinctive Dürrenberg dark blue is a special feature of the textile finds. Fig. 4 shows what a strong colour was achieved here. However, detailed photographs under the microscope indicate that the blue was dyed on very light-coloured wool fibres and not on dark brown ones to achieve the dark tone. Further research and analyses are needed to understand the production of Dürrenberg dark blue.

Other colours were also created in the Iron Age by mixing different fibres. The mine offers the unique opportunity of identifying fabrics made of mixed blue and red fibres. An iridescent colour results when red and blue are mixed together and imitate purple. Due to the trade connections of the inhabitants to the Mediterranean region, the use of real murex purple must have been known. Even in pre-Roman times, this dye was immeasurably valuable. By imitating the colour, the Dürrenberg people could also have expressed their wealth. Further investigations into these unique finds are planned.

But other details such as spin directions, patterns, fabric quality and thread diameters also provide a picture that illustrates the textile traditions of the Dürrenberg and distinguishes it from other times and regions. While the variability of textile techniques can still be recognised in the Hallstatt period, a

consolidated textile tradition crystallises in Austria's La Tène period.

The use of different weaves and patterns in combination declines in the Dürrenberg material. Only four pattern categories can be identified in the textiles. Check patterns, striped patterns, spin patterns and colour effects in the fabric determine the design. 57% of the pattern variants are stripe patterns. These are incorporated into the fabrics in a few patterned threads but with a lot of contrast. There are also fine pattern sequences of sometimes one to three pattern threads in different colours (fig. 5). The otherwise concise image of the Celts in the chequered pattern can most probably be revised on the Dürrenberg. There are just 8% chequered patterns compared to the other variants. As with the stripes, the pattern is formed from just a few threads. More popular are the colour effects created by using different threads in the warp and weft. This effect accounts for 29% of the patterns. The final pattern is spin patterning. This is quite common in the Hallstatt period (Lau 2021, 60) but rare in the Dürrenberg textiles. Due to the fact that the salt mine was used from Hallstatt D to the La Tène period, it could be an indicator that the spin pattern textiles are older and date to the Late Hallstatt period. This internal chronology could be investigated in more detail with targeted radiocarbon 14C dating (14C dating).

### Outlook

The mine as a "Dürrenberg laboratory" provides an insight into the textile tradition of a micro-region in a way that is otherwise hardly possible.

An important aspect will be the question of resources in and around the mine. Local textile production requires a wide range of resources to be utilised, including both plant and animal products. Analytical evidence for sheep's wool, linen and/or hemp, horsehair, tree bast or leather can be compared with interdisciplinary co-operations. Wool fineness measurements can furthermore help classify wool quality.

The utilisation of resources, production of textiles and working in the mountains requires close communication within the society on the Dürrenberg. Textile traditions and design concepts can make statements about this differentiated community and possibly reveal social groups. A comparison of the textile finds from the mine with the mineralised textiles from the surrounding graves is aimed for in order to answer these questions. Possible qualitative differences between the mine and the graves can clarify the differentiation of social groups. Questions can also be asked about labour-specific clothing in

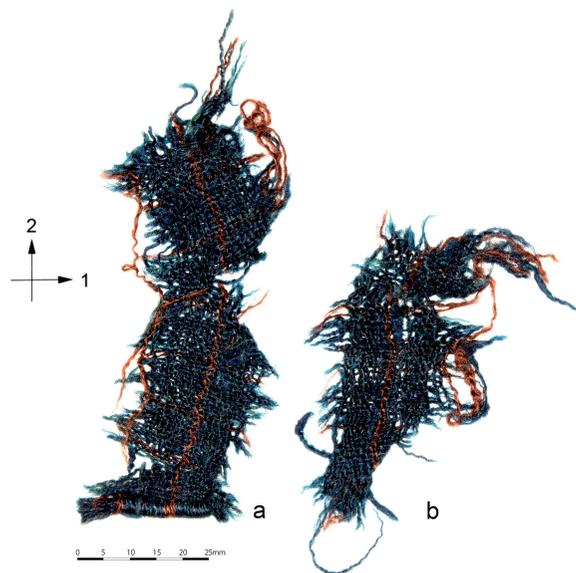


Fig. 4: Textile inventory number 2375, dark blue textile fragments with a red chequered pattern (Image: Ronja Lau/Keltenmuseum Hallein)

the mountain. This can be discussed with the help of different fibre usage or the analysis of technical fabric details.

Archaeological textiles help to develop a picture of numerous prehistoric societies. Clothing was and is a distinctive component of people, their identity and their sense of belonging.

With approximately 600 different textiles the statistical relevance for this research is set and classifies the site as the biggest pre-Roman textile complex in Europe. Both an emerging database and the documented finds

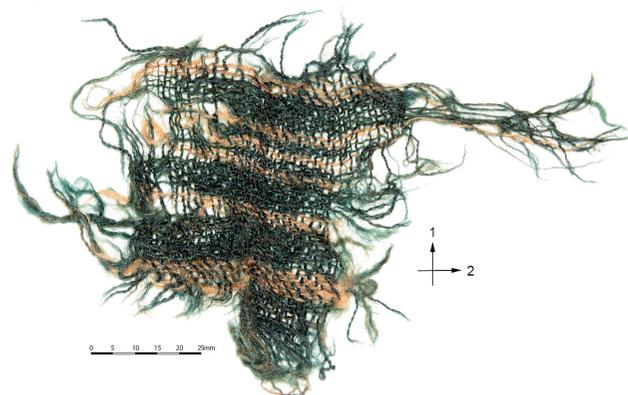


Fig. 5: Textile inventory number 818, a green fabric with light brown stripes (Image: Ronja Lau/Keltenmuseum Hallein)



can serve as a basis for further questions and enrich this work, make it accessible to future researchers.

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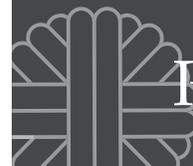
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Audrey Gouy

# Etruscan dress in context: from digitisation to motion capture

## Introduction

From 2019–2021, the Marie Skłodowska-Curie project, *TEXDANCE (Textiles in Etruscan Dance, Individual Fellowship, grant agreement ID 839799)* was hosted at the University of Copenhagen, in partnership with the University of Oxford. This proposed an original study of an aspect of Etruscan ritual and religious practices. It explored dance, which had a key role and constituted an important form of non-verbal religious communication, and its props, primarily textiles. The scope was to examine how textiles make the movements of dance, their ritual functions, their diversity, their performativity, the ritual function of costumes in dance, and the social relations which intertwine. *TEXDANCE* combined three kinds of sources: primarily the iconographic representations as they constitute the most important documentation for Etruria; Latin and Greek texts as there are no usable Etruscan texts; and archaeological evidence. Among the issues the project addressed, the most important were: what kind of textiles and dress were used in dance? How were they used in this context? How did they indicate movements, and which ones? Were they Etruscan productions and can this be confirmed by archaeological finds? If not, what did a Mediterranean origin for the textiles mean in ritual practices and beliefs? What social differences do the textiles reflect among dancers? Did textiles make sounds during the dance?

These questions have been answered through the following objectives: 1. Types of dress and textiles in dance: materials, colours, forms; 2. Motion textiles: the study of dress movement in dance; 3. Textiles acoustics: the sounds of dancing dress; 4. Circulation and fashion: Etruscan dress identity; 5. Textiles

and aristocratic lifestyle: community organisation, ritual practices and dance; 6. Ritual textile making: aristocratic female education and lifestyle; 7. Visuality of dance textiles on artefacts: a narrative system (<https://ctr.hum.ku.dk/marie-skłodowska-curie-projects/previous-marie-skłodowska-curie-projects/textdance/>).

*TEXDANCE* helped to explain the types of textiles used, how they were made, the sound they produced in the ritual, and their specificities compared to those of the Mediterranean area. The textiles of pre-Roman Italy and in particular of Etruria have been the subject of several important works by Larissa Bonfante (1975, updated 2003), and Margarita Gleba (2008). These studies provide a remarkable analysis of the production and use of Etruscan and pre-Roman textiles and dress. *TEXDANCE* proposed a different angle of research, by emphasising the performative and ritual use of textiles.

## Recontextualising Etruscan dress

The project entitled *Digital recontextualization of ritual textiles from classical Etruria (fifth century BCE)* that has been carried out since January 2023 at the University of Lille, France, with the Research Federation Visual Sciences and Cultures (FR-SCV) and the State-Region plan contract (CPER) *ENHANCE – Embedding a Human Dimension in Cultural Heritage*, aims to continue the research begun with *TEXDANCE*. Based on the results produced, the objective is now to recontextualise the dress and textiles specifically used in Etruscan dance, by emphasising the experience of textiles, the relations and interactions between textiles and the body, and by using new digital tools. The research is exploratory and as such focuses on specific case studies, which



are the *Tomba del Triclinio*, *Tomba del Letto Funebre*, *Tomba dei Leopardi*, *Tomba Bartoccini*, and the *Tomba del Cacciatore* from the necropolis of Tarquinia (Italy). Three research objectives were defined as: 1. To reconstruct the dress used in Etruscan dance (real and 3D reconstruction); 2. To test the real reconstructions made, and record their potential movement using motion capture (now MoCap); 3. To replace the data in a digitally-reconstructed historical context, which will help understanding of the forms of Etruscan dance and of the textiles used, the impact of dress in dance, and the temporality of specific Etruscan ritual practices. It will also help better understanding the sources of ancient dance and textiles (primarily iconography). Thus, this project plans to produce unprecedented documentation and new tools for research, for scientific community and students. Targeting museums and

a large audience, it will offer innovative means of interaction for public dissemination using digital technologies. Also, as it raises crucial methodological questions, it will foster epistemological reflections on the use of digital tools in the study and dissemination of information about past societies.

### Digitisation of the Tomb of the Triclinium

The project has primarily engaged with the digital study of the Tomb of the Triclinium. Discovered in 1830, the monument is located in the Monterozzi necropolis (Calvario) of Tarquinia (Italy). It is a single funerary chamber, almost square in plan, dug into the rock. Its dimensions are as follows: height 252 cm; left and right walls height 195 cm; length 430 cm; width 350 cm. The tomb, which is accessible by a staircase also dug into the rock (*dromos*), is dated circa 470 BCE.



Fig. 1: Study of the Tomb of the Triclinium, Tarquinia (Italy): a – (top left) paintings kept in the Archaeological Museum, Tarquinia (Italy), being studied by engineers Nicolas Bremard (UMR 9189 CRISTAL & PIRVI, France) and Jérémy Cundekovic (University of Lille and FR-SCV, France); b – (top right) digital reconstruction of the paintings; c – (bottom left) inside the tomb, with engineer Nicolas Bremard (UMR 9189 CRISTAL & PIRVI, France); d – (bottom right) digital reconstruction of the architecture (Images: Audrey Gouy and University of Lille, France)

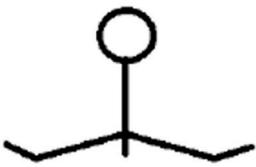
Phase 1	Phase 2	Phase 3	Phase 4
			



Fig. 2: Hypothetical reconstruction of the movements of the Etruscan castanet player ©Audrey Gouy: a – (left) bronze showing phase 1 of the castanet dance (private collection); b – (middle left) bronze showing phase 2 (Opera del Duomo Museum, Orvieto, Italy); c – (middle right) bronze showing phase 3 (Archaeological Museum, Bologna, Italy); d – (right) bronze showing phase 4 (Soprintendenza per i Beni Archeologici dell’Emilia Romagna, Bologna, Italy) (Images: *The Christos G. Bastis Collection, Sotheby’s, New York, Thursday December 9, 1999, New York, 118–121; Bizzarri 1972, 26, n. 24; Sassatelli 1988, 293; Ortalli 2002, 71*)

The frescoes which covered its walls (entrance wall, side walls, back wall, and double-sloped ceiling) show several scenes: a banquet on the back wall, horsemen on the entrance wall, and dance scenes on the side walls. It is on these dance scenes, in which textiles play a crucial role, that this project focuses. All of these frescoes were detached in 1949, and taken out of their archaeological context, which has modified the understanding and experience of them. Since then, these paintings have been kept at the Archaeological Museum of Tarquinia (Italy).

To retrieve and offer the most accurate experience of the tomb to researchers and a large audience, it has been decided to digitally replace the detached paintings in their original archaeological context, and thus to reinsert the frescoes in the tomb. Therefore, a study mission was carried out in May 2023, which consisted of digitising the entire Tomb of the Triclinium, namely

the paintings preserved at the Archaeological Museum (fig. 1a and fig. 1b), and the architecture of the tomb (fig. 1c and fig. 1d) where these paintings came from. In both cases, the digitisation was carried out using lasergrammetry (FARO), supplemented by numerous photos, both wide and detailed, in order to ultimately obtain a high-quality reconstruction of the tomb. On the frescoes, both ultraviolet light and RTI were used to differentiate traces of restoration and modern additions.

Back in Lille, the engineers involved in the project juxtaposed the digitisation of the frescoes with that of the tomb’s architecture. The presence of remains of pigments and frescoes in the chamber facilitated the superimposition of the paintings on the architecture. The digital juxtaposition revealed the dialogue that was originally meticulously created between the architecture and the paintings, something that has



been lost since the detachment in 1949. The result of this digital juxtaposition is a reconstructed 3D model of the tomb, into which the digital recordings of the dance movements and textiles will subsequently be inserted, with the aim to better understand the possible use of the tomb's space, the ritual represented on the walls and its whole experience, as well as the process of creation of Etruscan iconography.

## **Digitising motion**

In 2019-2021, one of TEXDANCE's objectives was to study the motion of dress in Etruscan iconography. The project highlighted that clothing expressed several types of movement, and thus contributed to the definition of dance, and to its understanding. The project now at the University of Lille aims to test these movements and to record them using MoCap.

MoCap is the process of recording patterns of movement digitally. It is now regularly used for different human movements, such as dance. This technique is often associated with modern practices and applications (sport, medicine, animation), but also can be useful to test ancient movements and choreographies. Before testing MoCap on dress, some dance movements for which several hypotheses were proposed in the author's PhD thesis on Etruscan dance (EPHE-PSL, Paris and Ca' Foscari University, Venice, 2017). One on those hypotheses concerns the castanet player, who regularly appears in ecstatic and dance scenes with arm movements. The study of Etruscan iconography assumed that the choreography performed by this player included a progressive gradation, and different moments (fig. 2). Indeed, it initially consisted of having a very measured posture. The arms remained close to the body and moved very little. The figure might have been walking. As the dance progressed, the walking became faster, the arms alternated more and more widely, until they were swinging from one side to the other. The figure's bust and head also tilted and swayed more and more from one side to the other. The final moments consisted of twirls, with the arms and hands raised above the head. These hypotheses have been recorded using MoCap and are available on Zenodo (DOI 10.5281/zenodo.10201929).

The three-dimensional capture of the castanet player's possible choreography is relevant for several research and dissemination issues. It contributes to a biomechanical analysis of the movements, and as such to the study of specific techniques, postures, and gestures possibly performed by this player in Etruscan dance. It also questions the spatial and temporal aspects of ancient choreography, and contributes to insights into the kinematics and dynamics of ancient movements.

Moreover, the record of these movements constitutes a digital archive of hypothesis, which provides a basis for future research, and enables researchers to discuss, compare and share interpretations. Eventually, the capture of ancient dance movements, thanks to avatars, can be integrated into virtual and augmented reality environments. These can be used to create immersive dance experiences and interactions, and in particular to recreate ancient dance events, providing audiences with a new way to experience and learn about ancient ritual practices.

## **The motion capture of dress**

The MoCap system usually records the movement of objects and living beings based on their inherent fixed skeleton. As such, it precisely tracks the position and motion of various body parts in a three-dimensional space. In textile research, MoCap has been used by the Centre for Textile Research, University of Copenhagen, to record the body movements of specific spinning and weaving processes. But what about textiles themselves? To what extent MoCap could benefit research on ancient textiles and dress practices? Recording and capturing the motion of textiles presents several challenges, notably due to the lack of a fixed structure and the great variability of the material. But there are also opportunities.

## **Research objectives**

The use of MoCap involves four crucial steps: 1. To place the sensors/small reflective markers on the body, which fixes them on rigid and articulation parts such as ankles, knees, elbows or shoulders; 2. To strategically position and synchronise multiple high-speed cameras around the subject, allowing the capture of its movements from different angles; 3. To collect the data captured by the cameras – a specialised software processes the exact position and orientation of each marker in three dimensions (the University of Lille uses Qualisys); and 4. The data gathered are post-processed, for analysis in animation or simulation.

While usually used for replicating realistic human and object movements, MoCap can play a role in the study of ancient dress practices, and can provide valuable insights into how clothing and textiles behaved when worn. As such, it can help in the study of ancient dress by testing and experimenting with archaeological hypothesis.

Therefore, the aim is now to investigate and understand the behaviour of dress in Etruscan ritual practices, and to recreate and test the functionality of ancient clothing in practical scenarios, primarily in dance performances. This should provide practical insights



Fig. 3: MoCap test preparation details: a – (left) the skirt in viscose selected for the preliminary experimentation; b – (right) the Velcro strip being attached to the lower part of the garment (Images: FR-SCV)

into how clothing was used, how it was experienced by the dancers, and its impact on both the dancers and the ritual. MoCap focuses on four crucial aspects: 1. Understanding draping and fitting, i.e. assessing how ancient clothing was draped and placed on the body, how it might have been adjusted or pinned for optimal fit; 2. Analysing fabric behaviour, i.e. revealing how textiles and fabrics moved, stretched, and wrinkled based on the different movements performed, helping us to understand the characteristics of the fabrics used and how they influenced wearability; 3. Assessing ergonomics, i.e. evaluating how well (or badly) dress accommodated the movements and needs of dancers; and 4. Reconstructing dress movements, which contributes to gain a better understanding of how the different garments functioned together during dance. However, the motion capture of ancient dress requires careful consideration of historical accuracy and the use of appropriate fabrics and materials for the capture. Thus, MoCap should be combined with other research methods, such as textile analysis, archaeology, historical research, iconography analysis, and experimental archaeology.

### *Preliminary tests and results*

Before testing and capturing the movements of reconstructed Etruscan clothes as planned, preliminary tests have been performed with a skirt in viscose (fig. 3a). The aim of these tests was to remove existing doubts about the possibility of digitally capturing

the movements of dress, and to determine what difficulties needed to be solved when working with objects as unstable as textiles. The tests were carried out on the FR-SCV digital platform, with Laurence Willard Delbarre, instrumentation and experimental techniques engineer.

Recording a human body is easy. The markers are placed on fixed bones and joints. The distance between two joints will likely not vary during motion capture, such as between the elbow and wrist – the arm amplitude will remain stable. It is not the same for dress. Recording textiles presents several challenges due to the absence of a fixed structure as emphasised previously. The first phase of the experimentation, which consists of placing the sensors on the cloth, is therefore crucial. It was decided to resolve as much as possible the problem of variability between two sensors, by multiplying the sensors over the area to be recorded, and by placing them very close to each other. The aim was to keep as much of a continuous trace in the structure as possible.

The investigation began by focusing on the movement produced by the lower part of the garment selected for the experiment. The aim was to see how it behaved in relation to the movements of the dancing body. Thus, a Velcro strip was stuck all along the hem of the garment (fig. 3b), to which the sensors were attached (fig. 4a). This resulted in a horizontal strip of sensors in the lowest part of the skirt. And in order to give the garment an orientation, two



Fig. 4: MoCap test preparation details: a – (left) the skirt to be recorded, with the sensors stuck on the Velcro strip; b – (right) dancer wearing the skirt (Images: FR-SCV)

sensors were placed vertically on the front part (fig. 4b). The next phase of the experiment was to record the movement of the skirt. This skirt, worn by a dancer, was positioned in the centre of the MoCap system, and therefore was surrounded by multiple high-speed cameras. To set the fabric in motion, the movements performed were as follows: 1. walk; 2. turn around; 3. turn from side to side; 4. alternating walk and lift of each leg; and 5. alternating jump and lift of each leg. The recording is available on Zenodo (DOI 10.5281/zenodo.10201976, see test 1). The first results were very satisfying since it was possible to follow the different movements

of the fabric. Some sensors tended to occasionally disappear from the capture, notably during the first four seconds of the recording, then occasionally during the recording. This is due to minor issues with calibration and placement of the cameras around the body. Despite these minor issues, it was possible to track and calculate the movement of the cloth. However, there was missing information regarding its height, its overall movement, and its movement relative to the upper body. So, vertical lines of sensors were added on the right and left sides of the fabric (fig. 5a), and the wearer put on the MoCap upper jacket with sensors placed on



Fig. 5: MoCap test preparation details: a – (left) the skirt to be recorded, with the sensors stuck on the lower part and sides of the garment; b – (middle) dancer wearing the skirt, with sensors on the upper body (front); c – (right) dancer wearing the skirt, with sensors on the upper body (back) (Images: FR-SCV)

several crucial articulation points (fig. 5b and fig. 5c). Subsequent testing and recording, based on a similar sequence of movements, yielded more results on the overall trajectory of the garment, on the relationship between the fabric and the moving body, on fabric behaviour, and ergonomics. This second recording is also available on Zenodo (DOI 10.5281/zenodo.10201976, see test 2).

### *Research perspectives*

These preliminary tests showed great potential for understanding dress movements and determined that it was possible to capture the behaviour of the future reconstructions of dress used in Etruscan dance, as planned for the future. The next tests should be carried out with linen and wool skirts to see the differences in behaviour depending on the type of fabric and fibres. The experiment will be expanded to also study different types of clothing such as mantles, as well as other types of dance and movements. Finally, these tests will be expanded with the capture of the reconstructed Etruscan dress. Since the dress responds to movement based on its design, construction, and materials with the capacity of enhancing (or restricting) the dancer's performance, future testing will consider complementary aspects of dress, such as stretch and flexibility, drape and flow, cut and fit, pleats and folds, linings and undergarments, fastenings and closures. As further tests will be performed, additional papers will be published to document and question the experiment. The data collected will contribute to the understanding of the impact of dress and textiles in performative rituals such as dance, but also to put into perspective the iconographic sources of Etruscan dance and thus to better understand the creative process at work in the visual construction and codification of dance and textiles in ancient iconography.

### **Conclusion**

The study of ancient dress and textile practices usually involves a combination of archaeological, anthropological, literary, iconographical, and textile analysis approaches and techniques, which allow researchers to reconstruct and understand the dress and textile practices, including the materials, techniques, functions, and cultural significance of those practices in various societies and time periods. Digitisation, and MoCap, can definitely complement these methods, by documenting, analysing, and sharing information, and in doing so they foster advanced analysis and interpretation, but also make information more accessible, and preserve valuable data.

### **Acknowledgements**

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Magdalena Przymorska-Sztuczka

# Textile tools, fabrics and craftspeople in the Wielbark culture (Poland, first to third century CE)

## Introduction

The aim of the project, *Textile tools, fabrics and craftspeople in Wielbark culture. Holistic approach to the evidence for textile production from Czarnówko, Lubowidz and Wilkowo as the case studies* is a comprehensive look at the relationship between the types of textile tools, fabrics, and the people who made them. The project is based on artefacts discovered in the Wielbark culture cemeteries in Czarnówko, Lubowidz and Wilkowo, Lębork commune, Poland. These three sites, dated from the second half of the first century CE to the third century CE, provide a rich set of textile tools – spindle whorls, distaffs, needles, hooks, and one of Poland's most numerous collections of fabrics from the Roman period. The numerous imports in the grave furnishings of the people of the Wielbark culture indicate extensive and intensive trade contacts with the Roman provinces. Of the many artefacts associated with the textile production of the population of the Wielbark culture, only fabrics (Maik 1988; 2012; 2013; 2015a; 2015b; 2018; Maik and Wtorkiewicz-Marosik 2020; Przymorska-Sztuczka 2017) and distaffs (Schuster 2010) have been thoroughly analysed. Other tools have yet to be the subject of detailed research. Despite their commonness, textile-related tools are artefacts with excellent research potential. Their detailed analysis can answer specific research questions regarding prehistoric textile economy, for example determining the leading type of spindle whorls or the co-occurrence of different categories of textile artefacts in burials, as well as determining changes and influences on textile production coming from other areas.

## Methodology

The primary aim of the textile-related tool studies was a detailed metric analysis, of which the statistical analyses formed the basis of further research. The tool inventories were compiled according to the documentation principles formulated by the Centre for Textile Research team (Andersson Strand and Nosch 2015). They, therefore, included data on height/width/length, diameter, weight, bore diameter, shape, possible ornamentation, other features not mentioned above, and traces of use. A similar descriptive scheme was applied to all categories of textile-related tools discovered at the sites included in this study. Traces of use were documented using a Dino-Lite Edge digital microscope, model AM7515MZT, and a Sony Alfa 500 camera with a macro lens. Technological analyses of fabrics were made on standards, according to which the weave, the density of threads in the warp and weft per 1 cm of length, the direction and angle of yarn twist and its diameter are determined (Emery 1980). For archaeological textiles from present-day Poland, the description was developed by Janina Kamińska and Andrzej Nahlik (1958) and Jerzy Maik (1988), based on fabrics from the Roman and early medieval periods. Technical analyses of the textiles were carried out with a Dino-Lite Edge digital microscope, while a Zeiss microscope with transmitted light was used to determine the raw material. Approximately ten measurements of the diameter, thread, and twist angle were taken for the smallest textile fragments. If the fragment was large enough, 50 or more measurements were taken from the threads of both systems and the density per 1 cm at various locations in the fabric. SEM analyses and strontium isotope tests were performed



for ten fabric samples. Five samples were forwarded on for dye analyses by ultra-performance liquid chromatography coupled with mass spectrometry (UPLC-MS).

## Objectives

The research plan analysed textile tools and fabrics. The analysis of the tools made it possible to summarise the data and draw basic conclusions and generalisations about the collection, for example, identifying the most common type of spindle whorls. An important aim was also to analyse the tools for traces of use and compare them with those observed on the reconstructions used in the experimental work. The project also verified the origin of the fabrics' raw material (local or non-local, gauging the strontium isotope content), determined fibre qualities, and identified dyes. The cemeteries in Lubowidz, Czarnówko and Wilkowo are all within a radius of 10 km of each other. Therefore, they form a complex of neighbouring and contemporary necropolises. It thus became possible to identify patterns of use and distribution of textile tools in burial equipment. Does it indicate the existence of a specialised group of people professionally involved in textile activities?

## Research material and preliminary results

A total of 770 textile fragments were examined. Most of the textiles discovered in Czarnówko, Lubowidz and Wilkowo were made from sheep's wool. Only in 12 fragments was the raw material identified as plant fibre, probably flax. This collection is dominated by fabrics in a 2/2 twill weave, as in all Wielbark culture cemeteries where fabrics were discovered (Maik 2012, 109) (fig. 1). There are also 2/2 twill spin-patterned fabrics (mainly 4z4s in both systems) and less numerous textiles in diamond, herringbone, and tabby weave, as well as cords/fringes and selvages made in tablet weave. However, given the considerable fragmentation of the material, the percentage of fabric of each type may have been somewhat different. Fabrics from cemeteries under study are, therefore, in line with the general trend in textile production prevailing in Europe at that time (Bender Jørgensen 1988, 1992; Maik 2012).

Selected fragments from the Czarnówko cemetery (ten samples) were sent for strontium isotope analyses, comparing ratios between  $^{87}\text{Sr}$  and  $^{86}\text{Sr}$ . The wool in the fabrics from the eight samples is likely to come from areas of northern Poland, thus indicating a local origin. However, the strontium isotope content of the fabrics from grave numbers 1458/10 and 1802/15 is much higher than in the other samples. The non-local

origin of these fragments is evident, but their exact origin cannot be determined with certainty. The author of the analysis is very cautious in pointing to the area of central Scandinavia as one of the possible areas of their origin. Thus, in the fabrics examined, nothing indicates 'southern' imports.

For five fabric samples, dye tests were carried out using the technique of ultra-performance liquid chromatography coupled with mass spectrometry (UPLC-MS). No dyes were detected in one fabric sample only (grave number 1458/10). In two samples, from graves R406/99 and 1495/12, alizarin, rubiadin and purpurin were identified, i.e. the dye compounds that are found in madder (Eastaugh et al. 2004, 244; Hofmann-de Keijzer et al. 2013, 147; Bystry 2019, 182). Alizarin was also detected in fabric fragments from graves R374/96 and 1802/15, although it was the only dye substance preserved there in these cases. It is assumed with a high degree of probability that these fabrics were dyed in red or its derivatives obtained from madder roots.

A series of microphotographs of the fabric surface using scanning electron microscopy (SEM) techniques were also taken for ten selected fragments from Czarnówko. These photographs showed that, in some samples, there had been significant degradation of

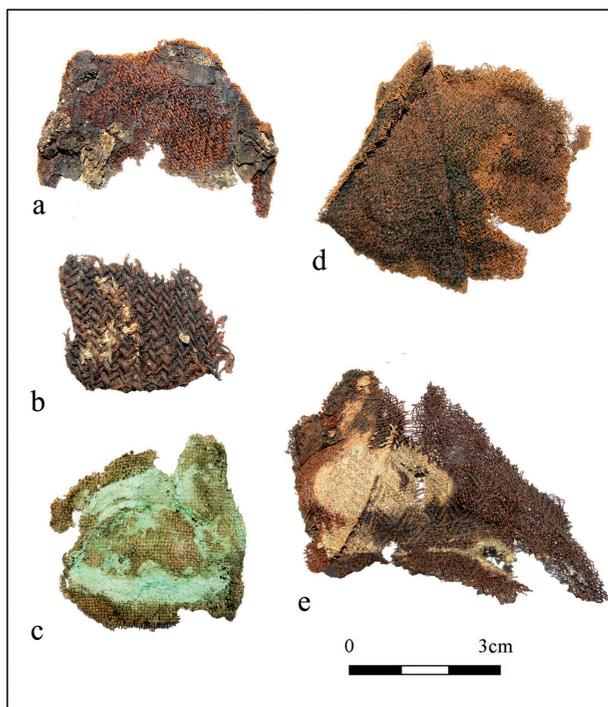


Fig. 1: Selected textiles from the cemetery in Czarnówko: a, b – 2/2 twill weave (wool); c – tabby weave (linen); d – 2/2 twill weave, spin-patterned 4s4z (wool); e – diamond weave (wool) (Images: Magdalena Przymorska-Sztuczka)

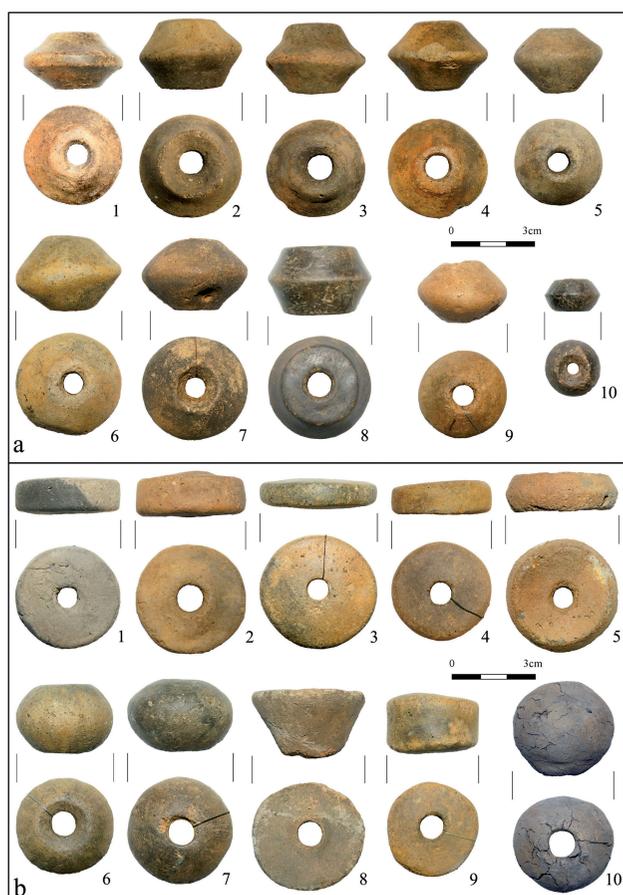


Fig. 2: Selected spindle whorls from cemeteries in Czarnówko, Lubowidz and Wilkowo: a – biconical; b – discoid (1–5), ovoid (6–7), conical (8), cylindrical (9), spherical (10) (Images: Magdalena Przymorska-Sztuczka)

the fibre surface, depriving the fibres of the scales characteristic of wool. In eight samples, the average thickness of the individual fibres was approximately 18.5 µm. In contrast, in the two remaining samples (from graves 530/09 and 1497/12), the average was approximately 25 µm. Therefore, the raw material used for these textiles was very high quality compared to earlier periods (Słomska and Antosik 2020, 128). The fabric quality remained consistently high throughout the Roman period in Poland (Maik 1988, 103–105).

Spindle whorls were the most numerous category of textile-related tools discovered in the analysed cemeteries. A total of 356 specimens were found during the excavations – 282 in Czarnówko, 35 in Lubowidz, and 39 in Wilkowo. These differences are due to the number of burials discovered at these sites (Wilkowo: 201 graves, Lubowidz: 308, Czarnówko: 1,730). The most numerous were biconical spindle whorls (fig. 2a). They accounted for approximately 80% of the total collection (fig. 3a). It is quite a diverse

group of artefacts. Some have slightly concave or flat bases. There are also differences in how the largest diameter is shaped, the curve of which can be sharply or gently profiled. This type predominated at each cemetery under study and became the leading type for the entire Roman period (Przymorska-Sztuczka in preparation). Discoid spindle whorls ranked second in terms of quantity (fig. 2b: 1–5). They are also the most homogeneous. The vast majority were between 3.0 and 4.5 centimetres in diameter and mostly about 1 centimetre high. The weight, however, varied more – mostly oscillating between 15 and 30 g. A few of the whorls in this group have a sharp curve on their largest diameter, which gives them a slightly biconical cross-section (fig. 2b: 5). There were also specimens made of sandstone in this group. The ovoid spindle whorls were less common (fig. 2b: 6, 7). Other types, such as conical, cylindrical, and spherical, occurred only marginally (fig. 2b: 8–10). In the studied assemblage, spindle whorls weighing between 15 and 25 g were the most numerous (fig. 3b). Nevertheless, there is a wide variation in weight and diameter parameters across the groups, irrespective of the shape of the whorls (table 1).

Some attention should be given to the manufacture of spindle whorls. This collection contains carefully made specimens, especially for biconical whorls. They often have a sharp, well-defined curve. At the same time, however, there are asymmetrically made artefacts with a biconical cross-section on one side and an oval cross-section on the other. Some of these tools were probably made by people who were already highly experienced in the craft, while the more irregular specimens may have been made by beginners. A small group of tools also held traces of use. These were generally chipping

Type of spindle whorl	Average diameter [cm] (min.-max.)	Average weight [g] (min.-max.)
Discoid (N=35)	3,65 (2,10–4,50)	19,84 (4,15–44,00)
Cylindrical (N=10)	2,77 cm (1,90–3,50)	15,33 (5,96–24,10)
Conical concave (N=1)	4,10	15,63
Conical (N=9)	3,89 (2,80–5,00)	23,48 (15,45–38,38)
Biconical (N=267)	3,31 cm (1,70–4,70)	20,92 (2,67–43,93)
Ovoid (N=29)	3,20 (2,30–4,00)	19,30 (6,34–36,34)
Spherical (N=3)	3,43 cm (3,40–3,50)	32,17 (26,64–36,71)

Table 1: Average weight and diameter of particular types of spindle whorls

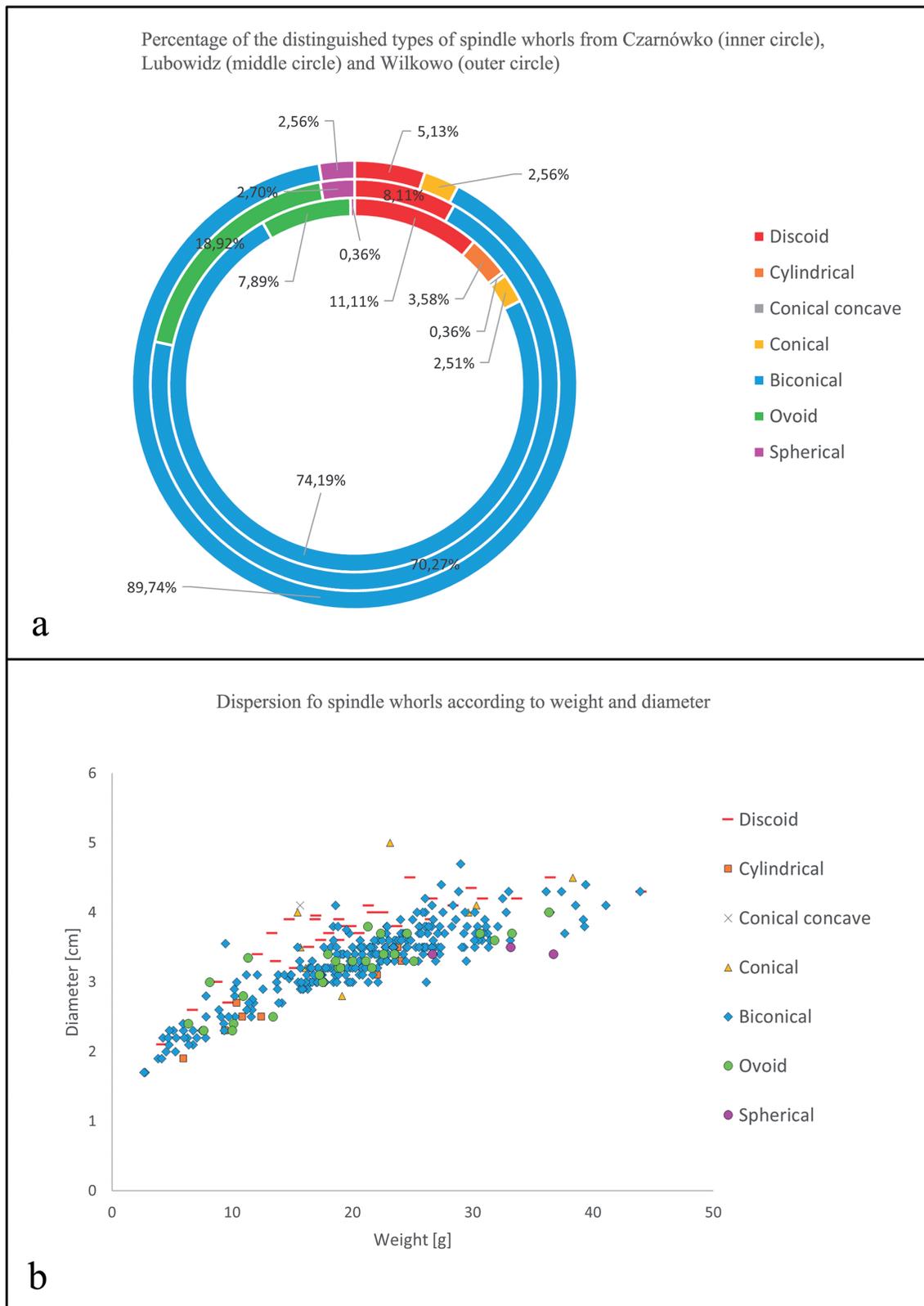


Fig. 3: Percentage of spindle whorls types in the studied collection (a) and dispersion of whorls according to weight and diameter (b) (Images: Magdalena Przymorska-Sztuczka)



on the edges and at the hole (fig. 2a: 4, 7), occurring when the spun thread breaks and the spindle hits a hard surface. However, it is essential to note that some of these traces may have happened in other ways, such as during storage or post-deposition processes.

Needles were the second most numerous category of artefacts related to the textile economy discovered in the cemeteries in the study area (fig. 4a). A total of 106 specimens were found in the graves. This collection included objects made of copper alloys (90) and iron (16). Among the copper alloy specimens, 7 to 8 cm long items predominate. Most have a slightly flattened eyelet with a groove to facilitate threading. Some needles, however, do not have this feature. The different ways of producing the eyelet suggest that needles were manufactured in more or less specialised workshops. Despite their smaller numbers, the artefacts made of iron were more varied – the specimens between 8 and 9.5 cm predominate. However, a more significant

proportion of artefacts between 13 and 15 cm exist. Thus, needles are divided into two groups: slender and shorter specimens, mostly made of copper alloys, and larger objects made of iron.

Hooks, which originally were parts of spindles, first appeared in Polish territory in the pre-Roman period (Stącel 2021, 106). Forty-five spindle hooks were found in the archaeological material from the cemeteries under study (fig. 4b). All of them are made of a copper alloy wire, except for one object made of iron. Two types were distinguished: Group 1 comprises specimens with a twisted shank, while Group 2 comprises those with a plain shank. A further division considers their material: subtype A – hooks made of copper alloys, B – of iron. Because hooks were usually made of a wire 1 to 2 mm thick, we often deal with broken specimens, of which either the bent part or a fragment of the shank has survived. The length of the fully preserved spindle hooks in the analysed assemblage ranges from

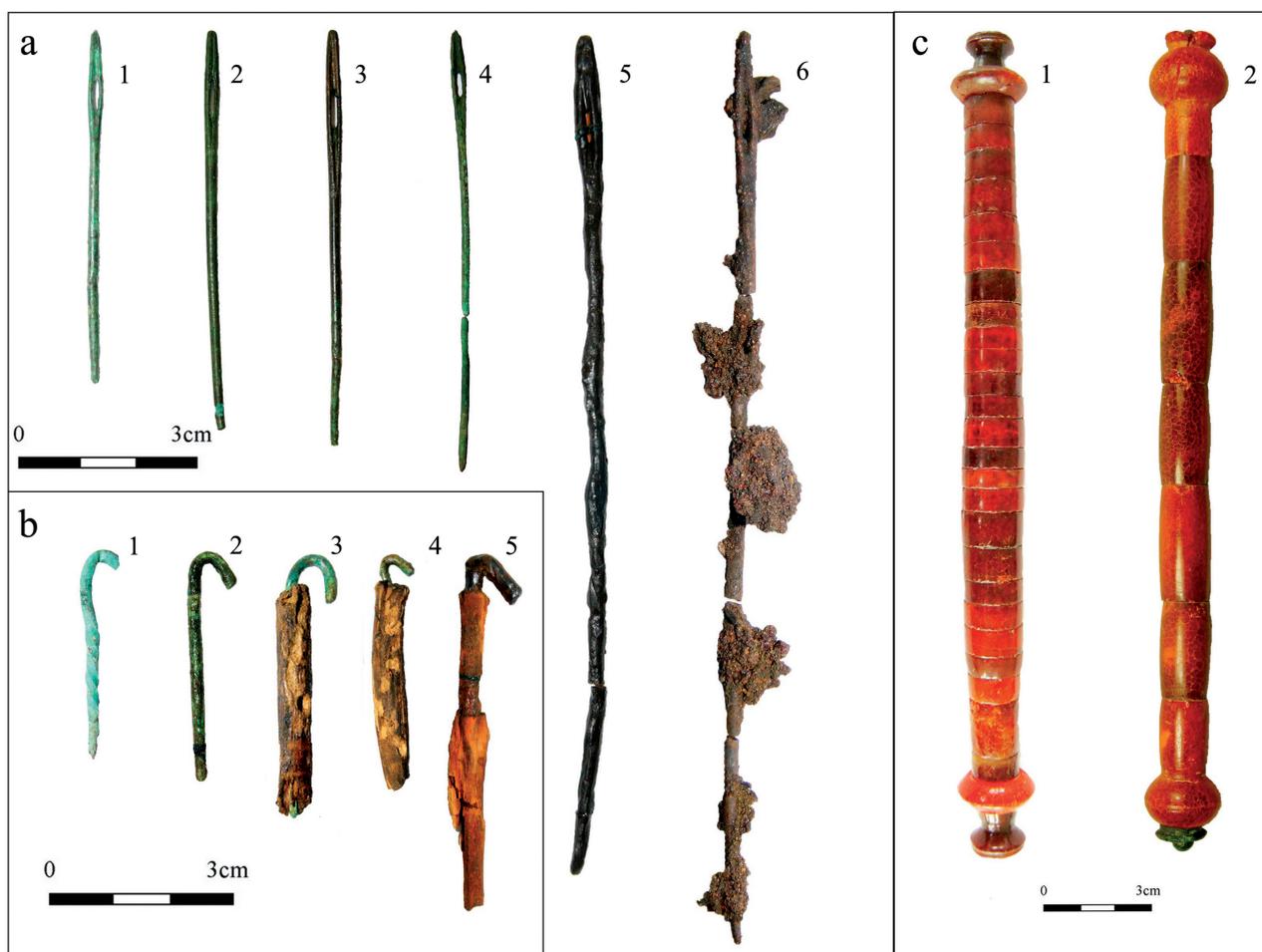
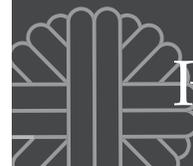


Fig. 4: Other textile-related tools discovered in cemeteries in Czarnówko, Lubowidz and Wilkowo: a – needles; b – hooks; c – distaffs (Images: Magdalena Przymorska-Sztuczka)



approximately 3 to 4.5 cm. The predominant specimens are those with a twisted shank. Five specimens show signs of use in the form of a groove on the bend of the hook. These have been formed by the spun thread rubbing against the surface of the copper alloy hook. A dozen hooks have the remains of a wooden shaft. These remains adhered to the part of the hook shank that was screwed into the spindle. Some wooden fragments are preserved enough that it was possible to measure their diameter: it varied between 5 and 8 mm, but they were probably slightly bigger, given some wood shrinkage. Unfortunately, the species of tree from which the spindle shafts were made was not determined.

The least numerous textile-related tools were distaffs (fig. 4c). Only two intact artefacts and one copper alloy element were discovered, the last being probably the end of a distaff. Both specimens were made of amber beads strung on a bronze rod. The distaff from Lubowidz has a total length of 22.7 cm. It consists of seven amber elements, while the specimen from Czarnówko is 22.5 cm long and made of 29 beads. It is difficult to determine today whether the distaffs discovered in the Czarnówko and Lubowidz cemeteries were merely an expression of the high status of the women buried with them or whether they were used in the spinning process. Based on the author's experience, spinning thread using such a distaff is very effective – the electrostatic properties of amber cause the fibres to stick to the tool. Therefore, the selection of a luxurious raw material like amber does not exclude the effective use of these objects as tools.

## Conclusions

The data acquired, although limited, allowed the capture of many aspects of textile production. The high quality of the threads and the high density of some fabrics (even 20-25 threads per 1 cm) suggest that professionals were involved in at least parts of the production. The analyses indicate that most textiles were produced locally, and some were dyed. Cross-referencing tools and archaeological information made it possible to compare the frequency of burial equipment with textiles and/or textile tools and to identify the correlations between their components. Among the 2,200+ burials from the three cemeteries included in the study, 375 were equipped with at least one category of textile-related tools. The cemetery in Czarnówko stands out from the other contemporary necropolises in Lubowidz and Wilkowo. Of approximately 1,730 graves discovered there, at least one tool category

was found in 291. This implies that about 17% of the burials were equipped with some textile-related tools. The percentage of graves in the other smaller cemeteries varies slightly. For Wilkowo, it is about 20%, while in Lubowidz, it is somewhat more than 14%. A similar situation is also found in other cemeteries of the Wielbark culture population, such as Kowalewko (about 17%) or Weklice (about 15%). Of course, with this type of calculation, it should be considered that some of the graves and their equipment may have been destroyed, providing only a partial picture. Unfortunately, in many cases, human remains were preserved in poor condition. The sex of the individuals was mainly determined based on archaeological gender markers, such as jewellery (bracelets and necklaces), spurs, and textile tools. However, where it was possible to determine the sex of the deceased anthropologically, most textile tools belonged to female burials.

The research results presented here, although obtained for only three cemeteries, are of considerable importance for studying changes in textile production in Poland during prehistory. The broad approach of the project aims to undertake is the most comprehensive, source-based and experimentally justified reconstruction of different aspects of the textile industry of the Wielbark Culture. Both the tools and the remains of fabrics preserved in the graves provide a unique opportunity to conduct extensive, interdisciplinary research on the production and use of textiles in Poland during the Roman period.

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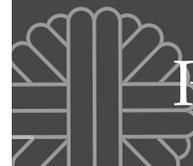
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Luise Ørsted Scharff Brandt

# Imported fur in Viking Age Denmark and its importance as a visual marker

## Introduction

Extensive international trade and exchange of goods is one of the major characteristics of the Viking Age, the final era of the Scandinavian Late Iron Age (800-1050 CE) (Roesdahl 1998; Brink and Price 2008). Because contemporary Arab written sources frequently mention fur traded by the Vikings, it has been seen as one of their key commodities. The records describe how species such as arctic fox, beaver, marten, ermine, and sable were hunted in current day northern Scandinavia and Russia and brought by the eastern Vikings (Rus) via the Russian rivers to the growing Arab fur market in exchange for beads, silver, gold and silk (Kovalev 2001; Vedeler 2014). An example of the economic value and signalling power of fur traded by the Rus is given by the Arab traveller, geographer, and historian al-Mas'ūdī, from Baghdad, who wrote in 943 CE: "The black furs are worn by Arab and non-Arab kings... There is no king who does not possess a fur coat or a caftan lined with the black fox fur of the Burtās" (Martin 1986; Fadlan 2012). The value of fur as a visual marker of status is also mentioned by a ninth century European source about the Frankish king Charlemagne: "... he protected his shoulders and chest in winter by a close-fitting coat of otter or marten" (Turner 1880). While the significance of imported fur for the Arab and continental European market is well-described, the quantity and use of fur as a visual marker in Scandinavian homelands – Denmark, Norway, and Sweden – has never been researched in depths and is thus still poorly understood. This project aims to explore that.

Fur and its procurement in Scandinavia has been notoriously difficult to study: the only Scandinavian written sources to Viking fur and fur trade are centuries

later (Sturluson 1889; Adam of Bremen 2000), iconography depicting clothed figures is scarce and stylised (Manning 2016; Vedeler 2019), and zooarchaeological evidence (Wigh 1998) does not reveal the provenance and use of furs. Furthermore, in archaeological contexts, fur usually degrades rapidly.

However, in rare cases, Scandinavian fur has been preserved and recorded (Bender Jørgensen 1986; Ågren 1995). If preserved, a serious obstacle in fur studies is species identification (Rast-Eicher 2016). Fibre identification by microscopy is extremely difficult and often provides erroneous results (Brandt et al. 2014; Sinding et al. 2015). DNA often does not survive in archaeological contexts, and thus analysis of the more robust proteins has lately become the preferred method for identification of fur (Hollemeier, Altmeyer and Heinze 2008; Hollemeier et al. 2012). The first proteomic identification of beaver fur in elite Viking Age Danish burials was by Brandt et al. 2022). As beaver was not native to Denmark, this is also the first direct evidence that fur was in fact imported into Denmark during this period. Using proteomics, five examples of non-native beaver fur were identified in high status burials, as well as squirrel and marten fur. The beaver fur was most likely used as clothing (fig. 1) and thus suggests that Danish Vikings used luxury fur as visible markers of status. The study also highlighted four gaps in current knowledge, which need to be addressed to fully understand the extent of the Danish fur trade and its role.

## Four gaps in knowledge of fur in Danish Viking Age

First and surprisingly, there is no overview of the extent of Viking Age fur in Denmark or Scandinavia as a whole, and no systematic examination of contexts for fur has yet been performed. Currently, fur has mainly



Fig. 1. Part of a garment with tablet woven-bands and fur from Hvilehøj (NM C4280) (Image: Roberto Fortuna, National Museum of Denmark)

been recorded in elite contexts, and even then it is only described briefly or in footnotes (Bender Jørgensen 1986; Iversen, Näsman and Vellev 1991; Sørensen 2001) with a few, recent exceptions (Mannering 2015 and 2018). Therefore, the extent of Danish Viking Age fur is unknown. Fur may have been degraded, not acknowledged or registered during excavation, or actually absent.

Secondly, we lack knowledge of the diversity of the species that were used for fur. In order to be able to identify fur, proteomic methods and databases need updates. The successful biomolecular identification of species depends on 1) preservation and successful extraction of biomolecules; and 2) on the accessibility of suitable references. In this study (Brandt et al. 2022), key deficiencies in proteome databases were highlighted: currently, several candidate species such as squirrel and otter (Martin 1986; Fadlan 2012) are not available in proteome databases and this limits the ability for complete confidence in the species identification, as species not present in the databases cannot be completely ruled out. As an example, one sample was misidentified as beaver until translation of DNA nucleotide sequences for keratin proteins allowed more potential species to be searched and

led to a final identification as squirrel. Therefore, new species references are required to clarify the range of species utilised.

Thirdly, in most cases, it is not clear if furs are local or non-local. Although at least one non-local species was identified (Brandt et al. 2022), it was not possible to identify its provenance and speculate on the route/s through which it was traded. At the same time, the possibly native squirrel and marten fur could have been imported from distant subpopulations with finer coats. Genomic DNA sequences could have revealed population structure and mapped ancient individuals to geographical regions. In the study, this failed due to poor DNA preservation whereas proteomics allowed a robust identification of species, but with lower resolution not allowing for population structure. New methods are therefore needed to characterise fur as local or non-local and to explore the possibilities of identifying their provenance.

Fourth and finally, there is a lack of understanding of the prestige of fur. In previous research (Brandt et al. 2022), Danish Viking Age fur from wild animals was most likely associated with clothing and not furnishing or accessories (the Swedish picture may



differ, Malmius 2020). It thus seems that fur was mainly used for display (fig. 2). On the contrary, it has been shown that dehaired, tanned skins (leather) were used for everyday objects such as straps, armour, and shoes, and came from domesticated species (Warming et al. 2016; Brandt, Ebsen and Haase 2020; Brandt and Mannering 2021) (fig. 3). To understand if the fur of wild species were generally used for clothing and display, and by whom, a systematic analysis of a larger material corpora is crucial.

### The goals and purposes of the project

By tackling the above four scientific challenges, the project aims to answer to what extent Denmark and Scandinavia were part of the international fur trade and shared ideas of visual status markers. This will be achieved through four distinct, though complementary, objectives:

- 1) Locate and register Viking Age burials with fur and examine the use and context of fur;
- 2) Use proteomic methods and references to identify the species of Viking Age fur;
- 3) Conduct a pilot study to test  $\delta^{13}\text{C}$ :  $\delta^{15}\text{N}$ :  $\delta^{34}\text{S}$  analysis as a tool for characterisation of fur as local or non-local and to explore its potential to identify provenance; and
- 4) Determine if fur was a visual marker of status in Viking Age Denmark.

### Locating Viking Age fur

The project will focus on Danish material from the ninth to the tenth century. Decreasing preservation conditions due to intensified cultivation, ploughing, and drainage of the arable land make new finds of organic materials unsuited for biomolecular research. The failure to extract proteins from fur from the recently excavated Fregerslev grave (Bagge and Hertz 2017) is an example of this. Finds excavated a century ago have experienced less degradation and provide successful biomolecular analysis (Brandt and Mannering 2021; Brandt et al. 2022). Therefore, this project focuses primarily on the rich archive of material in museum collections.

Preliminary examinations of the collections at the National Museum of Denmark (Brandt and Mannering 2021; Brandt et al. 2022) showed that fur was present in burials with no records of it. This project therefore hypothesises that a systematic review of Danish Viking Age burials will reveal a number of fur finds that have never been registered. The collection at the National Museum of Denmark contains at least 149 Viking Age burials with preserved textiles or textile imprints (Bender Jørgensen 1986), indicating



Fig. 2 Garments found in the burial mounds of Bjerringhøj and Hvilehøj reconstructed through the project *Fashioning the Viking Age* (Image: Roberto Fortuna, National Museum of Denmark)

good preservation of organic materials and thus possibly fur. The finds have never been systematically examined for the presence of fur. Northern European trends are studied through visits to three well-known collections: Birka, Sweden (Geijer 1938; 1980; Hägg 1974; 1986), Oseberg, Norway (Christensen, Ingstad and Myhre 1992; Christensen and Nockert 2006), and Hedeby and surrounding chamber graves, Germany (Müller-Wille 1976; Eisenschmidt 1994; Arents and Eisenschmidt 2010; Pedersen 2014).

### An interdisciplinary project

Finds are systematically examined for the presence or absence of fur and documented in terms of preservation conditions. Because graves are selected based on the preservation of textiles, their status can be evaluated based on status markers in clothing, and also grave construction and grave goods, and the 149 selected graves vary considerably in terms of these parameters (Bender Jørgensen 1986). The general correlation between finds of fur, preservation



conditions, and status is discussed to understand if fur is only found in elite graves.

We aim to identify the animal species of fur finds based on optimised proteomic methods including protein sequencing (LC-MS/MS) and peptide mass fingerprinting (PMF) and to expand the protein reference databases by de novo sequencing with species such as squirrel and otter, which are currently not part of the database.

This project also characterises fur as local or non-local and explores possible isotopic clustering of animals that share similar isotope ecologies. Analyses of strontium, carbon and nitrogen isotopes are widely applied to bone and teeth for respectively provenancing and exploring trophic levels, whereas

tissues such as fur and hair are much less studied. The  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios of hair have been shown to inaccurately reflect its provenance due to exchange of Sr with the surrounding environment (von Holstein et al. 2015; Hu et al. 2020; Toxvaerd 2020) and currently the accuracy of Sr baselines is debated (Thomsen and Andreasen 2019; Price 2021).  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  display larger variation between seasons than between the regions of interest (northern Europe and western Russia) (George Darling et al. 2006) and furthermore samples can exchange O with atmospheric water (Holstein et al. 2018). In this project, provenance is explored based on  $\delta^{13}\text{C}$ :  $\delta^{15}\text{N}$ :  $\delta^{34}\text{S}$ , which are all abundant in fur. C and N are well established for diet and can aid provenancing in combination with other isotopes. Sulphur is particularly promising based on a new sulphur isoscape of Europe demonstrating variations in Scandinavia (Bataille et al. 2021), and new unpublished data of variation in the UK suggests that animals hunted in low lying wet areas would be very distinctive.

Based on the evidence from these analyses, a qualitative and comparative analysis of the fur finds and their contexts will be performed, focusing on the evidence of fur being part of clothing and the status of the deceased, the species of fur, and its isotope ecology. Based on this analysis, it will be possible to compare the identified Danish burial contexts with fur with sources about the use of fur in continental Europe and in the Arab world (Hägg 2003; Fadlan 2012) and discuss the possibility of an internationally shared symbolism of luxury fur in clothing.

The project pushes state-of-the-art research by documenting the Viking Age fur trade from tangible archaeological material: it provides the first large-scale systematic documentation of fur in Denmark and characterises it in terms of species and isotope-signature. The project creates a new interpretative framework revealing the (international) role of fur as a visual marker of status and its probable visual effect to legitimise power nationally, but also in an international political setting, as a shared symbol of power during travels, trade, raid, and negotiations. The project develops proteomic methods and references for the candidate fur bearing animal species, for the benefit of the entire proteomics field as well as test isotopic analysis as a tool for studying the origin of fur.

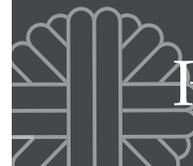
The project is expected to run from 1 September 2024 to 31 April 2028.

#### Acknowledgements

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Fig. 3. Part of a pair of female one-piece shoes from Hvilehøj, Denmark (NM C4281 A) made of goat skin (Image: Roberto Fortuna, National Museum of Denmark)



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Charlotte Rimstad

# Female dress in the Late Viking Age

## Introduction

The interest in the Viking Age (circa 800 to 1050 CE) is immense today and the demand for knowledge of clothing from the period seems to be ever growing. In the Early Viking Age, the women in Scandinavia wore dresses attached to oval brooches, however in the later part of the period these brooches suddenly disappear in the archaeological material, meaning that a new dress type must have been used. Why this change happened and how the new style looked are central questions in the project *Female Dress in the Late Viking Age*, based at the National Museum of Denmark. The duration of the project is ten months and it is funded by the Ministry of Culture, Denmark. The principal investigator is Charlotte Rimstad with Ulla Mannering as a close collaborator.

## The grave from Hørning Church

In the Late Germanic Iron Age there was a shift from wearing smaller fibulae on the shoulder to wearing oval brooches further down on the chest (Jørgensen and Jørgensen 1997, 59). Knowledge about the well-known suspended, or apron dress as it is often called, is based on finds of these oval brooches and textiles from graves (Hägg 1974; Bau 1981; Lønborg 1993; 1999). The brooches often contain straps that held the dress together, but whether it was actually a dress with suspenders or perhaps just a development of the Iron Age peplos dress still remains to be investigated. Regardless of the dress type, the oval brooches suddenly disappear in the Danish grave contexts of the Late Viking Age, meaning that women were wearing different styles from then on. The project *Female Dress in the Late Viking Age* will thus focus on the following research questions:

- What did the female dress look like in the Late Viking Age?

- Why was there a change in the way dress was constructed?
- Which decorative elements were part of the elite female outfit?
- What did the female dress look like in the rest of Europe and how were the garments related?

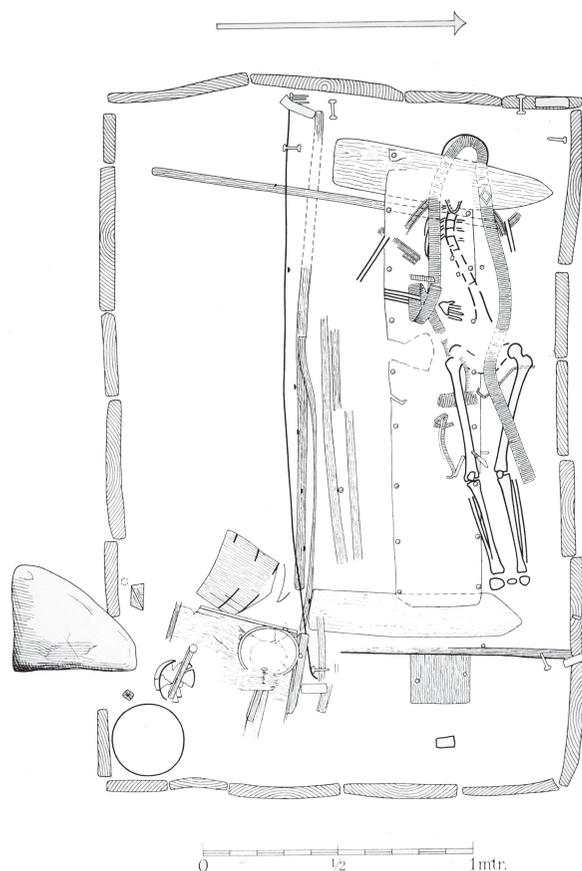


Fig. 1: Overview of grave A from Hørning Church (Illustration after Krogh and Voss 1961, 25)



Fig. 2: Fragment of a tabby-woven wool textile next to a tablet-woven band from grave A. (Photo: Charlotte Rimstad)

In order to shed light on the new type of dress, several Danish high-status female graves will be studied. The project takes its starting point in grave A from Hørning Church, near Randers in Jutland. This grave was excavated in 1960 during a renovation of the church floor and while the standing church was elevated in the 1100s, the excavation found traces of an older wooden stave church beneath the floor (Krogh and Voss 1961; Voss 1991). At the centre of the church, a female chamber grave was found, dated to around 1000 CE (fig. 1). The stratigraphy showed that the female had at first been buried beneath a turf mound, which had later been removed for the wooden church to be built on top of her grave. The woman must have been of great importance, and the building of the church seems to have included her in the transition from Norse religion to Christianity.

The woman had been buried in a wagon bed and her bones were poorly preserved, with only a few long bones and the lower jaw present. The grave also contained other interesting items, such as a small table with a bronze bowl on it, probably a small washing table, as well as a wooden bucket, a ceramic vessel, two whetstones and five beads. Despite the poor preservation of the woman herself, it was clear that she had been wearing an outfit with at least five brocaded tablet-woven bands of silk and silver (fig. 2). The warp threads are of silk as well as a now disintegrated plant fibre, probably flax (Hedeager Krag and Ræder

Knudsen 1999). The weft threads are of silver, sometimes with the silk warp being pulled forward on top of the silver thread, creating geometrical patterns. The smallest band is merely 0.8 cm wide, whereas the largest band was originally about 5 cm wide and 2.5 metres long. It was observed going from the woman's forehead, along the shoulders and down to the legs, as if it had adorned a veil. The other bands were narrower and had clearly been placed on the sleeves elsewhere on the woman's outfit. There were also remains of wool textiles, such as a gauze tabby weave connecting to some of the tablet-woven bands as well as a fine 2/1 wool twill. The project will carry out new analyses of the textiles, especially of the tablet-woven bands and their contexts, conducted by weaver Marie Wallenberg. Remnants of fur were found underneath some of the fragments and species identification analyses will be done in collaboration with the project *Imported fur in Viking Age Denmark and its importance as visual marker*, led by Luise Ørsted Scharff Brandt (see project description in this volume). Moreover, dye and fibre analyses as well as radiocarbon dating will be included (Vanden Berghe et al. 2023; Skals et al. 2024). The dye analyses will be performed in collaboration with the *Textile Colours of the Viking Age* project, led by Ulla Mannering (see project description in this volume).

#### Comparative material

The grave from Hørning Church will be compared to other similar graves containing these elaborate bands from the same area. One example is the Hvilehøj grave, also near Randers, dated to the late tenth century, which had a tablet-woven band of blue silk threads, silver and gold and several other silk bands attached to a fur garment (Mannering and Rimstad 2023a). Similarly, the female graves from Fløjstrup, Fyrkat grave 4, and Fårup contain similar delicate bands, even if also poorly preserved. The Fløjstrup grave, dated to the ninth century contained remnants of a small, blue band of silk samite and is the oldest find of silk in Denmark (Rimstad et al. 2024). From the Fyrkat grave, dated to the tenth century, the famous "vølv" grave, a whole block is preserved, still with the lower jaw in situ. The X-ray shows how the tablet-woven band was placed in the neck region, perhaps edging a neck opening (Mannering and Rimstad 2023b). The Fårup grave, similarly from the tenth century, contained a band found to the right of the buried woman (Brøndsted 1936, 107–108).

All these finds suggest that there was a female elite in the area of mid-Jutland in the late ninth and tenth century, all displaying elaborate materials of silk, gold,



silver and expensive dyes. Such tablet-woven bands with precious metals are not found in Denmark before this era, so why do they suddenly appear? In the years 800–1200, Byzantine fashion influenced all of Europe and it is an obvious thought that it also reached the outskirts of the continent. It has been suggested that this type of dress was a certain Christian fashion, which came to Denmark in these first years of Christianity (Hägg 1991; Hedeager Krag 2003). However, the tablet-woven bands are part of a very Nordic tradition, making it likely that only the materials and perhaps the very idea of the new fashion travelled, whereas the bands themselves were locally produced. Regardless of whether these women saw themselves as Christian or not, they clearly had international connections, as neither silk, silver or gold are found in Denmark, and an important aspect of the project is therefore to compare these graves to the iconographic and written sources available from the rest of Europe. The project thus seeks to answer questions about the development of garments, production, import and identity in the last part of the Viking Age. It will nuance the knowledge of women in this period, where research has traditionally concentrated on the role of male power in the formation of state, towns and religion in Denmark (see, for example, Krogh and Leth-Larsen 2007; Christensen et al. 2021; Sindbæk 2022). This project will demonstrate the empowerment of women and their long-distance connections through more subtle means such as garments and decoration.

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Ulla Mannering

# Textile colours of the Viking Age (TeCoVa)

## Introduction

The *Textile Colours of the Viking Age* project 2024–2028, will examine how colours were used in clothing and cloth culture in general, and how colours were produced, perceived and understood within the social and cultural contexts of the Danish Late Iron and Viking Ages (600–1100 CE).

It has already been shown that the use of textile plant dyes began at the beginning of the Iron Age (circa 500 BCE) when dyeing technology was integrated into Scandinavian textile design. Traces of organic dyes, primarily of yellow and more rarely blue and red, are documented as the first appearance of plant-dyed textile colours (Vanden Berghe et al. 2009; Demant et al. 2021; Mannering et al. 2024) (fig. 1).

By the Late Iron and Viking Ages, on the other hand, textile colours were well-integrated into cloth culture, but basic and systematic knowledge about exact colour schemes and dyeing techniques is lacking. The current understanding of textile colours in this period is largely based on a few studies from the 1980s and 1990s, conducted at a time when the methodology was still being developed (Bender Jørgensen and Walton 1987; Walton 1990; 1991). These early and scattered research results, primarily taken from high-status contexts, have long been used to generalise about Scandinavian visual appearance in the Viking Age, suggesting, for instance, that Dubliners preferred purple, while people in England preferred red and Scandinavians favoured blue colours (Walton 1989). More recently, systematic dye analyses conducted within the *Fashioning the Viking Age* project (2018–2023) of all the textiles preserved from the two high-status contexts, the Bjerringhøj male grave and the Hvilehøj female grave in Denmark (Mannering 2018; Mannering and Rimstad 2023), have identified less frequent and

more exotic dye substances such as luteolin yellow, madder, kermes and Polish cochineal, indicating that other colours than blue played a significant part in local Scandinavian textile production and clothing design (Vanden Berghe et al. 2023) (fig. 2). Colours were being used by elites (and presumably others) in complex ways—why?

It is thus time to update the present understanding of Late Iron and Viking Age textile colours, including the use of natural wool hues. Wool pigmentation and the use of fibre colours in textiles is a method as old as weaving technology in Denmark and was continuously used in textile design from at least the onset of the Bronze Age, sometimes even combined with plant dyes (Frei et al. 2017). For instance, in the Early Iron Age, wool colours were used in combination with plant dyes as a different and possibly resource-saving technique that could easily change the visual perception of fibre colours (Mannering 2011; Vajanto 2015). Analyses of wool fibre quality have shown that



Fig. 1: Plant dyed yarns at Lands of Legends in Lejre, Denmark (Image: Charlotte Rimstad)



Scandinavian prehistoric sheep breeds most likely developed independently from other European breeds (Grömer et al. 2013; Rast-Eicher and Bender Jørgensen 2013; Skals and Mannering 2014; Bender Jørgensen and Rast-Eicher 2016; Larsson et al. 2024; Skals et al. 2024a). Although white wool seems to be preferred for many textiles in the Late Iron Age, because they are more receptive to plant dyes, wool colours nevertheless seem to gain an increased use in the Viking Age (Skals et al. 2024b). For this reason, wool quality and colours will also play an important role in the current project, and a necessary aspect to investigate to fully understand Late Iron Age and Viking Age colour schemes.

Textile colours from natural wool pigments or plants, however, never occur in isolation. Just like pigments in paints (Bregnhøi and Christensen 2017), bead colours and Old Norse colour terms in Icelandic texts dated after the Viking Age, are important sources that can be used to study the overall world of colours (Thedéen 2010; Crawford 2014; Biggam and Wolf 2022). Necklace beads and other metal jewellery provide ideal means for such an examination. During the Late Iron and Viking Ages, jewellery and beads were closely linked to clothing and in direct conversation with textile colours. But unlike textiles, beads are made from materials that often retain their original colours (fig. 3). In a more direct way, they preserve evidence for preferred colour combinations and changing preferences, providing a new basis for studying habits of harmony or contrast and their effects. Late Iron Age beads have been studied before (Høilund Nielsen 1997) while bead colours of later periods remain poorly understood (Callmer 1977) and have primarily been studied through single, local contexts (Hreiðarsdóttir 2005; Callmer 2006; Delvaux 2018; 2022). Beads and jewellery thus offer an important opportunity for interpreting the Late Iron Age and Viking Age colour palette, but just as in the case of textiles and fibre materials, new work must first be undertaken.

### Project plan

The *Textile Colours of the Viking Age* project thus targets colour production, perception, conception, use, and change, and focuses on the following research questions:

- Which colours, organic and inorganic, were available in the Late Iron and Viking Ages? How

Fig. 2: Patterned and coloured silk samite found in the male grave from Bjerringhøj in Denmark dated to the Viking Age (Image: Roberto Fortuna)





Fig. 3: Some of the beads found in the female grave from Hvilkehøj in Denmark dated to the Viking Age (Image: Roberto Fortuna)

were they made and used?

- How did textile colours articulate gender, age, and status in material and textual sources?
- How did the visual appearance of textiles, beads and jewellery colours supplement each other?
- Do these new results change our perception of the visual appearance of Viking Age people?

In the project, textile samples are selected from a range of male and female graves belonging to the National Museum of Denmark, other Danish local museums and a selected range of Nordic museums with contemporary textile collections, which, first and foremost, are dated to the Late Iron and Viking Ages (600–1100 CE) (Bender Jørgensen 1986). From the same contexts, beads and metal jewellery will be studied.

The TeCoVa project is thus designed as the follow-up project that will include, finalise and frame the research already started and published in the *Fashioning the Viking Age* project (Mannering 2018; 2021), the *TRiVAL* project (Andersson Strand 2022) and the *Female Dress in the Late Viking Age* project (see project description by Rimstad in this issue). The TeCoVa project will also collaborate closely with the project *Imported fur in Viking Age Denmark and its importance as visual marker* (see project description by Ørsted Scharff Brandt in this issue).

The core work will take place at the National Museum of Denmark and include up-to-date textile and fibre analyses. Ulla Mannering and Charlotte Rimstad are in

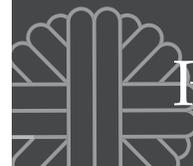
charge of the textile and context analyses while textile conservator, Asta Berenth Schunck, will be in charge of the fibre analyses that supplement the dye analyses. Dye analyses will be conducted by Ina Vanden Berghe at the KIK-IRPA Laboratory in Brussels in Belgium. Studies of beads, jewellery and literary sources will be conducted by Matthew Delvaux from Barnard College in New York, assisted by Jonas Reventlow Petersen. The student assistant is Tilde Yding Abrahamsen. Collaborators from other museums will be included and will be welcomed in the project as work progresses.

### Acknowledgements

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# DocZow: documentation of intergenerational transmission in Zoroastrian women's silk weaving

## Introduction

The DocZow project was launched in May 2024 to provide an innovative interdisciplinary approach to examining the intergenerational transmission of silk weaving as praxis and terminology through the intangible cultural heritage of Zoroastrian women. Although Iranian textiles are globally recognised for their high quality and long tradition and have therefore been studied from various perspectives, no systematic study of Zoroastrian oral sources related to weaving exists.

The project is hosted by the Centre for Textile Research (CTR), Saxo institute, University of Copenhagen. DocZow is supported by the European Union's Horizon Research and Innovation Program under the Marie Skłodowska Curie fellowship.

## Various aspects of DocZow

The first spark of research on silk weaving and the methods of intergenerational transmission of this intangible heritage began with receiving a grant (2021–2022) from the Department of Experimental Linguistics at the Goethe University in Frankfurt (Preservation and documentation of the language of Zoroastrian weavers and art of weaving). A decade ago, the head of this department produced a documentary film of a skilled Zoroastrian weaver, which showed her trying to pass on textile knowledge before her death. The Zoroastrian weaver spoke one of the 24 dialects of the Zoroastrian special language (Dari Behdini). She used textile terminology, which added to the difficulty of decoding her information, because silk weaving is the intangible heritage of Zoroastrian women, who hold a monopoly on practicing this craft. Being born in a Zoroastrian family, mastering all sub-branches of the Zoroastrian dialect, and in addition, my expertise in Iranian and Zoroastrian culture and art helped me

to extract and publish textile information from the documentary film (Pashootanzadeh 2022).

My research will be accomplished through an investigation of Zoroastrian women's silk weaving and a glossary in Dari Behdini and in English, which will include all aspects of terminology and the intergenerational transmission of silk weaving techniques.

The main policy of DocZow is based on the oral traditions and literature of Zoroastrian women, and in addition to silk and its secrets, it is related to the different characteristics of silk weavers and their audience as human beings. For this reason, this project has broad aspects that can be considered equal to the different dimensions of a human being.

## 1) Zoroastrian religion and culture

The author of the book *Silk and Religion* believes that Zoroastrianism is related to silk (Liu 2007, 24).

So, the first aspect of this research is based on the



Fig. 1: Zoroastrian women's silk dress at the Iranian Dolls and the Culture Museum (Images: Ali Golshan)



Fig. 2: Zoroastrian women's silk dress at Iranian Dolls and the Culture Museum (Image: Ali Golshan)

Zoroastrian religion, which overlaps with the symbols of Zoroastrian cultural identity.

In the Zoroastrian religion, the soul is a symbol of immortality, which is identified with the silk dress in Zoroastrian women's culture (figs. 1 and 2). Although clothes are considered the second skin of the body (Turner 1980/1993), the silk clothes of Zoroastrian women are the second skin of their souls. The reason why several Zoroastrian women's silk dresses survived until now is that the inheritance of the dress of the deceased maintains the continuation of the reincarnation chain of the second soul. This law was not true for non-silk clothes.

In its homeland, China, silk was known as the clothing of the dead leading to the ascension of the soul to heaven (Zhao 2022, 16) but among Zoroastrian women, it was always considered as the clothing of the living and as an immortal soul, which included an important part of their cultural identity. Zoroastrianism was the official religion during the Sassanid era (from 224 to 651 CE), when Chinese silk was imported to Iran through the Silk Road, and it led to the establishment of silk textile workshops inside and outside Iran. Due

to the importance of purity in the Zoroastrian religion, using silk and adding pigment to it were considered religious transgressions.

#### According to the laws of purity in Zoroastrianism:

1) Insects are impure and must be destroyed. The insects are called *xrafstra* and are created by the devil. Also, in the story of Tahmūres, which is a part of Zoroastrian religious literature, the devil teaches the method of sericulture to the wife of Tahmūres (Mazdapour 1999, 186). But the presence of the devil as a teacher of sericulture and the creator of silkworms did not stop the growth and publication of silk weaving by Zoroastrian women because of religious obstacles.

It seems that the efforts of Zoroastrian clerics to spread silkworms in the Sassanid era led to ignoring religious obstacles and making changes in Zoroastrian religious jurisprudence. First, because silkworms were spread further westward to Constantinople by Persian monks (Zhao 2022, 24) and secondly, in the *Bundahishn* book, which was compiled after *Vendidad*, silkworms and bees, whose wax is used



for silk weaving, were declared exempt from the *xrafstra* law (Bahar 1991, 99).

2) Natural dyeing and impregnating fibres with pigments leads to contamination. In addition, dyeing fabric with insect extracts such as coccus was associated with more Sharia prohibition according to *xrafstra* law (Mazdapour 2005, 257).

The jurisprudential law of living happily, which was more important than the law of cleanliness, led to the removal of legal obstacles in dyeing, and the only condition was the use of shiny and bright colours to spread the feeling of happiness. Because the rules of purity were established to maintain physical health and the rules of happiness were established for the health of the soul, which was the priority. According to Zoroastrian religious texts, Ahuramazda is a god of happiness, Zoroaster is a prophet who was born with a smile. Zoroastrians worship with gladness and believers speak happily in their prayers. Great gods and goddesses such as Mehr, Ashi, Tishtar and Anahita bring happiness to Zoroastrians, and the ultimate wish is happiness.

Therefore, silk and silk products were recognised as symbols of happiness and led to the creation of oral literature with happy themes, which is the most important feature of children's literature. Zoroastrian women weave colourful bracelets from silk threads to give as gifts during the Tirgan festival, which is meant to honour the Tishtar god. They believe that wishes live like silkworms inside these bracelets, which are a symbol of the silk cocoon, and after ten days, turn into beautiful butterflies and fly in the wind. For this reason, Zoroastrians remove these silk bracelets from their hands on the day that belongs to the Wind god and leave them to the wind to achieve their wishes. The same concept of happiness and wish fulfilment can be seen in the Zoroastrian shrine (*Seti-pir*) where women tie coloured silk threads to the water wheel in order for the water goddess Anahita to fulfil their wishes.

## 2) Oral literature and tradition

The second aspect of the DocZow project is oral history, which aims to teach the secrets of silk to Zoroastrian girls.

The oral history and tradition in Zoroastrianism has an ancient heritage. The evidence of this claim is the use of the strong oral memory of Zoroastrian priests in 300 CE, which made it possible to collect and revive the Zoroastrian encyclopaedia, *Vendidad* (Marzban 2023). The expansion of this oral memory can be found in the oral history of Zoroastrian women who teach the traditions of silk weaving in the Dari Behdini language



Fig. 3: Bibikük doll in Varjavand collection, Iran (Image: Azadeh Pashootanzadeh)

which has no other purpose than the intergenerational transmission of silk secrets to the Zoroastrian women's community. For this reason, oral language and history act as a vehicle for informal education in order to transmit oral traditions. Intergenerational transmission is key to safeguarding. The transmission of intangible cultural heritage in itself is a form of informal education that happens within communities. As such, it can provide both learning content and methods.

Zoroastrian women weavers use two informal group training methods: 1. Oral storytelling, legends and narratives for teaching theoretical information about silk weaving; and 2. The magical-symbolic theatre plays for teaching practical skills and techniques through motion spells that the audience had to imitate at the same time as the narration of legends. Theatrical movements were planned for two purposes: 1) Learning the practical steps of textile production and its repetition in the production process of silk textiles; and 2) Performing physical exercise necessary to

strengthen the muscles of the weavers. This double method changed with the industrial revolution. This not only changed the clothes and weakened the traditional weaving of Zoroastrians, it also made the narration of oral legends unimportant and lost the audience of women and girls as silk weavers. Instead, it was now the so-called “witches” or “sorcerers”, the female Zoroastrian magicians, who undertook the task of narrating the legends of silk weaving. However, the belief in the magical properties of these oral legends that accompanied the theatrical performances saved them from complete destruction. For example, the description of how the blue colour appears due to the oxidation of indigotin was assumed to be a magical practice (Tamburini 2022, 76).

The performance of puppet theatre with fabric dolls and symbolism showed the phases of silk weaving. Recycled fabrics are used to make the Bibikūk female doll (fig. 3) which is the protagonist of oral legends in magical-symbolic theatre performance that helps the audience learn the weaving methods.

But because the narrators, audience, theatre actors and puppeteers no longer know the technical complexities of silk weaving, the performers no longer understand the meaning of these oral legends. Moreover, the frequent migrations of Zoroastrian women have caused the audiences to be separated from their original cultural context and then fail to understand the concepts of oral history and meta-communications in the oral traditions related to silk weaving. Because the intergenerational transfer of silk weaving takes place through family relationships, the migration of young women led to the separation of old weavers from their female relatives and the interruption of the intergenerational transmission chain.

The oral history and tradition of silk weaving is divided into two significant narratives based on the division of duties between women/mothers and girls.

1) The serpent king (explaining the duties of married women and mothers): intermediate difficult stages (weaving, natural dyeing, painting on fabric with natural colours, implementing different techniques to produce fabrics).

2) The fairy king’s daughter (explanation of girls’ duties): initial stages (preparation of raw materials for natural dyeing, sericulture, spinning and sectional beam) and supernumerary stages (embroidery and patchwork).

“High-context” cultures rely more on nonverbal cues and gestures, and “low-context” cultures rely heavily on words and verbal communication. Due to lack of familiarity with different cultural layers, children are placed in the “low-context” group and education is done through language and educational literature. Adults are in the “high-context” category and their educational literature not only includes descriptive and cultural linguistics, but also a combination of non-verbal communication and metacommunication. The basic elements of metacommunication are mental symbols structured into communication codes, that can be understood by surrounding people and that characterise the values of the sociocultural community to which they belong (Presutti 2022, 202). Nonverbal means are highly important in the field of textiles on account of their highly visual nature. Nonverbal representation forms a continuum from figurative to abstract forms, and these configurations can represent a broad array of synonyms (Lervad 2013, 177).



Fig. 4: A witch’s dress decorated with written-spells, Iranian Dolls and Culture Museum, with detail (Images: Ali Golshan)



### 3) *Dari Behdini language*

The oral nature of these legends means the Dari Behdini language plays an important role in increasing the verbal share compared to the non-verbal. Language is the only carrier of cultural nuances and intangible heritage related to silk weaving, which enables intergenerational transmission among Zoroastrian women.

After the destruction of the Sassanids, Zoroastrians migrated from different parts of Iran to two desert cities (Yazd and Kerman) and adopted the Dari Behdini language as an ethnic language. Cultural diversity, multiplicity of languages, dialects and accents of immigrants led to the emergence of many sub-branches in this language. Therefore, the dialect continuum/dialect chain existing throughout Iran met at these two cities and created unique trans-cultural diffusion. Sociolinguistics and sociocultural approaches are suitable tools to decode some unusual and rare spells related to silk weaving terms used by Zoroastrian witches.

1) Verbal spells derived from onomatopoeias that were produced by tools and looms while working. These onomatopoeias are still used as old names for some tools and mechanical parts in the terminology of silk textiles.

2) Written spells inspired by oral history related to silk weaving were copied onto silk textiles (fig. 4).

It is difficult to understand the meaning of the symbolic images and to translate them into existing concepts and terms of silk weaving terminology. Because Zoroastrian silk weavers use cultural steganography - hiding messages for the communication of their female society, which they monopolise. However, it is also necessary to focus on the examination of the more specialised words and concepts of silk weaving in the wider context of material culture. Although cultural linguistics helps to decode the terminology of Zoroastrian women's silk weaving, historical linguistics is considered a suitable complement to cultural linguistics/ethnolinguistics due to the numerous migrations of Zoroastrians throughout history.

### 4) *Cultural economy and sociocultural anthropology*

"Activity benefits" are close substitutes to the cultural and leisure economy and are therefore predominantly a private good enjoyed by the person undertaking the activity (Gørtz 2006, 9). Allocating a part of the income obtained from the sale of silk products for the sake of education and intergenerational transmission,

dissemination and marketing of silk weaving by Zoroastrian women led to the transformation of their homes into educational and business environments. For this reason, female neighbours were considered colleagues and together they created a wide range of terms related to silk weaving and its cultural economy which could only be understood in the Zoroastrian women's local community. These words include trade names for various silk techniques and products, symbolic code names for numbers, business terms and social relations between colleagues, buyers and merchants that exist in commercial invoices. Therefore, the methods from cultural economy and sociocultural anthropology can be used for this part. Sociocultural anthropology is a portmanteau term used to refer to social anthropology and cultural anthropology together. It is one of the four main branches of anthropology. Sociocultural anthropologists focus on the study of society and culture.

### **Aims and methodology**

The overarching aim of this project is to collect, extract and record the silk textile heritage in the intergenerational transmission of Zoroastrian women, and to explain the methods of transmission through oral history and intangible culture. DocZow aims to achieve four main results.

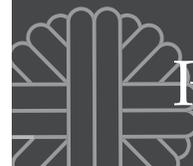
1. A documentation and collection of Zoroastrian oral traditions and literature about women's silk textiles, in their original languages accompanied by English translations.

2. A glossary of textile terminology in oral sources and the equivalence of mixed or different terms with Dari Behdini terms and concepts, and their translation into English.

3. An interdisciplinary investigation and discussion of silk textile weaving of Zoroastrian women in the chain of intergenerational transmission using oral history.

4. A comprehensive investigation of the intergenerational transmission as intangible cultural heritage and material culture related to Zoroastrian women's silk textiles as a symbol of cultural identity.

The methodology of this project is highly interdisciplinary. The methods are descriptive-analytical, and the type of research is qualitative. Collecting information from the Zoroastrian populations, which includes literature, culture and oral traditions, will be done 1. in library research, 2. as fieldwork and 3. using written and oral documents (interviews with 19 or 20 people) - most as semi-structured interviews, supplemented by a selection of in-depth interviews.



## Acknowledgements

The DocZow project would not have been born without the incredible support of Eva Anderson Strand and Marie-Louise Nosch at the Centre for Textile Research, from the very beginning. After that, I thank Susanne Lervad's scholarly guidance in silk textile terminology and Irene Skals Livermore's unique training in the field of textile fibre microscopy, which has facilitated the progress of the project. Finally, DocZow would not be possible without the input and cooperation of many Zoroastrian women (silk weavers and witches), and for this I am grateful to all of them.

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# Textile crossroads: outcomes of the EuroWeb COST Action 19131 *Europe through Textiles*

## Introduction

The four-year Action CA 19131 *Europe through Textiles: Network for an integrated and interdisciplinary Humanities* (EuroWeb), funded by the European Cooperation Program in Scientific and Technical Research (COST) and the European Commission, successfully concluded on 12 October 2024. Conceived at the Centre for Textile Research in Copenhagen and coordinated by the University of Warsaw, this initiative brought together 256 registered participants from 32 countries, along with over 300 informal followers. Together, they collaboratively established an extensive, textile-focused network, uniting scholars from various disciplines, heritage professionals, craftspeople, designers and artists.

By employing textiles as a prism through which European history is reviewed, EuroWeb offered a new understanding of the past, in which textiles are seen as active components shaping economies, technologies, languages, aesthetics and symbolic values, as well as social and individual identities, including gender, age and status.

The main objectives of EuroWeb included: 1) proper acknowledgment of the formative role of textile production and textiles in narratives about the European past; 2) identification of linguistic and semantic structures in European languages that refer to textiles and textile technologies; 3) development and dissemination of interdisciplinary methods in textile research that bridge different theoretical and

methodological approaches grounded in European scholarship; 4) dissolving the dichotomy between practice and theory through the integration of various disciplines, cultural institutions, traditional crafts and design; 5) forging new notions of inclusive European identity based on a sense of belonging and cohesion resulting from common traditions related to textiles.

These objectives were achieved within the organisational framework established for all COST actions. EuroWeb was led by a core group that included the action chair Agata Ulanowska (PL), the vice-chair, Karina Grömer (AT), and key leaders: Marie-Louise Nosch (DK) – the originator of EuroWeb – Magdalena Woźniak (PL), Louise Quillien (FR), Christina Margariti (EL), Francesco Meo (IT), Francisco B. Gomes (PT) and Riina Rammo (EE). The core group activities were supported by a 60-member management committee representing all participating countries.

Individual tasks were carried out within the working groups (WG), each focused on specific themes: textile technologies (led by Christina Margariti); clothing identities (Magdalena Woźniak); textile terminologies (Louise Quillien); and the fabric of society (Francesco Meo). In addition, two WGs were responsible for dissemination of results (F.B. Gomes), and coordination (Riina Rammo and Cécile Michel, FR), while two other teams were implementing the major deliverables: the *Digital Atlas of European Textile Heritage*, led by Catarina Costeira (PT) and Alina Iancu (RO) and former leader Angela Huang (DE);

and the EuroWeb anthology published as *Textile Crossroads: Exploring European Clothing, Identity, and Culture across Millennia*, led by Kerstin Droß-Krüpe (DE), Louise Quillien and Kalliope Sarri (EL). The extended Core Group also included the WG vice-leaders, the Virtual Networking Manager (Hana Lukesova, NO), the Gender Balance and Inclusiveness Managers (Hana Lukesova and Francisco B. Gomes), and Senior Mentors (Mary Harlow, UK and Susanne Lervad, DK).

Thanks to the exceptional dedication and collaboration of EuroWeb participants, European textile heritage was thoroughly explored and discussed through 24 conferences and workshops organised directly by the COST Action, alongside additional scientific meetings supported by EuroWeb. Early career researchers and colleagues from Inclusiveness Target Countries (ITCs) – countries identified by COST as having fewer EU-funded grants – benefited from 76 individual grants awarded to support their participation and research. Career development was further enhanced through 11 training schools and several dedicated

mentoring programmes. Many of these events remain accessible to the general public via the EuroWeb YouTube channel (<https://www.youtube.com/@euroweb-europethroughtextiles>).

### Scholarly results and online resources

Following the successful achievement of its specific objectives, the EuroWeb Action has significantly enhanced the visibility of European textile heritage through a range of publications, online resources, and dissemination activities across the participating countries. In parallel, new research questions have been identified and addressed for the first time, or explored in greater depth within broader chronological and social contexts.

The EuroWeb publication record comprises a total of 55 articles and chapters, with the majority co-authored by two or more COST Action members. Many of these have been published in the dedicated collections, demonstrating EuroWeb commitment to fostering collaborative and interdisciplinary research. One of the major deliverables is the already mentioned 2024



Fig. 1: Participants of the EuroWeb concluding conference in Warsaw (Image: Katarzyna Żebrowska)



Fig. 2: EuroWeb core group (from left to right): Alina Iancu, Francisco B. Gomes, Francesco Meo, Louise Quillien, Magdalena Woźniak, Christina Margariti, Rossella Magli (COST Science Officer), Agata Ulanowska, Karina Grömer, Riina Rammo, and Iwona Zielińska (EuroWeb Grant Holder Manager) (Image: Katarzyna Żebrowska)

open access EuroWeb anthology *Textile Crossroads: Exploring European Clothing, Identity, and Culture across Millennia*. This impressive volume includes 17 individual chapters collaboratively written by 57 authors from 20 countries (<https://digitalcommons.unl.edu/zeabook/161/>). Another achievement is the 2024 open access monograph *The Common Thread. Collected Essays in Honour of Eva Andersson Strand* (<https://www.brepolonline.net/doi/10.1484/M.NAA-EB.5.138139?mobileUi=0>) edited by Ulla Mannering (DK), Marie-Louise Nosch, and Anne Drewsen (not participating in EuroWeb). Fourteen chapters were co-authored by EuroWeb members. Edited by Christina Margariti, Hana Lukesova, and Francisco B. Gomes, the open access *Heritage Science* journal collection *Advanced Analytical Techniques for Heritage Textiles*, with five articles by EuroWeb members, is yet another achievement showcasing innovative approaches to the study of heritage textiles (<https://www.springeropen.com/collections/aatht>). The last, forthcoming milestone is the monograph *Funerary Textiles in Situ. Towards a Better Method for the Study of Textile-related Burial Practices*, edited by Elsa Yvanez (DK) and Magdalena Woźniak. Set for publication by Springer in 2025, it features 10 chapters authored and

co-authored by EuroWeb members, further advancing research on complex usage-patterns for textiles in burial practices.

Additionally, EuroWeb has effectively used digital platforms to reach a broader audience of professionals and the general public by creating online multimedia publications and sharing the recordings of virtual and hybrid events, as well as other online content, via the COST Action's media. One of the major deliverables is the *Digital Atlas of European Textile Heritage* (<https://atlas.euoweb.uw.edu.pl/>), a digital repository containing thousands of records on prehistoric, ancient, medieval and modern textiles and textile crafts, dating from 10,000 BCE up to 2000 CE. This project was made possible through the collaborative effort and commitment of the Digital Atlas Team and numerous EuroWeb participants who contributed their research and data. Currently, the Digital Atlas documents in English 1,763 textile tools and 62 workshops, 3,738 textiles, 261 cloth seals, 2,079 archaeological sites and 771 collections.

The open access resource documenting linguistic and semantic structures referring to textiles and textile technologies in ancient and modern European languages has been developed by the Working

Group led by Louise Quillien. The *Textile and Clothing Terminology Online platform* (<https://textileterm.hypotheses.org/>) is designed for researchers, educators, and the public, offering a searchable collection of textile terms and extensive resources on clothing terminologies from the invention of writing to the pre-industrial era, including terminologies in the languages of the EuroWeb participating countries.

### Europe through Textiles: A personal perspective

In addition to significant scientific and dissemination achievements, numerous EuroWeb members have described their participation in the COST Action as a transformative experience and a unique opportunity for professional and personal growth. As the EuroWeb network spans 32 countries and includes hundreds of participants, it is important to highlight that these shared personal-level experiences represent another key outcome.

For many, EuroWeb has served as a catalyst for expanding individual collaborations, expertise, and research perspectives. Members have frequently reported a sense of belonging to a vibrant, supportive, and inclusive community, which has enhanced their professional satisfaction and overall work experience. Particularly positive feedback has been received regarding the various opportunities facilitated by EuroWeb, such as conference grants, short-term mobility visits to other institutions, and training schools. These initiatives have been praised not only by trainees, who benefited from learning and skill-building, but also by trainers, for whom the schools provided a valuable platform for developing and enhancing their teaching abilities. Another notable resource that many members have highlighted is the COST Action's *Communication Plan* ([https://euroweb.uw.edu.pl/wp-content/uploads/2023/02/EuroWeb-Communication-Plan\\_2023\\_LowRes\\_ForWebsite.pdf](https://euroweb.uw.edu.pl/wp-content/uploads/2023/02/EuroWeb-Communication-Plan_2023_LowRes_ForWebsite.pdf)), developed by Francisco B. Gomes. Widely praised for its clarity, specificity, and rigour, the plan has been described as an exemplary guide to project communication policies.

Finally, the close networking fostered through collaborative projects, conferences, workshops,

and training schools has led to the formation of friendships that go beyond professional collaboration. These personal connections have played a significant role in creating a supportive environment, helping to make the stresses of everyday academic work more manageable.

### EuroWeb legacy

The EuroWeb Action has established a strong and sustainable foundation for ongoing research, education, and public engagement through its extensive network, open-access publications, and digital platforms. Key digital resources, such as the *Digital Atlas of European Textile Heritage* and the *Textile and Clothing Terminology Online* platform, alongside the EuroWeb website and YouTube channel, will continue to be maintained beyond the conclusion of the COST Action, ensuring long-term accessibility and impact.

In addition to preserving the established network, EuroWeb has fostered the development of new ideas and collaborative networks that build upon its achievements. EuroWeb members have already applied for nine new grants inspired by the COST Action's research, six of which have been successfully funded. Notably, the direct continuation of EuroWeb's work is ensured through the COST Innovators Grant starting next year: *Building a Heritage-Based Knowledge Hub to Empower the Green Transition in Textiles and Fashion* (HERITEX-HUB). Led by Francisco B. Gomes, the new action chair, and hosted by the University of Warsaw, HERITEX-HUB will further advance the EuroWeb legacy by addressing contemporary challenges in textiles and fashion through a heritage-based perspective.

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# Dress for success. A co-organised Centre for Textile Research workshop at the 13th ICAANE

25 May 2023, University of Copenhagen, Denmark, and online

The International Congress on the *Archaeology of the Ancient Near East* (ICAANE) is a biennial conference focusing on the study of the Near East and promoting a multidisciplinary approach to its cognitive, material, and environmental evidence from the most remote phases until the Islamic period. Every second year since 1988, ICAANE has brought together specialists from an array of archaeological branches, including iconographers, art historians and textile researchers. The 13th meeting was hosted in Copenhagen by the University of Copenhagen and took place from Monday 22 to Friday 26 May. Within the framework of the 13th ICAANE, Rachele Pierini (CTR, Saxo Institute, University of Copenhagen, Denmark) and Noemi Borrelli (L'Orientale, University of Naples, Italy) co-organised the workshop: "Dress for Success. Textile, Furniture, and Power Accessories Expressing Status in the Ancient Near East and the Aegean (3rd-1st millennia BCE)".

"Dress for Success" had the ambitious goal of gaining better knowledge about identities and social structures in the Aegean and Near Eastern societies from the third to the first millennia BCE by exploring the elements that identify a person as high-ranking. In particular, it delved into the textiles these people wore, the pieces of furniture and power accessories associated with them, and the contexts in which these items were displayed or the circumstances in which they were acquired. As a result, "Dress for Success" hosted eight papers, of which four focused on the Near East and four on the Aegean. All the papers extensively analysed textile elements (fabric, pattern, embroidery, colours, garments, provenance, raw materials); furnishing pieces (chairs, stools, tables); power accessories (sceptre, staff, crowns). To accurately reconstruct the roles and status of the people wearing and using these items, the organisers brought together specialists with a solid expertise in archaeological, iconographic, and textual sources. As such, "Dress for Success" also solidified the results from each specialised area by promoting trans-disciplinary collaboration, thus contributing significantly to unravelling the social structure and dynamics of Eurasian and Middle Eastern societies.

The organisers Rachele Pierini and Noemi Borrelli opened the workshop with an introduction presenting an overview of the topics, areas of expertise, and expected results. "Dress for Success's" papers were organised in two sessions each containing four talks, chaired respectively by Borrelli and Pierini.

The paper "Prestige on Display: Markers of Social Status in Early Bronze Age Babylonia" by Noemi Borrelli and Palmiro Notizia (University of Bologna, Italy) opened the first session. It examined the elements that identify high-status individuals to determine the relationship between the economic and cultural value of these objects. Additionally, it reconstructed the context within which they were gifted by combining data from textual sources and iconographic parallels. In particular, the talk focused on the end of the third millennium, during which the Ur III state (2112-2004 BCE) kept detailed administrative records, which shed light on the material culture of Babylonian society in the Early Bronze Age.

Agnete Lassen (Yale University, US) presented "Seals of Power in the Old Assyrian Period". By exploring the imagery and style of seals of the elite in Old Assyrian society and comparing royal and office seals with those belonging to elite Assyrian merchants, her paper argued that the merchants valued quality and material as opposed to the city administrators, for whom iconography was more important.

With "Assyrian Imperial Elites and Textile Culture of the First Millennium BCE", Salvatore Gaspa (University of Padua, Italy) brought the focus onto the Neo-Assyrian period. He surveyed Assyrian royal garments to unravel the meaning of Assyrian kingship in the imperial phase and the god-inspired mission of the ruler of the "Land of Aššur". Additionally, he analysed how royal garments show how the superior status of the royal person was emphasised by visual interaction between the king's clothes and other elite textiles characterising the presence of the king in the scene.

Louise Quillien (CNRS, ArScAn laboratory, France) closed the first session with the paper, "Royal Dress and the Expression of Power in Babylonia, 1st millennium BCE", which explored how garments, accessories,

and regalia were used as a body language to express the nature of the king's power and the mediums of expression of a royal ideology. This is particularly important in the context of the 1st millennium BCE Babylonia since several regimes succeeded each other as rulers. In this context, it is possible to observe what messages royal dress conveys in terms of the origin of power, the identity of the royal person, and the discourse towards the governed people through the analysis of textual and iconographic sources. By weaving together all these data, Quillien showcased how the dress of kings and queens was one of the mediums of expression of a royal ideology.

The first paper of the second session bridged the Near East and the Aegean with Assaf Yasur-Landau (University of Haifa, Israel) and Chiara Spinazzi-Lucchesi (University of Copenhagen, Denmark) presenting "International Fabrics? Cypriot White Slip Pottery and Elites Linen Clothes of the Late Bronze Age". The talk explored the possibility that the Cypriot White Slip pottery imitates elite linen clothing produced during the Late Bronze International Age by analysing the decoration on the pottery and contemporary 15th to 14th century BCE "Syrian" elite dress, shown in 18th dynasty Egyptian tombs and decorated with elements resembling embroidery and fringe tassels.

With "Status in a Nutshell. A Praxeological/Phenomenological Approach to Seals as Power Accessories", Diamantis Panagiotopoulos (University of Heidelberg, Germany) explored the role of Minoan and Mycenaean seals as status items and examined how these artefacts embodied and mediated power. With a fresh study of these artifacts, Panagiotopoulos's approach focused on the practices of wearing, exposing, using, and perceiving seals. By shifting the scholarly attention from the objects' 'genotype' (seals as an ontological entity) to 'phenotype' (the transformation of seals through the impact of their social environment), the paper envisaged elucidating to what extent their symbolic potential was perceived as an expression of

individual or rather collective identity.

Janice Crowley (Australian Archaeological Institute at Athens, Australia) presented "The Scarf and the Cloak. Prestige Garments for Aegean Elites", which addressed the gendered and symbolic use of prestige garments. The identification of elite personages in Aegean iconography is challenging due to the similarity of dresses. However, different indications for status may be present, as Arthur Evans thought by observing what he termed the "sacral knot". More evidence has now established that there are two items under Evans' term, namely the "cloak knot" and the "scarf knot". On this basis, Crowley investigated the images for each knot and argued that the scarf is worn by elite females and that the cloak envelopes elite males.

To close the workshop, Vassilis Petrakis (University of Athens, Greece) offered the paper "Seated in Power: a look at "participatory" imaging of thrones and (foot) stools in the Mycenaean palatial world". By examining the ideological content of the seated posture in the Mycenaean palatial period, Petrakis argued that furniture was part of a broader apparatus aiming to integrate it with figural imagery placed on them and, also, that the proactive role of the human participants using such furniture was critical in the formation of a powerful visual message. Also critical in his view is the dynamic, transformative role of the human participants using such furniture since it contributes to the formation of a powerful visual message.

"Dress for Success" has raised new questions and added new thoughts on old matters and has successfully showcased how to merge two quite distinct and specialised fields through cross-disciplinary studies. This project received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 101020245.

*By Rachele Pierini & Noemi Borrelli*

## Sailing textiles. From prehistory to early history

29 to 30 April 2024, University of Gothenburg, Sweden, and online

The conference *Sailing Textiles: from Prehistory to Early History* spanned two days at the University of Gothenburg in Sweden, a port city with an important maritime history. As introduced by Serena

Sabatini, the organiser of the conference, sailing has been an important technology throughout the past for many different cultures in creating spheres of communication, trade, and culture. The Euroweb



Fig. 1: Gothenburg – Sailing textiles: discussion and workshop after presentations (Image: Serena Sabatini)

conference, *Sailing Textiles*, was aimed at discussing the role of textiles in such technology throughout different periods from a variety of perspectives.

Separated into four sessions, the presentations covered the topics of sail production, boat technology and rigging, raw materials from an archaeological perspective, and other maritime related textiles such as seafaring clothes. Nineteen speakers from various backgrounds such as archaeology, conservation, weaving and ropemaking, from Sweden, Denmark, Norway, Estonia, Germany, Spain, Italy, Malta, France, and the United Kingdom, were invited to share their expertise and ongoing research.

The raw materials of sailcloth were investigated through landscape analysis for the Viking Age, notably through the archaeobotanical investigation

of scandinavian hemp cultivation by Morten Fischer Mortensen and the zooarchaeological analysis of sheep in Scandinavia by Jonas Holm Jæger.

As for the spinning and weaving of sails, possible tools for the making of sailcloth from the Bronze Age Aegean were discussed by Maria Emanuela Alberti, while evidence for the production of sails in the Roman world was presented by Madeleine Miller. A discussion of more general weaving tools, techniques and cloth variation was presented by Marie Ekstedt Bjersing.

Adjacent to textiles, cordage and rigging constitute an important part of any sailing vessel. Such components made from sparto grass were discussed by Carmen Alfaro in the sewn plank ships of the Western Mediterranean, whereas the configuration and



Fig. 2: Gothenburg – Sailing textiles: linen cloth samples woven by Marie Ekstedt Bjersing (Image: Serena Sabatini)

techniques of bast ropes and cordage were explored by Olof Pipping and Jörn Bohlmann.

While sails constitute an integral part of seafaring textiles, various other textiles are required on a ship. For example, the caulking and use of recycled textiles in the Roman period were explored by Laure Meunier, scenes depicted on Aegean Bronze Age iconography were discussed by Tina Boloti. Furthermore, the various textiles and fibres recovered from a 14th century Estonian cog ship were presented by Riina Ramno and their conservation explained by Maria Romet. The type of clothing worn for sailing during the Late Iron Age and Viking Age with ethnographic parallels to the Faroe Islands was presented by Eva Andersson Strand.

The discussion of sailing textiles came to life with the help of ethnography, literary sources and experimental sailing. Specifically, Mikael Fauvelle related indigenous sail technology and iconography from the Americas to Bronze Age Scandinavia. The technology of prehistoric ships of Scandinavia and Atlantic Europe was explored by Boel Bengtsson with

wider ethnographic and iconographic parallels. Living sailing traditions were supplemented with data from the experimental voyages and sail performance of the ships at the Roskilde Viking Ship Museum by Vibeke Bischoff. Finally, historical sources documenting the production of sailcloth were presented by Marius Borg-Heggedal and Jörn Bohlmann in the context of early industrialisation, and by Claire Bonavia in regard to the traditional art of sailmaking in Malta.

The conference included a workshop on the first day, during which participants could try spinning fibres and weaving on the warp-weighted loom, feel various textiles, cordage and rope, and discuss research. Further questions and discussions were held at the end of the second day. In summary, the conference was an excellent opportunity to explore sailing textiles from different angles and create room for discussion between the theoretical backgrounds of textile and maritime archaeology and the more practical aspects of craft and textile production.

By Elsa Heebner

## Mycenaean and Indo-European linguistics: planting the seeds for integrating research fields and weaving data together

15 to 17 May 2024, Centre for Textile Research and NorS, University of Copenhagen, Denmark, and online

Linguistics is at the core of textile research, as shown by CTR projects such *Skin, Fur and Leather Terminology* (2015-2018) and publications such as Marie-Louise Nosch and Cécile Michel (eds), *Textile Terminologies in the Ancient Near East and Mediterranean from the Third to the First Millennia BC*, Oxford 2010 and Salvatore Gaspa, Cécile Michel, and Marie-Louise Nosch (eds), *Textile Terminologies from the Orient to the Mediterranean and Europe, 1000 BC to 1000 AD*, Zea Books 2017. As such, expanding the horizon of linguistic research also results in equipping the textile researcher with more fine-tuned tools for the study of textiles and textile terminologies. In this context, Mycenaean has a truly unique position since it is a relatively new subject in the field of classics, with the script encoding Mycenaean (Linear B) only being deciphered in 1952 and revealing Mycenaean

as the earliest form of the Greek language.

With the aim to promote the integration of Mycenaean studies and Indo-European linguistics, Rachele Pierini (CTR, Saxo Institute) and Birgit Olsen (NorS) joined forces to co-organise the workshop: *Branch out: Rethinking the branching order of the Indo-European language family through the diachronic morphophonology of the o-stem genitive singular ending*. Co-organiser of the workshop was also Eugenio Luján (Complutense, University of Madrid). The workshop took place at the University of Copenhagen (UCPH) on 15 to 17 May 2024, with 15 presenters and about 35 in-person attendees as well as 40 online registered attendees. The Copenhagen event hit a major milestone since the workshop discussed advanced drafts of the book on morphophonology that Pierini, Olsen, and Luján are co-editing. The research question that the workshop

analysed (namely, the reconstruction of the o-stem genitive singular ending) is rooted in a vexata quaestio in Indo-European linguistics, and Mycenaean data shed new light on the topic and expanded the area of research. Times are thus ripe for re-examining the data in all the branches of the Indo-European language family.

The Anatolian branch was analysed by Craig Melchert and Ignasi Adiego. Melchert analysed data from Hittite and hypothesised that innovation in the formal expression of possession in Anatolian is bidirectional since convincing examples have been offered for development of at least two new genitive endings from inflected genitival adjectives. Adiego analysed the Luwic group (Luwian, Lycian, Carian, Pisidian and Sidetic) and brought together data to trace the presence of morphemes that can be traced back to the construction of the PIE o-stem genitive singular ending.

The Greek branch was analysed by Rachele Pierini and Matthew Scarborough. Pierini analysed Mycenaean data and argued that the supposedly two endings that Mycenaean shows are actually the same ending, with -Xo being the earliest form and -Xo-jo a subsequent

development of the ending. Scarborough analysed data from the first-millennium BCE Ancient Greek dialects and critically reviewed the main advantages and disadvantages afforded by the current hypotheses. Martin Joachim Kümmel analysed the Indo-Iranic branch, with particular emphasis on controversial examples that might also allow for other explanations, according to the general development of nominal inflection. Michael Weiss analysed the Italic branch, which offers a number of thorny problems. Weiss surveyed the epigraphical, antiquarian, and literary data for the morphemes functioning as thematic genitive singulars, examined the phonological questions involved in the further development of the ending in some specific sub-branches and critically reviewed the theories about the original distribution of the concurrent endings. Eugenio Luján analysed the Celtic branch and the different endings the sub-branches show; in addition, he hypothesised some connections on geographical and chronological basis. Birgit Olsen analysed the ending in Armenian, the data of which are peculiar in the o-stems since it is the only paradigm with an original distinction between genitive and ablative singular and, at the



Fig. 3: Copenhagen – Mycenaean and Indo-European linguistics: the Branch Out organisers, speakers, and team (clockwise from bottom left): Birgit Olsen, Rachele Pierini, Eugenio Luján, Brian Joseph, Matthew Scarborough, Martin Joachim Kümmel, Miguel Villanueva, Craig Melchert, Bartomeu Obrador-Cursach, Ignasi Adiego, Simona Marchesini, Patrick Stiles, Hannes Fellner, Linda Rocchi, Matilda Agdler.

same time, the only place where the two cases merged by analogy. Patrick Stiles analysed the evidence of the Germanic languages, critically evaluated the hypotheses on the reconstruction of the ending and offered a new reading of the data. Hannes Fellner analysed the evidence from Tocharian, a branch in which the genitive singular in the continuants of o-stem substantives and adjectives and pronominals are still a matter of debate. He discussed and evaluated the different proposals for the origin of these genitive forms in the light of recent advances in understanding of the evolution of the Tocharian nominal system. Miguel Villanueva analysed the Balto-Slavic branch and focused in particular on a variant that is one of the main contributions of the branch to the reconstruction of the ending. Brian Joseph analysed the evidence from Albanian, in which there appears to be no direct descendant of any of the possible Proto-Indo-European starting points and there are several innovations that differentiate the o-stem genitive in Albanian from the parallel paradigmatic cell in other branches of the family. Additionally, he examined the Balkan character of Albanian to offer insights into the role of Albanian in contributing to the reconstruction of the genitive ending.

Simona Marchesini analysed the Messapic evidence by critically reviewing the hypotheses on the two

endings and evaluating how their explanation impacts the relationship between Messapic and other Indo-European languages, particularly the western group. Bartomeu Obrador-Cursach analysed the Phrygian data by exploring the potential consequences of the recently identified thematic singular genitive beyond its use as a patronymic and comparing its Indo-European cognates from a dialectal perspective. Wojciech Sowa analysed the evidence from Thracian and Macedonian, fragmentarily attested languages that require an *ad hoc* approach precisely for this. As such, he addressed the reliability of the existing material and explored the possibility that these desinences could additionally support the claimed idea of the existence of a Balkan linguistic area in prehistoric times.

The workshop is part of the Marie Skłodowska Curie project *Trans-PLANT* (MSCA grant agreement 120018) and has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 101020245. The workshop was further generously supported by the Carlsberg Foundation and the Ludvig Wimmer og Hustrus Legat.

By Rachele Pierini

## North European symposium for archaeological textiles, NESAT XV

22 to 24 May 2024, University of Warsaw, Poland, and online

The XVth meeting of the Northern European Symposium for Archaeological Textiles (NESAT) was hosted by the University of Warsaw in Poland, for the second time, from 22 to 24 May 2024. It followed on from the conference 'After EuroWeb. Expanding Horizons in Textile Studies and European Networking', which concluded the COST Action CA 19131 'EuroWeb. Europe through Textiles'. Together, these two events marked a full week of textile research at the University of Warsaw, demonstrating the potential of textile studies in Europe. The organising committee consisted of Agata Ulanowska (University of Warsaw), Marcin Wagner (Faculty of Archaeology, University of Warsaw), Magdalena Woźniak (Polish Centre for Mediterranean Archaeology, University of Warsaw,

CTR Copenhagen), Marta Żuchowska (Faculty of Archaeology, University of Warsaw) and Katarina Žebrowska (Faculty of Archaeology, University of Warsaw), Marta Żuchowska (Faculty of Archaeology, University of Warsaw) and Katarina Žebrowska (Faculty of Archaeology, University of Warsaw). The other members of the committee were Johanna Banck-Burgess (Landesamt für Denkmalpflege Baden-Württemberg, Germany), Helena Březinová (Institute of Archaeology ASC, Prague, Czech Republic), Margarita Gleba (University of Padova, Italy), Karina Grömer (Natural History Museum, Vienna, Austria), Sanna Lipkin (University of Oulu, Finland) and Ulla Mannering (National Museum of Denmark, Copenhagen, Denmark). The conference was held both

face-to-face and online, enabling a wider audience to follow the presentations, in addition to the almost 90 people in attendance.

The authorities of the Faculty of Archaeology welcomed the participants, then Agata Ulanowska gave the opening speech to launch the conference, and the first session was then rounded off by contributions from two of the textile archaeology deans, Jerzy Maik and Frances Pritchard, who were able to put textile research into perspective over a long period of time and long research careers. The day then moved on to textile production from the prehistoric to the Roman period, mainly through case studies from archaeological excavations, before concluding with new projects and approaches from the Roman to the Viking periods.

The second day focused on technical aspects in the morning, with studies and reconstructions of tablet weaving and research into metallic threads, with a number of interesting experiments. Communicating what worked and what did not is particularly important for everyone. The afternoon was devoted to medieval fabrics in Europe, with several examples illustrating the complexity of fabric research, and ended with analyses and experiments on dyes.

The third day allowed the participants to take a step back from textiles by exploring the field of gendered interpretations, tools and other organic materials discovered with fabrics, then funerary and religious textiles and finally new research carried out on objects already known, or with new technologies.

The day ended with the presentation of 13 posters, which clearly demonstrated the dynamism and renewal of research on fabrics and allowed the presentation of research from students as well as established researchers.

The National Museum in Warsaw granted conference participants free admission to discover its very rich collections during the conference, including numerous paintings and religious sculptures from the renaissance with magnificent representations of textiles. Free guided tours of the Central Campus of University were available to learn the history of this unique site.

The conference ended with a gala dinner, held in the Columned Hall of the University of Warsaw, a relaxing and convivial moment at the end of three intense days of exchange and information.

Excursions were scheduled on Saturday, 26 May to discover more about fibres and textiles, or Polish history: the National Museum in Warsaw, the Linen Museum in Żyrardów, the Central Museum of Textiles in Łódź, tickets to the Central Museum of Textiles, and finally the Royal Castle in Warsaw, including a pre-opening visit to the exhibition about the destruction and restoration project of the castle.

The conference proceedings will be published in the peer-reviewed *Warsaw Studies of Archaeology* series by Brepols.

*By Laure Meunier & Émeline Retournard*



Fig. 4: Warsaw – NESAT: the participants on the final day of the conference (Image: Agata Ulanowska)

# Hallstatt Days (*Halštatski dani*) – workshop and fashion show

14 to 16 June 2024, Kaptol, Croatia

This year, the festival *Hallstatt Days (Halštatski dani)* was held in the municipality of Kaptol, Croatia, with the theme “Textiles of the Iron Age” with a diverse programme including a scientific conference as well as a public communication event. The conference was supported and organised as an activity within CSF project IP-2020-02-2371: *Creation of European Identities – Food, Textiles and Metals in the Iron Age Between Alps, Pannonia and Balkans (IronFoodTexMet)* and co-organised by Iron Age Danube Cultural Route, the Centre for Prehistoric Research and the University of Zagreb.

The first day comprised conference presentations by Italian, Bulgarian, Slovenian, Austrian, Croatian and German Iron Age textile researchers. Margarita Gleba reported the results of the textile aspects of the project “IronFoodTexMet” from the Croatian Science Foundation. Bela Dimova presented her research dealing with textiles from Bulgaria and Greece from the first millennium BCE and their technical features. New insights into the excavations at Donja Dolina

and its textile production were presented by Julia Katarina Fileš Kramberger, with some interesting findings on Iron Age textile tools. Matija Črešnar gave his presentation on the first sketch of Early Iron Age textile production in Slovenia. Researchers working on Austrian materials, Kayleigh Saunderson, Ronja Lau and Karina Grömer, presented Iron Age textiles mineralised in graves as well as from the salt mines of Dürrnberg and Hallstatt, along with the differences in the textiles’ contexts.

In the evening Julia Katarina Fileš Kramberger gave a keynote speech on textile archaeology and her research in Croatia to a public audience. Furthermore, an exhibition was opened at the Kaptol municipality building, showing five different costumes from the Early Iron Age, a virtual reality experience of an Iron Age burial and various research posters.

On the second day, a round table was held on the topic “Big data in textile research – Quo vadis?”, which brought many discussions on how to organise, deal with, host and publish the increasingly large sets



Fig. 5: Kaptol – Hallstatt days: featured models in costumes of the fashion show in Kaptol by Karina Grömer (Image: Margarita Gleba)

of data on archaeological textiles. Some ideas were brought forward and will be published in the future. The public festival took place on the third day, featuring many interactive activities for children, cooking inspired by the Iron Age and a fashion show organised by Karina Grömer, Julia Katarina Fileš Kramberger and Kayleigh Saunderson at Kaptol's main square. In the fashion show, members of the

public as well as researchers were dressed in costume recreations based on textile research from the Neolithic to the Roman period.

This event showed how research and public communication can go hand in hand, and everyone looks forward to the Hallstatt Days of 2025.

*By Kayleigh Saunderson*

## Interweaving. Textile networks and perspectives in museum and archaeological context

27 to 29 July 2024, University of Applied Sciences Cologne, Germany, and online

The working group of textile conservators of the German Association of Conservators-Restorers in Germany (Verband der Restauratoren, VDR) held their biennial conference at the Cologne Institute of Conservation Sciences, University of Applied Sciences Cologne. The conference topic, Interweaving – textile networks and perspectives in museum and archaeological context, gave the speakers the opportunity to present a broad range of aspects connected with the conservation of textiles in museum collections, heritage sites or from archaeological contexts. This was well reflected by the comprehensive programme with 26 presentations and nine posters about conservation techniques and concepts, archaeological textile finds, new approaches for documenting, analysing and determining textiles and fibres. The thematic spectrum was extended by two artist talks by Janine Böckelman and Tomas Kleiner as well as a small exhibition of modern textile art, compiled especially for this occasion. The conference aimed to bring together professionals working on the preservation of textiles from different thematic, temporal and geographical contexts in order to establish new networks for interdisciplinary work, to find new practical approaches and for highlighting the importance of textiles as source material. This was achieved through extensive discussion following each presentation continuing during coffee breaks and the evening event at the courtyard of the Cologne Institute of Conservation Sciences. The hybrid approach allowed the attendance of 211 participants in total with 68 attendees in person.

The first day of the conference began with warm welcomes from the steering committee of the

Verband der Restauratoren (Nadine Thiel), the board of the working group of textile conservators (Kerstin Heitmann) and the Professor for textile conservation (Nicole Reifarth) at the Cologne Institute of Conservation Sciences.

The first contribution was from Britt Nowak-Böck (Bavarian State Office for Heritage Management) who focussed on the significance and handling of archaeological textiles and other organic materials from archaeological sites in Germany. She also presented current institutional mechanisms and concepts for the preservation and valuation of these objects. In their talk, Nicole Reifarth (University of Applied Sciences Cologne) and Christine Pümpin (University of Basel) highlighted the importance of micromorphological analysing methods for textile archaeology, allowing for an investigation of the very last traces of organic remains. Ingrid Stelzner (Leibniz-Zentrum für Archäologie Mainz) presented the initiative NFDI4Objects which is dedicated to the systematic gathering, indexing, and the establishing of general accessibilities of research data (FAIR principles) connected to mobile cultural heritage. In her contribution, Sandra Plötz (Dresden University of Fine Arts), focussed on the reshaping of the textile support of a severely damaged 19th century painting, in particular the fixing of cracks and the closing of a big lacunae lacuna with a dyed plain weave intarsia. Maren Lencer (University of Applied Arts Vienna) reported on the evacuation, interim storage and the subsequent conservation work on objects from the collection of the Ethnographic Museum in Kruja (Albania) which was damaged by an earthquake in 2019. The next talk was given by Hannah Flock and



Fig. 6: Cologne – Interweaving: a view from the opening of the conference (Image: Tracy Niepold)

Leonie Hoffmann (Aachen University) who presented a selection of medical textiles which may be suitable materials for conservation and restoration measures. Medical textiles are used for example for tissue repair of the body or as filter materials and are subject to strict legal regulations with regard to the used raw materials and their chemical stability. Anne Sicken (University of Applied Sciences Cologne) gave a talk about modern synthetic fibres and explained chemical and physical reactions which are responsible for changes of the fibre's properties during ageing reactions.

The second day of the conference began with a programme block on archaeological textiles. Tracy Niepold and Helmut Voß (both Bavarian State Office for Heritage Management) presented the recovering, documentation and results of the investigation of an early medieval chamber grave (700 AD). Andrea Fischer (Stuttgart State Academy of Art and Design) and Christina Peek (The Lower Saxony Institute for Historical Coastal Research) reported on the training practice of students in conserving and investigating archaeological metal finds with adhering organic remains. Silvia Mitschke (Reiss-Engelhorn-Museen Mannheim) presented her PhD thesis in which she investigated a corpus of Roman textile fragments from the city of Mainz. Anja Bayer (Abegg-Stiftung Riggisberg) presented the in situ-documentation of archbishop Erkanbald's burial († 1021) placed inside the nave of Mainz Old Cathedral. Diane Lanz and Gabriele Schrade (both independent textile conservators) developed a new device for dry cleaning textile surfaces with the help of a combination of airflow and suction, which was presented in their talk. In her contribution, Ulrike Reichert (independent textile conservator) reported on the conservation and investigation of the two dalmatics of St Ambrosius

preserved as relics in the church of St Ambrosius (Milan). Emma Damen and Pierre Maes (both De Wit Royal Manufacturers) presented the removal, wet cleaning and remounting of several 18th century gobelins from the Vanderbilt Mansion (New York). In their talk, Johanna Banck-Burgess (Landesamt für Denkmalpflege Baden-Württemberg) and Ingrid Stelzner (Leibniz-Zentrum für Archäologie Mainz) presented results of the THEFBO-research project on Neolithic textiles from wet archaeological surroundings in southern Germany. Janet Schramm and Gaëlle Liengme (both Swiss National Museum) presented the results of their work on designing support devices for wet and dry conservation treatments of Neolithic textiles as well as for the long-term storage of these items. The last contribution of the day was given by Alice Burkhardt (Bavarian State Office for Heritage Management) who investigated the impact of iron ions on the preservation of waterlogged archaeological textiles.

The third day of the conference started with Inga Anne Vollmer-Bardelli (Leibniz-Zentrum für Archäologie Mainz). She presented an emergency programme for saving mobile cultural heritage threatened by natural catastrophes or acts of war. Nadine Kilchhofer (Abegg-Stiftung Riggisberg) emphasised the need for interdisciplinary cooperation in terms of preserving original upholstery of historical furniture, which is an often-neglected source for historical handicraft.

The contribution from Dorte Schaarschmidt (Niedersächsisches Landesamt für Denkmalpflege) and Tereza Štolcová (Slovak Academy of Sciences) was about the chamber grave of Poprad-Matejovce (Slovakia, late fourth century AD). The talk focussed on the challenges in decision-making of how much and in which way unprocessed block lifts with preserved archaeological organic remains

or sample material should be kept and stored for future research. In the following presentation, Nora Brockmann (Victoria and Albert Museum) showed the application of laser for cleaning fragile decorative elements of Chinese hairpins, made of wires, silk and cotton fabrics. Susanne Domke (LVR-Landesmuseum Bonn) presented the conservation of numerous rags, pieces and fragments of garments from a wet archaeological context in the city of Krefeld dating to 18th or 19th century. The contribution of Katrin Kania (independent archaeologist) and Tracy Niepold was about a possible method for producing membrane threads used in the Middle Ages as a substitute for solid metal threads.

The final presentation was given by Berit Hildebrandt (University of Göttingen). In her presentation, she raised questions about how to implement textiles more in university education and how to establish networks for a better cooperation between disciplines to enable an improved exchange of knowledge and to diminish fear of contacts. These questions were further addressed during the final discussion round. As the very last programme point, the attendants were able to visit the conservation laboratories of the Cologne Institute of Conservation Sciences.

*By Tracy Niepold*

## Ancient silk splendour. The world of samit and taqueté course

26 to 30 August 2024, Krefeld, Germany

*Ancient Silk Splendour – Recreated* is a one-week course on weft-faced compound tabby and twill – also called samit and taqueté. The course combines the theory of weft-faced compound weaves, analysis of historical textiles and learning to weave weft-faced compound textiles. The course is held at two museums with theory lessons and practical weaving at the Haus

der Seidenkultur / House of Silk Culture, and at the Deutsches Textilmuseum / German Textile Museum. It is taught by Barbara Thomas.

The course started with a bonus historical architectural tour of Krefeld's weaving heritage and the Haus of Seidenkultur jacquard looms. A silk weaving centre in the 19th century, Krefeld retains facades of weaving workshops and the grand houses of their owners. They stand as a reminder of the enormous wealth generated by silk. The theory lessons provided a thorough overview of the weaves and their development in the Late Roman and Byzantine empires of the first millennium CE. Samit and taqueté were popular for their large, colourful patterns that repeat over the fabric. Also produced in wool, they were particularly stunning when woven in silk. The patterns were repeated mechanically via the loom set up using of two warps, a binding and main warp, and two or more wefts. These stunning silk textiles were sought and controlled by the wealthiest patrons in the imperial courts and church hierarchies.

The group examined late Roman and early medieval textiles from the German Textile Museum collections (fig.



Fig 7: Krefeld – Ancient silk: analysis of Roman and medieval taqueté and samit wool and silk textiles with teacher Barbara Thomas, curator Annette Paetz gen. Schieck and two course participants at the Deutsches Textilmuseum / German Textile Museum, Krefeld (Image: Susanna Harris)



Fig 8: Krefeld – Ancient silk: warping and weaving a weft-faced compound twill textile during ‘Ancient silk splendour – recreated’. Haus der Seidenkultur / House of Silk Culture, Krefeld (Image: Susanna Harris)

7). The textiles were enlarged by USB microscope and projected onto a large screen, which allowed everyone to clearly see their construction. The course follows CIETA vocabulary across the theory and practical aspects, thereby reinforcing its application and understanding. A substantial handout included vocabulary, diagrams, completed analysis of several of the silks examined during the course, loom set up for both weaves, suggestions of bibliography and several articles.

Now to the looms. With six looms set up for taqueté or samit we had ample opportunity to practice our weft-faced compound weaving skills. At first, they were baffling and the cause of a few headaches. By the end of the course we could move between looms, work out how the design operated, the lifting sequence of binding, main warps and insertion of the wefts as latté and Interrompu. Just as I was getting into a comfortable rhythm Barbara suggested I change the weft sequence operated by the treadles to create a more efficient lifting sequence.

A highlight of the course was setting up a samit weave with seven thread point repeat, using 450 silk warps (fig. 8). It took three of us a day and much focused concentration. The Roman and medieval textiles collections were also a very special visit. Another nice touch was that we all designed our own seven-point repeat pattern which we were encouraged to weave on several looms set up in different yarns, scales, samit and taqueté.

The course is for weavers, archaeologists and historians and can accommodate beginners to more

advanced. The only specified background is to know the difference between tabby and twill. The varied background of participants was enriching. Krefeld is accessible by train with connecting airports Frankfurt and Dusseldorf, and accommodation was easy to find online. The course is held in German with an English summary, depending on participants. Details of fees and upcoming courses are on the Deutsches Textilmuseum website. The next course will take place in 2026, and you are welcome to express interest in advance. See contact details below.

I found the combination of examining ancient textiles, theory and weaving gave an accelerated learning curve in how to identify the features of these two weaves. Barbara Thomas is a generous and knowledgeable teacher. I highly recommend ‘Ancient Silk Splendour - recreated’ for those wanting to learn or improve their weaving and analysis of these fascinating textiles.

#### Useful links:

Ancient Silk Splendour – Recreated course details: <https://www.deutschestextilmuseum.de/en-gb/leere-seite8cccb316>

Deutsches Textilmuseum, Krefeld: [Ausstellungen \(deutschestextilmuseum.de\)](https://deutschestextilmuseum.de)

House of Silk Culture, Krefeld: <https://seidenkultur.de/startseite>

E-mail samit weaving course: [samit@seidenkultur.de](mailto:samit@seidenkultur.de)

*By Susanna Harris*

# 30th European Association of Archaeologists (EAA) annual meeting 2024

28 to 31 August 2024, Rome, Italy

For the 30th anniversary of EAA conferences, the Sapienza University in Rome in Italy was a perfect choice for the annual conference. With the vast and extended history, “the Eternal City” has through centuries influenced European culture and made it the perfect surrounding and host for an international conference of this size. The motto for the EAA 2024 conference was “Persisting With Change” which encouraged the participants to focus on links between past and present, and also this year the ComTex community (EAA Community for Textile Archaeology and Conservation) had a strong presence at EAA with the involvement and organisation of the following four sessions:

- EAA Session #330 – Textile Records: past, present and future of textile-related artefacts recording in the Mediterranean and beyond. Organised by Alina Iancu and Kalliope Sarri.
- EAA Session #579 – Digital approaches in textile archaeology from the field to the museum. Organised by Margarita Gleba, Elsa Yvanez, Islam Shaheen and Hana Lukesova.
- EAA Session #717 – INTERWOVEN. Textile Exchanges Across the Mediterranean from Prehistory to us. Organised by Nina Ferrante, Leyre Morgado-Roncal, Giulia Muti and Patricia Rosell Garrido.
- EAA Session #733 – Interdisciplinary approaches to the archaeology of Roman textiles – a story told through threads. Organised by Francesca Coletti, Maureen Carroll and Kerstin Droß-Krüpe.

Besides these sessions, the subject of textiles also appeared and were discussed in many of the other sessions. It is interesting and delightful to see that textile research is a topic that naturally fits into many themes and perspectives. For this issue of ATR, two of the ComTex sessions have made detailed summaries, which are reported below.

## **EAA session 717. INTERWOVEN. Textile exchanges across the mediterranean from prehistory to us, 29 August 2024**

The session INTERWOVEN, was organised by Nina Ferrante, Leyre Morgado-Roncal, Giulia Muti

and, Patricia Rosell Garrido, and comprised 11 contributions of 15 minutes each and two discussion slots that opened the room for debate (fig. 9). The goal of the session was to re-investigate diachronically the interaction and exchange of ideas, technologies, objects and people across the Mediterranean through textiles. In other words (and provocatively) what if Penelope was the one moving?

The contributions covered a long timeframe, from the Neolithic to the Late Medieval period, and geographically the whole Mediterranean area and its immediate neighbours. The journey began with Joaquina Soares’ contribution on the “Engraved Stone Plaques” from southwest Iberia, which provided valuable insights into Mediterranean textile production, identity, and economy. Then, Gaia Cecconi continued with her study of spindle whorls found at the Chalcolithic site of Yavne East (Israel), exploring comparisons between different Mediterranean spinning techniques. Taking over on the topic of the interplay between technology and identity, Giulia Muti investigated transmission networks in the Late Bronze Age eastern Mediterranean through the lens of Aegean-styled discoid loom weights. Madeline Bowers followed the thread by describing Aegean textile culture after the destruction of the Mycenaean palaces, analysing textile tools and surviving textiles from the Greek mainland and Cretan sites.

Moving from the eastern to the western Mediterranean, contributions by Ester López Rosendo and Paloma Bueno Serrano focused on Phoenician textile production in the Bay of Cádiz (Spain) and the relationships with local and foreign cultures. Shifting the focus to the representation of textiles in the Ancient Mediterranean, Nina Ferrante focused on Phoenician and Punic dressing, drawing comparisons with other contemporary cultures, while Audrey Gouy explored the role of textiles in Etruscan rituals and their usage in specific practices. Then, the session moved to more recent periods with Helen Victoria Poulter’s paper highlighting how Roman globalisation intertwined with textile traditions introduced new cultural influences during the Iron Age and Roman era in Britain. Lena Larsson Lovén delved into the lesser-studied topic of textile re-use in ancient Roman society, emphasising the role of specific associations of artisans

(*collegia centonarii*) specialising in textile recycling and mending. The last stop on our journey across the Mediterranean was Cristina Scibè's discussion of the extensive Euro-Asian trade network, which, between the late 13th and early 14th centuries, facilitated the exchange of silk and gold fabrics between east and west, with a notable diffusion in Italy.

The session achieved its main goal: to provide an overview through time and textile exchanges across the Mediterranean. Its wide-ranging review confirms and re-affirms the multiplicity, variety of connections between them, going beyond spatio-temporal limitations. Moreover, it is precisely here where the agents involved become relevant. Textile practices and its vestiges are the result of techniques that speak of the socio-economic reality of each historical period. Simultaneously, it is also observable how there are traditions that are maintained over time.

Due to the good reception of the session and the interest aroused, a future monograph is planned to keep disseminating the gathered input. This is just the starting point of new fascinating research questions that require further research for which the Interwoven team will continue working.

*By Nina Ferrante, Leyre Morgado-Roncal,  
Giulia Muti & Patricia Rosell Garrido*

### **EAA session 733. Interdisciplinary approaches to the archaeology of Roman textiles – a story told through threads, 30 August 2024**

The session was organised by Francesca Coletti (Department of Classics, Sapienza University of Rome, Italy), Maureen Carroll (Department of Archaeology, University of York, UK), and Kerstin Droß-Krüpe (Department of Alte Geschichte, Ruhr-Universität Bochum, Germany). This regular session consisted of 15 talks and was affiliated with ComTex (EAA Community for Textile Archaeology and Conservation). The session aimed to provide new knowledge and data related to the archaeology of Roman textiles by bringing together scholars from different disciplines and fostering interdisciplinary discussion. The papers covered a wide geographical area, from the eastern Mediterranean to northern Europe. This session aimed to investigate the technology and economy of textile production in the Roman Empire by integrating data from a broad range of evidence, such as fabrics, textile tools, literary sources, and archaeological contexts, in order to generate new knowledge regarding natural resources, technical operations, tools, workplaces, and social practices connected with Roman textile cultures. Numerous papers focused on materials from old and new excavations conducted in Egypt and the eastern



Fig. 9: Rome – EAA: some of the presenters and organisers of the INTERWOVEN session #717 (Image: Silvia Berrica)

Mediterranean. The evidence from Palmyra and Dura Europos was extensively reconsidered to tackle the production and consumption of delicate and polychrome textiles and the use of fabrics by the army. B. Fowlkes Childs (New York University) focused on several textiles from both sites, contributing to a better understanding of the representations of luxury textiles on Palmyrene sculptures dated to the second to third centuries. J. Poskrobko, M. Ferrari, R. Lackner and N. Shibayama (The Metropolitan Museum of Art) presented the interesting outcome of the scientific investigations conducted on four textile fragments with shaded bands from Dura-Europos. With a different approach and research questions M.A. Wijnhoven (Institute of Archaeology of the Czech Academy of Sciences, Brno) took into consideration multiple examples from Dura-Europos as well as from Central Europe, such as *Carnuntum* in Austria, to examine the collective evidence for Roman scale armour featuring textile remnants, including the methods employed to affix scales onto this foundation. The importance of textiles in the different elements of the Roman soldier's defensive weaponry during the Imperial age and the possible presence of regional differences and standardisation was discussed in detail by F. Spagiari and E. Malaman (University of Padua). Large deposits of Roman organic materials, including textiles, discovered in Egypt and Lower Nubia were discussed by F. Cozza (University of Salento) and S. Hitchens (Independent Researcher). The former focused on the textiles from Soknopaiou Nesos (third century BCE to eighth century CE) found during the 2019–2022 excavation campaigns; the latter on the textiles from Qasr Ibrim, discussing the Roman legion's clothing and the textile traditions at the edge of the Roman empire.

Moving from east to west, B. Hildebrand's (Georg-August-University Goettingen) contribution aimed to take a comprehensive approach to the origin, production, (re-)use, and trade of delicate fabrics made of plant and animal fibres that were traded along the Silk Roads in Late Antiquity and during the Early Islamic period. Ongoing projects on Roman textiles from Central and Northern Europe were presented. P. Linscheid (University of Bonn) talked about two projects, "Textile finds in the LVR-Landes Museum Bonn" and "The Textile Archive of Hans Jürgen Hundt", related to plenty of textiles from Roman Germania Superior and Inferior, most of them came to light in third-century graves near *Villae Rusticae*, others found in settlements and still unpublished. M. Carroll (University of York) presented an ongoing

project on the mortuary practice in the city of Roman York and its environs of pouring liquid gypsum over the wrapped corpses of adults and children in stone or lead sarcophagi in the third-fourth centuries.

Lastly, different scholars provided new data on textile materials and workshops from Pompeii and the Vesuvian area. Indeed, due to the exceptional preservation of textiles, textile tools, and workshops, the ancient city of Pompeii represents a privileged context for studying Roman textile production and consumption at the centre of the Empire. G. Rossignoli, A. Cagnini, M. Galeotti, R. Gennaioli, A. Patera, D. Petrocchi, S. Porcinai, C. Scibe and G. Rotondi (Opificio Delle Pietre Dure) together with F. Miele (National Archaeological Museum of Naples) reported the interdisciplinary investigation on the golden Roman textiles stored at the National Archaeological Museum of Naples. The carbonised textiles and the fabric imprints on the human plaster casts were the focus of a second presentation on Vesuvian textiles by F. Coletti (Sapienza University). Coletti discussed the technology and standardisation of the textile materials, and the reconstruction of garments and their reuse. In this framework, the importance of highly sensitive analytical tools for the analysis of textile artefacts was outlined in the presentation given by I. Serafini, A. Ciccola, F. Coletti, M. Galli, G. Favero (Sapienza University, Department of Classics), A. Bosi (CNR-ISC), M. Gleba (University of Padua), G. M. Kavich and T. P. Cleland (Smithsonian Institution – Museum Conservation Institute).

The contribution presented the preliminary results of the new methodology combining dye and protein analysis applied to wool samples from the Vesuvian area and the textile collection of the Museum of the Roman Ships in Nemi (first century, Italy). Differently, G. Casa (Sapienza University) offered new insights for studying Pompeian textile work places, considering a workshop-based approach and a broader approach to the Pompeian "topography of textile production" to identify production districts. Lastly, B. Dimova (University of Padua) shed light on the Italian ADigTex project carried out by Sapienza and Padua Universities and focused on textile technology, production and trade in the Roman world. It will deliver a Roman Textile Database (RTD), starting from the large corpus of Vesuvian textiles. The RTD will enable multi-scalar analysis of textiles and allow for identifying empire-wide chronological, geographical, and social trends.

We hope to unite all the speakers in one upcoming publication of the conference proceedings and look

forward to maintaining discussions on this critical topic in the years ahead. The organisers thank all participants for engaging in presentations and sharing such exciting content, contributing to a highly productive session.

*By Francesca Coletti*

**EAA session 330. Textile records: past, present and future of textile-related artefacts recording in the mediterranean and beyond, 31 August 2024**

The session Textile Records was organised by Alina Iancu, currently affiliated at the National Institute of Archaeology of Romania, and Kalliope Sarri from the University of Peloponnese, both members of the Hellenic Centre for Research and Conservation of Archaeological Textiles in Athens (ARTEX).

The main aim of the session was to bring together archaeologists and textile experts from across Europe to share their insights into the history of recording lesser-known classes of textile artefacts, and to suggest new methods for integrating these finds into general archaeological publications with the same consistency as other finds. The organisers were interested in producing a concise and comprehensive step-by-step guide with basic information on how to correctly record, describe, illustrate and publish lesser-known textiles and textile tools in the field.

The driving factor in proposing and leading such a scientific session was the fact that in the general archaeological literature objects such as loom weights are still misinterpreted as fishing net weights, spindle whorls are mistaken for beads, buttons for tokens, while clay spools are considered to represent simple thread bobbins, potter's marks or kiln supports. In contrast, distaffs and spindles are seen as writing implements, hairpins or cosmetic spatulas. However, recent advances in the field of archaeological textiles provide good grounds for a reassessment of the old literature and for an in-depth analysis of how professionals in archaeology might approach and better publish textile-related artefacts in the future.

The session brought together 14 presentations given in person or online grouped into three panels and separated by discussion slots. The first slot began with a general presentation by Sophia Vakirtzi on the importance of the archaeological context in the recording of textile tools, using examples from the prehistory of the Aegean. In the second lecture, Magdalena Przymorska-Sztuczka presented the successful collaboration between field archaeologists, conservators and textile archaeologists in the case of

the exceptional textile finds in the necropolis of the Wielbark culture in Wilkowo. Kalliope Sarri analysed some enigmatic types of prehistoric clay objects that could be associated with textile production, such as small conuli and clay objects in the form of anchors.

A series of three presentations by Ilija Danković, Anique Hamelink and Macarena Bustamante-Álvarez approached and discussed in detail the symbolic meaning and functional role of various Roman distaffs and spindles, including the so-called finger distaffs and other short distaffs made of bone, amber and jet.

The second part began with a lecture by Liviu Mihail Iancu on lead spindle whorls and loom weights found in the Aegean and Pontus in the first millennium BCE. Claudia Vega Medeiros and Leyre Morgado Roncal analysed the ancient terminology related to the loom and weaving tools between the first and fifth centuries CE. Elisabeth Trinkl gave an overview of the types of loom weights, based on their morphology over the millennia, while Tina Boloti presented the interpretation of the tools made from recycled pottery based on a case study case from Koukonisi, Lemnos. The last presentation of the second section was given by Alina Iancu and focused on a special class of textile tools known in archaeology as bobbins or spools, discussing their functionality in the context of weaving on a warp-weighted loom.

The third part comprised three further oral presentations. Sanne Houbj Nielsen reassessed the role of the funerary model chests from Iron Age Athens as potential toolboxes and yarn containers, Gaia Sabetta presented how the wear patterns of textile tools should be recorded using RTI, while Gerasimoula Ioanna Nikolovieni showed practical examples of how to communicate textile artefacts through scientific and digital storytelling.

In addition to the above presentations, a poster on the same topic was prepared by Alina Iancu and Kalliope Sarri, entitled "Making Textile Tools from Scratch: Potsherds and Fragments of Bricks Recycled for Spinning and Weaving". However, as the EAA poster policy was changed this year, the poster was not presented in the regular EAA session "Textile Records", but was available in the joint Sapienza College e-poster hall and on the EAA app.

It is our hope that the results and conclusions of this conference will soon be published in a joint volume to expand knowledge in this field and provide guidance for archaeologists across Europe and beyond to better interpret such objects.

*By Alina Iancu & Kalliope Sarri*

## A stone age history of clothing

6 to 28 September 2024, Halle an der Saale, Germany

A conference with the special topic *A Stone Age History of Clothing – Zur Geschichte der Kleidung in der Steinzeit* took place in Halle an der Saale in Germany, as the 17th Archaeological Conference of Central Germany (17. Mitteldeutscher Archäologentag), which has been hosted and organised annually by the Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt – Landesmuseum für Vorgeschichte since 2004. The conference took place on the premises of the Martin Luther University Halle-Wittenberg at the Steintor Campus. The organiser was Claudia Gärtner, and the scientific directors were Harald Meller, Olaf Jöris, Oliver Dietrich and Roberto Risch.

This year's conference focussed on clothing and dress in the Stone Age in all its facets and forms. After a welcome by Harald Meller and Olaf Jöris, the conference began with a short introductory lecture by Olaf Jöris on the many dimensions of Stone Age clothing. The lectures were then roughly divided into different thematic blocks. Lectures focused on textile archaeology, archaeobotany, archaeozoology, anthropology, genetics, biology and even dermatology. On the Thursday, topics in the areas of "From possibilism and imagination to science and perception", "Clothing and body ornamentation in Stone Age artistic depictions", "Human bodily conditions: phylogenetic and environmental adoptive benefits of clothing and chronological overview" were presented. On the evening of the first day, the ARTE documentary "Ladies and princes of prehistory" from the year 2021 was screened. The documentary was a winner and contender for various film awards. It was directed by Pauline Coste, who also presented a lecture on clothing and nudity in scientific reconstructions from the 19th century to the present day and a lecture on the richness and diversity of burial rituals in the Gravettian period and their potential for clothing reconstructions in documentaries.

On Friday, the topics "Materials and technologies", "Social signalling and the social-psychological underpinnings of clothing" and "How to enter afterlife: the burial evidence for Stone Age clothing" were on the agenda. This also included an experimental archaeology lecture by Martha Görlitz on the functionality of different spindle whorls in practical use. The keynote lecture of the conference was given by Karina Grömer on "Clothing, messages

and identity: theoretical and methodological aspects of research on clothing in Central European prehistory". Her presentation also focussed on the theoretical concepts of clothing.

After the keynote lecture, a reception was held at the State Museum of Prehistory in Halle. The conference participants were provided with a buffet and were able to visit the museum and the exhibition on their own or with a guide.

On Saturday, the focus was on the topic of "Social differentiation in burial contexts". The final round of discussions and the farewell ceremony took place in the early afternoon. The conference proceedings are planned to be published in 2025.

By Lukas Dobler

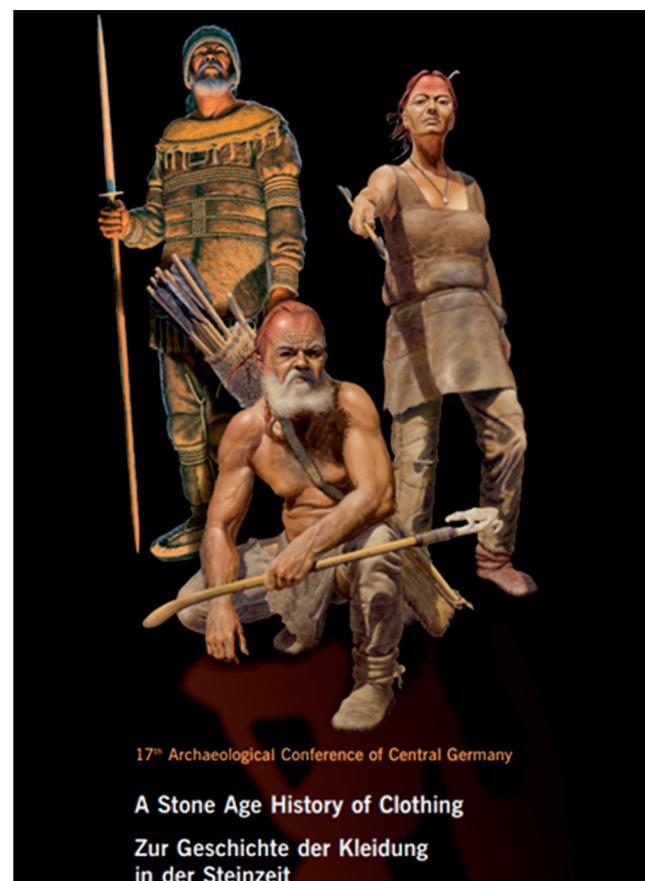


Fig. 10: Halle: cover picture from the *Stone Age History of Clothing* conference (Image: State Museum of Prehistory, Halle)

# Flax production through time: an interdisciplinary seminar

8 November 2024, Centre for Textile Research, University of Copenhagen, Denmark

The TRiVAL-project (Textile Resources in Viking Age Landscapes) and Kroppedal Museum organised in November 2024 a one-day interdisciplinary seminar for archaeologists, craftspeople, students, historians, conservators, volunteers, and others with an interest in flax in a prehistoric and historical context. The production of linen textiles and other flax products has had a significant impact on Danish society through the ages. In total, over 120 in-person and 35 online participants attended the seminar, demonstrating a large interest in this research field.

Knowledge about flax, its spread, and its use has significantly increased in the last couple of years, with scientific analysis, new excavations of flax production sites and facilities such as retting pits, finds of flax stems for retting, and new analyses of archaeological textiles, all providing new results, perspectives, and insights on the use and value of flax. The goal of the seminar was to present and share knowledge from new and old investigations about flax and flax production in Denmark from prehistoric to historic times. Additionally, it aimed to shed light on scientific methods regarding flax production and the possibilities they offer. The presentations covered information from several different research fields, spanning archaeology, history, craftsmanship, experimental archaeology, and various branches of science to contribute to a broader and more connected understanding of flax production, its economic and social importance, and its influence on society over time.

The first session introduced flax and flax production, covering everything from "How to grow your flax" to the final textile products. Pollen analyses demonstrate that flax has been cultivated since the Danish Late Neolithic but did not become common until the Pre-Roman Iron Age period (500 BCE – 1 BCE) when it was used for food and textiles. It can be assumed that many of the place names starting with 'Hør-' (flax in Danish) date back to the pre-industrial period, but also that many names are modern, i.e., from the period just before the Industrial Revolution. The earliest written mention of flax is from an original diploma from Grevlunda parish in Albo district, Scania, dated 15 March 1313. The most important archaeological

finds of linen textiles from prehistoric periods were reviewed, ranging from the very small linen threads on the body of the Huldremose Woman to the larger textile fragments from the late Iron Age. Archaeological linen textiles from the Middle Ages and modern times were also included in this presentation, as well as the traditions and superstitions associated with linen production. In the final lecture of the first session, we learned about the small Køng Museum between Næstved and Vordingborg, which has a rich history of the development of Denmark's finest linen industry. At Køng Factory, girls were trained in industrial flax spinning, and boys were trained to become weavers from 1787 until it closed in 1924

In the second session, Danish archaeological sites and artefacts related to flax production were presented. The construction of different types of flax drying pits, retting pits, structures for drying, textile tools, pit houses, and the location of these areas in the landscape were discussed. For example, the settlement at Firgårde in East Jutland has evidence of extensive flax production dating back to 50 BCE – 50 CE. Some locations boasted more than 80 pit structures for drying, such as the settlement at Kirstinehøj on

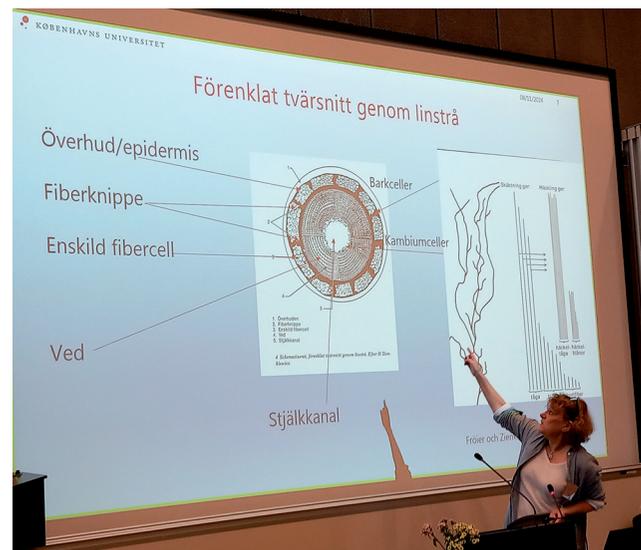


Fig. 11: Copenhagen – Flax production: Eva Andersson Stand giving the introductory lecture (Image: Kroppedal Museum)



Fig. 12: Copenhagen – Flax production: a view of the lecture hall and the participants (Image: Centre for Textile Research)

Sjælland, dated to the late Bronze Age – early Pre-Roman Iron Age (800 to 1 BCE). Another settlement on Sjælland, Næss, dated to 550 to 1050 CE, also had large-scale production demonstrated not only by retting pits and structures for drying but also tools suitable for producing linen cloth. Several sites on Fyn have traces of flax cultivation and production for both textiles and other uses from prehistory up to the 20th century. Finally, the session included an outlook on medieval flax production in the Rheinland, with ethnographic and experimental archaeological examples. Together, the session demonstrated that flax cultivation and the use of flax for both food and textiles are earlier than previously thought.

The last session combined scientific methods with ideas for the future use of flax and hemp. The speakers provided an overview of available and potential future methods such as aDNA for sampling, identifying, and tracking fibres from sites—a ‘who are you going to call?’ before, during, and after excavating. It is well known that pollen analyses are very important, and new analyses demonstrate increasing finds of hemp pollen in sea sediments, which indicate the use of hemp for rope and textiles as early as the Roman Iron Age (CE 1–400). It was also demonstrated how important

it is to do thorough fibre analyses. For example, not only flax and hemp can now be identified, but hops were also used for textile production, which was a big surprise for many in the audience. Just as in the past, the future could hold a bright spot for these fibres, and the Hemp4Tex project gave insight into this process. Throughout the day, attendees could feel, smell, and explore stems in different stages of production, textiles made from flax, and the tools used to work the fibres. In the evening, it was possible to try hands-on activities like preparing (breaking, scutching, and hackling), spinning (on drop spindle and spinning wheel), and weaving flax fibres at the Centre for Textile Research. A warp-weighted loom stands prepared for a future project with linen threads, and the attendees could get up close and personal with the astonishing amount of work that hides behind the soft textiles.

The programme and abstracts from the seminar can be found (in Danish) at: <https://archaeology.ku.dk/calendar/hoerproduktion-gennem-tiden/>

*By Camilla Fraas Rasmussen,  
Nikolaj Wiuff Kristensen  
& Eva Andersson Strand*

# Material literacy in object-based studies

4 December 2024, Uppsala University, Sweden

Uppsala University’s Textile Studies Research Group hosted a workshop to discuss how researchers examine textile and dress objects. The Uppsala group is developing the concept of ‘material literacy’ for training textile and dress researchers. The term ‘material literacy’ has been used in several different subject areas – from classroom practices for textile education today to understanding the consumers’ and makers’ familiarity with fibres, tools and techniques in the past. The Uppsala textile studies team proposes a new use of it to describe how a researcher’s perception of textile objects grows through experience-based preception. Contributions came from textile archaeologists, dress historians and curators, with educators, conservators and craft practitioners attending. All demonstrated and reflected upon how they defined material literacy in their own work.

Cecilia Aneer (Uppsala University), trained in traditional tailoring. Her paper, “Reaching beyond the object: Material literacy, position and objectives in three case studies”, comparing and contrasting her experience with objects at different stages in her development as a textile specialist.

Chrystel Brandenburgh, municipal archaeologist in Leiden, The Netherlands, presented the examination of a pair of shipwrecked 17th century stockings in “Small needles, big data: documenting knitted objects in the context of citizen science textile research”. Chrystel explained how an easily overlooked zigzag detail in the stockings revealed itself to be a clever counting aid during the reconstruction project. Katrin Kania’s research centres on the practical aspects of textile techniques and crafts. She described her process of looking at a range of original garments for reconstruction purposes in “What has been ... will be again”. One of her conclusions about examining original garments: “The question is not if you have forgotten something essential, it is how much, and when will you find out”.

Hilary Davidson (Fashion Institute of Technology, New York) presented “Establishing material literacy through positionality”. The notion that a researcher’s detailed biography provides a frame through which their work can be understood goes some way towards gauging their stage of development in material literacy. Susan North (Curator of Fashion before 1800, Victoria and Albert Museum, London) spoke on the subject of “Learning to Read (Old) Clothes” and discussed

the different portfolios of experience necessary for gaining sufficient familiarity with textiles and dress to examine them confidently.

Cecilia Candréus (Uppsala University) has researched the working conditions of early modern artisans and worked with 17th century ceremonial textiles. She reflected on how her material literacy has developed in ‘Guided by experiential knowledge’. One of her observations was that “there are significant advantages to considering the interplay between artisanal working conditions, access to materials, and the use of templates in object analysis”.

Jane Malcolm-Davies (Uppsala University) considered the importance of triangulating primary source data and then integrating craft expertise in “Re-positioning material skills and craft techniques at the centre of object-based research”. She identified how curators and conservators have opportunities to experience many textile objects, which provides one dimension of material literacy. Crafts practitioners develop familiarity with textile materials and techniques for handling them, which is another element of material literacy. The day ended with two large group discussions concluding that material literacy was a useful concept to consider in relation to textile research.

The Uppsala material literacy workshop is part of the final phase of *The Period Eye*, a research project funded by the Agnes Geijer Fund for Nordic Textile Research.

By Jane Malcolm-Davies



Fig. 13: Uppsala – Material literacy: Susan North, the V&A Museum’s Curator of Fashion before 1800, puts the examination of an 18th century gown in context (Image: Azul Tarazona Machicao)

# Nettie K. Adams

## 1934–2024

One does not embark on a textile archaeology journey after reasonable pondering and strategic considerations. It usually takes the serendipitous meeting between a crafty mind and a body of material. The latter is usually lying forlorn and understudied in an excavation storage magazine while the former is curious to tease as much information as possible from these sometimes unsightly rags. For Nettie K. Adams, this meeting occurred early in the 1960s, in the wake of the UNESCO Aswan High Dam salvage campaign in Nubia.

The site that became emblematic of this meeting is undoubtedly Qasr Ibrim. Now located c. 240 km upstream of Aswan, 70 km north of the modern border between Egypt and Sudan, the site barely survives as a small island surrounded by the waters of Lake Nasser. In earlier history however, this major settlement stood as a key point between two worlds, one turned towards the south and the other open to the Mediterranean, thus negotiating encounters between people, ideas and goods from the Kushite period in the mid-eighth century BCE to 1814 CE in the Ottoman period (Adams and Adams 2013). Perched high on a promontory, it housed temples and officials, as well as craftspeople and merchants. Most importantly for our story, the excavation of large midden deposits produced 25,000+ archaeological textiles every season. For Nettie Adams, there began the research of her life. Through years of hard work, patience, and curious inquiry, Nettie became a pioneer of ancient textile research and a true inspiration for anyone interested in the archaeology of the Middle Nile valley.

Before reaching Ibrim, Nettie had chosen the

adventures of archaeology very early on. Born in Tulsa, Oklahoma (USA) on 7 June 1934, she discovered archaeology as part of a Girl Scout program. Through her teenage years, she took part in the Senior Girl Scout Archaeological Camps organised by Bertha P. Dutton in the American southwest, the “Dirty Diggers”. This post-war initiative aimed at introducing girls to the cultural and scientific heritage of the region

and showed them new career possibilities in fields previously dominated by men (Fowler 2020). Nettie embraced that spirit and enrolled next at the University of Arizona, where she gained her bachelor’s degree in archaeology. There, she also met graduate student William Adams (Bill), whom she married in 1955 (More information on Nettie K. Adams’s personal history can be found at [https://www.kerrbrothers.com/obituaries/Nettie-K-](https://www.kerrbrothers.com/obituaries/Nettie-K-Adams?obId=32026744)



Fig. 1: Nettie K. Adams preparing a textile for study on the deck of the team houseboat at Qasr Ibrim (Image: archives N.K. Adams/ Centre for Textile Research, UCPH)

Adams?obId=32026744, consulted 29/10/2024).

Together, they started a shared career in archaeology, first surveying Native American sites along rivers of the southwest, and soon in Nubia, where they applied this “riverbank” experience for the count of the UNESCO Aswan High Dam project. They lived several years in Khartoum and Wadi Halfa, working at Faras and Kulubnarti for the then Sudan Government Antiquities Service. In 1972, their path led them to Qasr Ibrim, to work under the auspices of the Egypt Exploration Society (London, UK) and the Egyptian Antiquities Services. For the next 16 years, a season of excavation was organised every second year, for eight to 12 weeks, during which the crew of archaeologists

was housed on a flotilla of boats and barges under the cliff side, far from any amenities and supplies (fig. 1). Nettie joined Bill at Qasr Ibrim starting in 1976, accompanied by their young sons (Plumley 1977). Besides coordinating many aspects of the complex daily logistics, Nettie was soon in charge of the lab and documenting “small finds”, a task she pushed through publication for the rest of her career, all the way to the mid-2010s.

Nettie had previously worked on the textile finds excavated at Kulubnarti (Adams et al. 1998; Adams 1989a-b; 1990; 1999), but it is her meeting with the Qasr Ibrim material that truly made her the textile researcher that she became. While other sites, including those in Egypt and Sudan, would give at best a few hundreds of textile pieces a year, the astonishing quantity of material produced during the Qasr Ibrim excavations presented extraordinary challenges. Luckily, Nettie did not meet these difficulties alone but was accompanied by another textile pioneer: Elisabeth Crowfoot. Elisabeth Crowfoot joined the Ibrim team the same year as Nettie, as a textile expert, and soon associated Nettie with her work (Crowfoot 1977; Anderson and Adams 1979). In the following seasons, together they devised a quantitative approach that allowed them to analyse a vast amount of material. From the 1978 season, while Bill Adams mentions the recording of over 20,000 textile fragments (Adams 1979, 10), Elisabeth describes their method as such: “During the season thousands of fragments of textile were examined. It soon became obvious that it would be impossible to keep such a quantity, often from very similar and highly deteriorated fabrics. A great mass of the material, therefore, had to be catalogued briefly – fibre, spin, weave, grade, colour, borders, and other details – and then discarded, but should still provide valuable statistical evidence. The more interesting fabrics were cleaned and catalogued fully, a study collection being preserved as well as numbered pieces possibly suitable for museum exhibition” (Crowfoot 1979, 39). This encapsulates their approach for the following seasons: sorting immense quantities of textiles, processing basic but still precise data by the thousands, selecting, sorting again, washing, and analysing (fig. 2). Every season, they also compiled a brief summary of the material for the excavation report (Crowfoot 1977; 1979; Adams et al. 1983; Alexander and Driskell 1985). While these methods – especially the washing of archaeological textiles – would not be routinely carried out today, their combined efforts laid the foundations of our understanding of textile production and usage at Qasr Ibrim, and more generally in Nubia. Thanks to Crowfoot’s training

and continued correspondence, Nettie acquired a very solid knowledge and an extensive experience in dealing with such varied textile material.

Nettie, however, went far beyond the technical analysis of the weave, as she quickly understood the historical value of such exceptional material. She began publishing short articles focussing on the finds as early as 1981 (Adams 1981; 1986) in journals specialized in African archaeology and textile archaeology, comparing them with neighbouring sites (Adams 1985). She also devoted an in-depth study of a specific openwork technique, which she traced back to the Bronze Age period and the pot nets produced at Kerma (Adams 1998). Nettie kept herself well abreast of methodological advancements in textile research and used available resources in her network to enhance her documentation. For example, she sent samples for fibre identification by Scanning Electron Microscopy and attempted elemental analyses to identify the liquid that soaked offering textiles from the Isis temple at Ibrim (research conducted in 1987 by several scholars in the USA, including Donna Harris at Allied Fibre, unpublished).

This interest in understanding textile production through time and space developed with our growing understanding of the political changes in Nubia during Late Antiquity and the early medieval times, so she was able to identify larger trends and view specimens from Qasr Ibrim at a macro-regional scale (Adams and Crowfoot 2001; Adams 2013). In that respect, the painstaking sorting carried out in the field and the use of expanding study collections of representative examples for each period of Ibrim’s occupation proved invaluable. She combined solid statistical analyses, based on thousands and thousands of artifacts, with her observations on the manufacturing of threads, and discovered clear changes in the use of fibres through time: first flax, during the first Kushite phase of the site and then during the short occupation of the fortress by the Roman army, then the arrival and hegemony of cotton, during the Meroitic period, and the subsequent domination of wool, combined with a growing number of imported fabrics in the Medieval and Ottoman periods. She framed these fluctuations in the political and economic evolutions at the site itself and in Nubia in general (Adams 2007/2010). This was the first attempt in Nubian archaeology at linking textile data with economic interpretations and broader historical questions.

From the beginning of her research, she was also interested in understanding the textile material in its context of use, despite the immense difficulties posed by the archaeological context at Ibrim. Used and



Fig. 2: Nettie K. Adams and colleague at work on the textile-washing table, among the buildings of Qasr Ibrim (Image: archives N.K. Adams/Centre for Textile Research, UCPH)

reused, fragmented and dumped in refuse ditches or storage cellars, then excavated by archaeologists in troves, most of the artefacts had lost all information of provenance or context by the time they reached Elisabeth Crowfoot and Nettie Adams. Piecing together their original shape and function was, from there, a hard and rarely successful endeavour. Nettie chose to tap into other sources to interpret the material: using the plentiful Meroitic iconography showing high officials in different attire, she proposed parallels between images of ancient Sudanese costume and preserved finds of the same period (Adams 1989c; 2015). At a time when textiles were disregarded as an uninteresting material by many archaeologists, Nettie chose to entitle her 1989 seminal paper “Meroitic high fashion” in an unapologetic act of academic bravery, but certainly not without humour. She managed to show that dress practices were a crucial part of society and identified patterns of change in the Qasr Ibrim material as markers for social and religious transformations (Adams 2001; Adams 1996a). Her work was also marked by the discovery of an

incredible textile assemblage in a small temple dedicated to Isis and dated to the end of the Meroitic or Postmeroitic period, c.350–550 CE (Adams 1987; 1996b, 2006; Adams and Adams 2013; Driskell et al. 1989). Left abandoned in the temple after the conversion to Christianity, the textile material encompasses a wide array of objects that Nettie interpreted as the furnishings of a sacred building: tapestry pieces used to decorate the walls or altar(s), cases for sacred objects such as wooden containers and a pair of arms from a statue, or even textile bundles used to soak up milk or other liquids given as offerings to the goddess. Interestingly, the temple also contained a storage pit filled with loom weights and several textile tools, as well as a group of miniature textiles decorated with complex openwork borders and fringed tassels or tapestry patterns. Nettie put forward the hypothesis of a textile production carried out in the temple, maybe in a workshop setting, which included the teaching of specialised techniques. Drawing parallels with the Graeco-Roman world, she framed this material

in concepts of knowledge transfer and craft apprenticeship, opening avenues that remain, to this day, mainly unexplored in Nubian archaeology.

Without any doubt, Nettie's research has propelled textile research in Sudanese and Nubian archaeology, merging material analyses with theoretical thinking. Her relentless efforts to give talks and to publish in many different types of venues, specialised in textiles as well as open to the wider archaeological community, has made Qasr Ibrim a "household name" in textile research and has shown the high potential of textiles to answer wider historical questions. In that sense, Nettie was a pioneer in both textile and Sudanese archaeology. She was extremely generous with her knowledge, in her everyday work at the Webb Museum of Anthropology in Lexington as well as with her research, which she openly shared with other scholars. After a meeting in 2001, for example, she started exchanging with John Peter Wild, inspiring a growing research interest in the expansion of cotton production and trade in the ancient world. John Peter soon took over the documentation of Qasr Ibrim's textiles, together with his wife Felicity. They found themselves welcomed on site by the study collections assembled by their predecessors in the storage magazines at Shellal, supported by copious notes designed to enlighten newcomers to the material. Later, while residing in Cambridge, Nettie and Bill invited them to see their documentation and discuss the Qasr Ibrim assemblage, sharing their experience in a lively question and answer session. John Peter remembers Nettie as "having a firm grip on the archaeological background of all the finds, full of fertile ideas, and as someone who could always be relied on for a speedy response to a query from a distant correspondent".

Through emails and letters, she continued to be a driving inspiration for the next generation of textile scholars, starting with the present author. During my doctoral research in the 2010s, Nettie shared a lot of her work and data, sending me unpublished versions of her articles and very generously allowing me to use her photographic records of the Qasr Ibrim textiles curated at the Bolton Museum in the U.K. Sarah Hitchens, who recently conducted research on this large collection for her PhD, reports that opening the boxes and reading the textile inventories was like "walking in Nettie's footsteps". Neat notes and long lists of textiles, technical characteristics, and even early dye analysis results, reveal how meticulously Nettie went through the material, considering every aspect of the textile's manufacture. To start researching Nubian textiles is to dive headfirst into

Qasr Ibrim's material and – inevitably – to start following Nettie's ideas, one thread after the other, to continue weaving Nettie's work.

#### Acknowledgements

My gratitude goes first and foremost to Nettie, posthumously, for being so generous with me when I started my own journey in textile research. I also would like to thank her son Ernest Wheeler Adams and daughter-in-law Mary Ellen Foley for sharing Nettie's archives with me, including parts of her correspondence with Elisabeth Crowfoot and photographs and notes from her work in Qasr Ibrim. John Peter Wild also agreed to relate his memories of meeting Nettie and working in Shellal (relevant parts are here freely adapted from his text), while Sarah Hitchens described her working in Bolton Museum during a recent conversation.

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By Elsa Yvanez

# Amica Sundström

## 1973–2024

Amica Sundström, Stockholm, the first Antiquarian at the National Historical Museums has passed away at the age of 51. It is with great sorrow that we announce the passing of our dear friend Amica Sundström after a period of illness. Amica leaves behind a daughter, parents, siblings with their families, as well as many friends and colleagues in the textile field worldwide. Amica grew up in Stockholm and, after studying textile crafts at S:t Göran's Gymnasium, continued her studies in hand weaving at Stockholm Folk High School in Årsta. She then moved to Borås to study hand weaving at Väfskolan, the Textile School in Borås. At Väfskolan, Amica's interest in the analysis and reconstruction of older textiles was sparked, and this became an important focus throughout her career.

After studying archaeology at the University of Gothenburg and Stockholm University, Amica worked as a lecturer in woven constructions at Konstfack in Stockholm for 18 years. Concurrently, Amica worked on analysis projects and reconstructions of primarily archaeological textiles, such as the Gerum cloak and the horsehair-bound bands on the Högom man's outfit. In 2018, she was employed as the first textile antiquarian, a position she held at the time of her passing. Alongside this, Amica ran the company Historical Textiles and worked as an interpreter at the visual interpretation training centre at Fellingsbro Folk High School.

Amica had a great commitment to the dissemination of knowledge about textiles, and her technical expertise in textile constructions was immensely valuable in her work with the analysis of historical textiles. She was a co-founder of the Swedish Weaving Academy in 2017 and co-author of *The Art of Weaving* in 2021, together with Åsa Pärsson. The collective work to recreate four gold-embroidered medieval quilts resulted, among other things, in Amica and Maria Neijman being awarded the Mandelgren Prize by the Swedish Antiquarian Society in 2021.



Amica Sundström (Image: Bonnier)

Amica was an enthusiastic, curious, and generous friend and colleague. Her deep textile knowledge and willingness to share it will be missed by all who met her. The Historical Textiles Facebook page received an outpouring of affection and respect for Amica and her work. Here are some of the (anonymised) comments. Many of them were addressed to Maria Neijman, her colleague and fellow self-styled "textile nerd" at Historical Textiles ([historicaltextiles.org](http://historicaltextiles.org)):

"So very sad. Far too early to lose such a talented woman, researcher and above all, a formidable communicator ... Amica was such a sweet soul! It seems impossible to accept that someone who was so happy and alive just a few months ago, is now no longer here ... The sharing of knowledge, work and enthusiasm we have seen from both of you over the years is wonderful, and Amica is such a great loss ... A terribly sad loss, a young, talented researcher, a good loving person ... Amica was a kind and generous person. She shared her knowledge so freely and with excitement ... [Amica] was an example, and you are both an inspiration. A great loss but all the lessons and research are here to stay ... I remember fondly how she dressed to show off the

fabric from Margaret's golden skirt, how it shone in her eyes with joy and pride ... It is impossible to extinguish a star like Amica! We, who have had the pleasure of sharing Amica's unparalleled knowledge and wholehearted commitment to what she found joy in, have a hard time believing that she no longer shines ... [Amica] was a brilliant and amazing human being – I've learned so much through her work ... [Amica] was a bright light in the corona period and a beacon of knowledge ... [Amica] has left so many wonderful impressions behind, among other things with her art, knowledge, creativity and friendship."

*By Maria Neijman,  
friends and colleagues*



## Recent publications

***Ancient Egyptian Clothing: Studies in Late Period Private Representations, Volume 1* by Aleksandra Hallmann (2023). Brill**

This lavishly illustrated book provides a comprehensive analysis of clothing in Late Period Egypt (750 to 332 BCE) through a comparison of representations on reliefs, paintings, and statues to preserved textiles, and supplemented by references in ancient texts. It shows the historical evolution of clothing that extends far beyond the Late Period. The book reveals the influence of archaism and innovation, as well as how clothes reflect geography, ethnicity, and social roles. It provides some new criteria for dating and interpretation of representations through careful examination of changes in Egyptian fashion. The resulting work is of value to anyone studying dress in ancient Egypt and other areas of the ancient world. ISBN: 978-90-04-50131-7

Price: € 251.90

<https://brill.com/display/title/59306?language=en>

***Archaeological Puzzles in a Museum: Online catalogue and exhibition at the National Museum of Denmark homepage* by Maria Mossakowska-Gaubert (2023). University of Copenhagen and the National Museum of Denmark**

The National Museum of Denmark houses 112 textile fragments from Roman, Byzantine, and Early Medieval Arab Egypt, comprising the richest ensemble in Denmark. The aim of the online exhibition is to give an insight into the history of the collection and the textiles therein. The exhibition consists of three parts. The "Introduction", in English and Danish, includes general information on what a collection of Egyptian textiles is, how it is created, and the methods of reconstructing its history and that of the objects that form it. The "Catalogue" presents 30 selected fabrics, arranged according to the four stages of the collection's history. This section also contains detailed information on how and from whom the various objects were acquired. The indicative Bibliography is presented separately. For the visitor who wishes to go deeper into various topics, we have prepared eight "Case Studies".

The documents are presented in the form of 12 downloadable PDFs. A combined version is also available at: <https://en.natmus.dk/museums-and-palaces/the-national-museum-of-denmark/exhibitions/classical-and-near-eastern-antiquities/archaeological-puzzles-in-a-museum/>

***Der griechische Leinenpanzer im experimental-archäologischen Versuch: Eine Zwischenbilanz des Hamburger Projektes mit zum Hoplitenschild (The Greek linothorax in an archaeological experiment: Current results of a project in Hamburg with an outlook to the Hoplite shield* by Michael Zerjadtke (2024). Books on Demand**

Linen armour was the predominant type of breastplate in Classical Greece. It was worn by hoplites, many horsemen and lightly equipped peltasts. Due to its perishable materials, no example of this armour has survived to this day. Nevertheless, thanks to information from archaeological and literary sources, it is possible to make some statements about the nature and construction of the linen armour. However, more precise information about its construction and protective effect can only be obtained through experimental archaeological tests. The Hamburg project "linothorax" has been carrying out such experiments for several years. This volume provides a first comprehensive interim summary of this work. It contains an overview of the hoplite as a wearer of armour, the most important sources, the Hamburg experiments and the protective effect of the linen armour. Further chapters provide detailed descriptions of the manufacture of linen armour plates, bronze scales and breastplates. The book thus serves not only as an introductory work on linen armour, but can also be used as a guide for further experiments.

ISBN: 978-37-58-31561-9

Price: € 14.99

<https://buchshop.bod.de/der-griechische-leinenpanzer-im-experimentalarchaeologischen-versuch-9783758315619>

*Geschichte der Textilherstellung: Technologien, Erfindungen, Handel, Mode – von der Steinzeit bis heute (History of Textile Production: Technologies, inventions, trade and fashion – from the Stone Age up until today)* by Dieter Veit (2024). Hanser Fachbuch

When were the first textiles produced? What did people in Ancient Egypt wear? Which role did the fabric trade play in the Middle Ages? Why did the Industrial Revolution begin with textile production? Why do we all wear polyester today? What will the future of textile production look like? These and many other questions are vividly answered in this richly illustrated and well-written book. In addition to presenting all the important fibres, technologies for yarn and fabric production and inventions from the Stone Age to the present day, the book also looks at the social changes that have gone hand in hand with the production and trade of textiles. The global approach is particularly noteworthy: the focus is not only on Europe, but also on developments in Asia, Africa and America. Legends and fairy tales related to textiles, the changes in fashion over the centuries and common textile phrases round off the work and provide a link to our everyday lives.

ISBN: 978-3-446-47953-1

Price: € 99.99

<https://www.hanser-fachbuch.de/fachbuch/artikel/9783446479531>

*IX Jornadas Internacionales de Textiles Precolombinos y Amerindianos / 9th International Conference on Pre-Columbian and Amerindian Textiles* by Carolina Orsini and Federica Villa (2024). Zea Books

ISBN: 978-1-60962-304-3

Price: € 35

<https://www.lulu.com/shop/federica-villa-and-carolina-orsini/ix-jornadas-internacionales-de-textiles-precolombinos-y-amerindianos-9th-international-conference-on-pre-columbian-and-amerindian-textiles/paperback/product-579yg89.html?page=1&pageSize=4>

Free download: <https://digitalcommons.unl.edu/zeabook/152/>

*Le monde grec des foulons. Histoire et archéologie d'un métier du textile dans l'Orient grec (The Greek world of fullers. History and archaeology of a textile trade in the Greek East)* by Enora Le Quéré (2024). Presses universitaires du Septentrion

Fullers were among the textile craftsmen who were indispensable to daily life in Antiquity, but they have

been forgotten by history for far too long. Yet their role was crucial to the economy of textile production, as they were responsible for the finishing of the fabrics, and at the same time quite mundane, as people entrusted their clothes to them for daily cleaning. This book delves into the world of the fullers of the Greek East (including Egypt) and, based on a technical study of their workshops and an archaeology of their “chaînes opératoires”, attempts to place these textile craftsmen in their professional, economic, social and civic environment. By systematically comparing all available data – literary texts, inscriptions, papyri, iconographic and archaeological sources – we are able to bring these everyday workers out of the shadows and rehabilitate them as historical actors in Greek and Hellenised societies in the eastern Mediterranean for almost a millennium.

ISBN: 978-2-7574-4194-7

Price: € 30

<https://www.septentrion.com/fr/livre/?GCOI=27574100977530>

Free to read online: <https://books.openedition.org/septentrion/180327?lang=en>

*Life and Death in 3rd Century Vorbasse I-II – a case study of Late Roman Iron Age society in Jutland and surrounding areas* by Ulla Lund Hansen and Per Ethelberg (2024). University Press of Southern Denmark

Through three generations during a period of the Late Roman Iron Age, some of the people who lived in the settlement at Vorbasse were buried at the four cemeteries. There is one cemetery with richly furnished burials (Vorbasse I), one with a little less richly furnished burials (Vorbasse II), and two with simply furnished burials (Vorbasse III and IV). The four cemeteries were in use with overlap from the middle of phase C1b until the end of phase C2 or the very beginning of phase C3, largely corresponding to most of the third and the beginning of the fourth centuries CE. The location of the cemeteries and the pottery from the graves allow an estimation of which farmsteads the cemeteries belonged to. Vorbasse represents a rare opportunity in Danish archaeology to gain a unique insight into the connection between specific farmsteads in the village and the residents' cemeteries. The diversity and multiplicity of the grave goods clearly reflect the social layers within the settlement, their relations, as well as the different elite networks which existed across large distances in the Late Roman Iron Age. This publication of the cemetery evidence is the first of four volumes covering



the entire Vorbasse complex. It also contains a large section about the textiles in the graves and textile production in this period.

ISBN: 978-87-408-3531-1

Price: DKK 598

<https://www.universitypress.dk/shop/life-and-death-4131p.html>

***Medieval Clothing and Textiles 18* by Cordelia Warr (2024). Boydell and Brewer**

The essays collected here continue the journal's wide-ranging and eclectic tradition. Topics include literary evidence for linen armour; serial production in late medieval silks; the inventory of Isabella Bruce's bridal goods; the depiction of women textile workers in the frescoes of the Salone of the Palazzo della Ragione in Padua, Italy; ideal female beauty in the Middle Ages and the means used to attain and assess it; and social status as evidenced by clothing and textiles in the Scottish royal treasurer's accounts of the mid-16th century.

ISBN: 978-1-80543-305-7

Price: £ 50.00

<https://boydellandbrewer.com/9781837651856/medieval-clothing-and-textiles-18/>

***Mit Nadel und Faden: Schmuck, Tracht und Kleidung in der Eisenzeit (With needle and thread: Jewellery, costume and clothing in the Iron Age)* by Maria Kohle, Ines Balzer, Janine Fries-Knoblach, Steeve Gentner, Margarethe Kirchmayr, Thimo Brestel, Mario Schmidt, Robert Schumann and Jasmin Wallner (2024). Beier & Beran**

Die in diesem Tagungsband publizierten Beiträge gehen auf die 34. Jahressitzung der Arbeitsgemeinschaft Eisenzeit zurück, die ursprünglich 2021 im Rahmen der Tagung der Mittel- und Ostdeutschen sowie West- und Süddeutschen Verbände für Archäologie stattfinden sollte. Die Corona-Pandemie bestimmte jedoch 2021 weiterhin unser Alltags- und Arbeitsleben. Eine Umsetzung der Tagung war 2021 nicht möglich und auch ein Zusammenkommen für 2022 erschien ungewiss. Der Beirat und der damalige Sprecher der AG Eisenzeit entschieden sich daher die Jahressitzung der Arbeitsgemeinschaft als eigenständige Online-Tagung im Frühjahr 2022 umzusetzen. Diese fand vom 4. bis 5. April 2022 zum Thema „Mit Nadel und Faden: Schmuck, Tracht und Kleidung in der Eisenzeit“ statt. Insgesamt sechzehn Vorträge wurden präsentiert, die sich entweder dem Tagungsthema widmeten oder aktuelle

Forschungen zur Eisenzeit Mitteleuropas vorstellten. Viele der Präsentationen sind im vorliegenden Band versammelt. Alle Beiträge durchliefen ein zweifaches peer-review-Verfahren durch den Beirat der AG Eisenzeit.

ISBN: 978-3-95741-212-6

Price: € 39

<https://archaeologie-und-buecher.de/shop/zeitschriftreihen/beitraege-zur-ur-und-fruehgeschichte-mittleuropas-bufm/bufm-band-108-mit-nadel-und-faden-schmuck-tracht-und-kleidung-in-der-eisenzeit/>

***Must Farm Pile-Dwelling Settlement: Volume 2. Specialist reports* by Rachel Ballantyne, Anwen Cooper, David Gibson, Mark Knight and Iona Robinson Zeki (2024). McDonald Institute for Archaeological Research**

The Late Bronze Age pile-dwelling settlement at Must Farm is one of the most important and best-preserved prehistoric sites to have been systematically excavated in Europe. The settlement comprised a curving palisade enclosing five stilt-raised houses erected above a freshwater river channel at the edge of one most Britain's most intensively studied and internationally renowned Bronze Age landscapes: the Flag Fen Basin. Built in the mid-ninth century BCE, the pile-dwelling was engulfed by a catastrophic fire less than a year after construction, sending the buildings and their artefact-rich contents into the sluggish waters below. A combination of fire, water and rapid burial ensured extraordinary levels of preservation, whilst the manner of collapse and brevity of settlement gave the structural remains, and their vibrant material assemblages, a pristine quality. Each household had its own inventory comprising combinations of delicate textiles, wooden containers, hafts and wheels, complete pottery sets, bronze toolkits and the scattered remnants of necklaces of glass beads. Food remains included butchered wild and domestic animal bones, charred plants and seeds, and even the burnt residues of individual meals.

ISBN: 978-1-913344-17-7

Free download: <https://www.repository.cam.ac.uk/collections/266ae233-3f2a-4f2c-a341-5f61e3dd49f7>

***Sur un fil ou l'art de se vêtir au Moyen Âge (On a thread or the art of dressing in the Middle Ages)* by Géraldine Mocellin, Sylvain Demarthe and Nicolas Reveyron (2024). Éditions Faton**

Les récits bibliques ou hagiographiques comme l'ensemble du corpus littéraire associé à l'iconographie

permettent d'appréhender le vêtement au sens large, sans nécessairement apporter de contenu descriptif fidèle. Il signifie, décrit, illustre un contexte, un événement, révèle un statut social, se transforme jusqu'à incarner un style, une mode, allant même jusqu'à donner à percevoir la psychologie du personnage convoqué. Formes, couleurs ou matières donnent à voir et à comprendre les échanges commerciaux, les influences et animent les célèbres foires de Champagne ou encore de lointains comptoirs commerciaux. Vêtement combattant, tantôt cuirasse, tantôt atour de séduction ; vêtement des champs ou vêtement des villes ; vêtement de cour ou vêtement liturgique ; vêtement de la dérision du carnaval ou de la danse macabre ; tissus profanes qui par un transfert d'usage se muent en de précieuses reliques textiles, tous relatent une histoire de l'évolution de notre rapport au corps et à l'art de le vêtir. L'exposition Sur un fil ou L'art de se vêtir au Moyen Âge comme la publication éponyme proposent un voyage immersif au cœur d'un Moyen Âge sensible et tactile.

ISBN: 978-2-87844-373-8

Price: € 25

<https://www.faton.fr/editions/livre/un-fil.54206.php>

***The Common Thread: Collected Essays in Honour of Eva Andersson Strand* edited by Ulla Mannering, Marie-Louise Nosch and Anne Drewsen (2024). Brepols Publishers**

The Ancient Egyptians used textiles for both the living and the dead, the Greeks and Romans used it to signal their status, and it aided the Vikings in reaching the far shores of Europe and Eurasia. Textiles have surrounded us, literally and figuratively for millennia, but this common thread has long been ignored in scholarly research. With the inception of the Centre for Textile Research at the University of Copenhagen in 2005, however, this approach changed fundamentally, and today, every type of research discipline comes together to begin unravelling the stories told by textiles.

How do we understand textiles and how do we talk about them? Who produced textiles, where, and for what purposes? How do we conduct research into the origins of materials? How did cultivating flax or raising sheep change the ancient landscape? How have we researched textiles so far? What can we learn from textiles about society, gender, and production? This volume engages with these questions and explores how the fabric of society has changed through researching textiles in all its facets,

from archaeology and history to natural sciences. Taking as its starting point the research interests and career of its honorand, Eva Andersson Strand, this meticulously researched volume consists of three parts, covering the tools and techniques that form the basis of all research explores; how craftspeople made use of tools and techniques; and how textiles have been used over millennia to signify identity and status.

ISBN: 978-2-503-61277-5

Price: € 110

<https://www.brepols.net/products/IS-9782503612775-1>

Free download: <https://www.brepolonline.net/action/showBook?doi=10.1484%2FM.NAA-EB.5.138139>

***Textile Crossroads: Exploring European Clothing, Identity, and Culture across Millennia* by Kerstin Droß-Krüpe, Louise Quillien and Kalliope Sarri (2024). Zea Books**

Research from COST Action "CA 19131 – EuroWeb"

These essays on various aspects of textile research encompass a wide chronological perspective and vast geographical area, enriching traditional disciplines with innovative methodologies such as isotopic tracing of provenance, textile analysis, protein analysis, digital motion capture, and exploration of textile expressions in texts and folklore. All essays in this volume have been written by international teams of scholars from the participating countries. The anthology serves as a comprehensive and innovative resource, consolidating the research outcomes and insights gained from the interdisciplinary exploration of textiles in European history within the framework of EuroWeb. This volume has the potential to contribute to the advancement of European scientific excellence and competitiveness, fostering a deeper understanding of the cultural, technological, and societal significance of textiles and clothing in shaping European identity and heritage through the millenia. We hope that the anthology will find a wide and interested readership, and that it will inspire many new research projects in the field of textile history.

ISBN: 978-1-60962-315-9

Price: € 24

<https://www.lulu.com/shop/kalliope-sarri-and-louise-quillien-and-kerstin-dro%C3%9F-kr%C3%BCpe/textile-crossroads-exploring-european-clothing-identity-and-culture-across-millennia/paperback/product-w4v29kd.html?page=1&pageSize=4>

Free download: <https://digitalcommons.unl.edu/texroads/>



***Textiles of Ireland: Archaeology, craft, art* by Elizabeth Wincott Heckett, edited by Mary Ann Williams (2024). Cork University Press**

Archaeologist Elizabeth Wincott Heckett used to tell her students that only one technology made it possible for human beings to live all over the world and thrive, and that is the ability to make textiles. Her understanding of fibre and cloth was rooted in the experience of being raised in a family of women who sewed and knitted what they wore. She brought that same maker's sensibility to her study of Ireland's ancient textiles.

This book brings together 32 of Wincott Heckett's papers, talks and reports for the first time. It begins with an article that describes what an archaeologist encounters in the field. The second paper discusses how a sense of the 'right' pattern is passed from one generation to the next. Subsequent chapters explore textiles in chronological order, from a mysterious Bronze Age ornament, woven of horsehair, found in County Antrim, to the exquisite liturgical textiles created for the Honan Chapel in Cork in 1916.

While meticulously detailing technical information, Wincott Heckett often takes a fresh approach to the textiles that are her focus. That same spirit of curious consideration characterised the first research she published on headcoverings discovered during the excavation of Viking Age habitation sites at Wood Quay in Dublin. That paper, on a clothing type that came to be known, as the 'Dublin cap,' established her reputation and is included in this volume.

The book also includes previously unpublished reports on a fragment of nalbinding discovered in St Audoen's Church in Dublin; thirteenth-century metal buttons discovered on Barrack Street in Cork; and a fragment of charred linen, dating from the seventh century, discovered inside a kiln found in a souterrain during the excavation of a ringfort in County Kildare.

Frances Pritchard's thoughtful introduction gives readers an overview of Wincott Heckett's work and its importance. The text includes more than 100 photographs of artefacts and related materials. Illustrations by Rotterdam-based artist, Kelvin Wilson and archaeologist and textile maker Rhoda Cronin-Allinac, help bring the textiles to life.

ISBN: 2024945695

Price: € 59

<https://www.corkuniversitypress.com/9781782055716/textiles-of-ireland/?srsltid=AfmBOoqLH9JgYOTjfnkw6E97YjbS7BBApY3n6AURfAAr--EhKCZni8V4>

***Textiles of the Viking North Atlantic: Analysis, Interpretation, Re-creation* by Alexandra Lester-Makin and Gale R. Owen-Crocker (2024). Boydell and Brewer**

This volume offers the first full study of archaeological fabrics and their decoration found in the North Atlantic region and dating broadly from the Viking or Norse period. With contributions from both academic scholars and practitioners, it shows how approaching early medieval textiles from archaeological, historical and literary contexts, and through the processes of learning and employing the traditional skills of making them, brings about a more nuanced understanding of early medieval cloths: their creation, use and meanings within their respective societies. The book is divided into two parts. The first, "Textiles and their Interpretation", takes the reader on a journey from how wool was processed in the Viking Age, and the conservator's role in preserving and interpreting archaeological textiles, to different types of analyses that researchers use to understand and explain textiles from across the wide area of the Viking-influenced North Atlantic region. The second, "Understanding through Replicating", investigates the results of practical experiments in the reconstruction of surviving medieval fabrics and the resulting empirical conclusions that can be made about their manufacture and wider cultural implications.

ISBN: 978-1-83765-013-2

Price: £ 80

<https://boydellandbrewer.com/9781837650132/textiles-of-the-viking-north-atlantic/>

***Tøj og Tekstiler i Danmarks Oldtid (Clothing and Textiles in the Danish Prehistory)* by Ulla Mannering (2024). Turbine**

For thousands of years, textile and skins protected us against weather and wind. For the last 20 years research in some of the fantastic prehistoric textiles and clothing items belonging to the collections at the National Museum of Denmark has produced many surprising and new results. We now know much more about the materials, colors and the design of the prehistoric outfits constructed by our ancestors. It is well-known that clothes makes the man, and therefore it is no surprise in the outfits of what the Egtved, Huldremose and Hvidehøj women were wearing for burial. This book provides a comprehensive but easy-read overview (in Danish) of the development and production of the prehistoric textiles and clothing from the Stone Age to the Viking Age.



This is the third book in the series I Danmarks Oldtid (In the Danish Prehistory) which is a theme-based book series.

ISBN: 9788740669930

Price: DKK 299

<https://turbine.dk/produkt/toej-og-tekstil-danmarks-oldtid/>

***Viking Age Wool Fibres: Fashioning the Viking Age 4* by Irene Skals, Charlotte Rimstad and Ulla Mannering (2024). National Museum of Denmark**

This part of the Fashioning the Viking Age project presents the fibre analyses, based on yarn samples from all the textiles included in the *Fashioning the Viking Age* project, with the aim of obtaining a general impression of the wool used in Viking Age textiles. This material includes a selected range of samples from textiles

found in the graves of Bjerringhøj and Hvilehøj from Jutland in Denmark as well as from the settlement of Hedeby in Northern Germany. Furthermore, analyses of wool samples from different modern primitive sheep breeds have been made to enable the finding of materials of comparable quality for the reconstructed textiles in Project Parts 1 and 2. All results of the fibre measurements and calculations are presented in the included catalogue.

ISBN: 978 8776 02376

Price: DKK 184.75

<https://www.webshophum-en.ku.dk/shop/viking-age-wool-3365p.html>

Free download: [https://natmus.dk/fileadmin/user\\_upload/Editor/natmus/oldtiden/Fashioning\\_the\\_Viking\\_Age/Skals\\_et\\_al\\_2024\\_Viking\\_Age\\_Wool\\_Fibres.pdf](https://natmus.dk/fileadmin/user_upload/Editor/natmus/oldtiden/Fashioning_the_Viking_Age/Skals_et_al_2024_Viking_Age_Wool_Fibres.pdf)



## PhDs

**Peder Flemestad** was awarded the PhD degree in November 2022 at the University of Lund, Sweden, for his dissertation entitled *Order and Adornment: The Role of Dress in Plutarch*. It was published by Media-Tryck (ISBN 978-91-89415-47-8).

**Anique Hamelink** was awarded the PhD degree in December 2024 at the University of Amsterdam, The Netherlands, for her dissertation entitled *Monumentalising Identities: Presenting Dress, Gender and Identity in Funerary Portraits in the Roman North-west*. Several parts of the dissertation are published as articles and can be found on <https://uva.academia.edu/AniqueHamelink>

**Anne Kwaspen** was awarded the PhD degree in September 2024 at the University of Copenhagen, Denmark, for her dissertation entitled *Expressions through Style: The Significance of Technique and Shape in Early Medieval Egyptian Tunics*.

**José María Moreno-Narganes** was awarded the PhD degree in July 2024 at the University of Alicante, Spain, for his dissertation entitled *Working at Home: Spinning and Weaving Activities in the Domestic Space of al-Andalus (9th-13th centuries)*.

**Tracy Niepold** was awarded the PhD degree in June 2024 at the Otto-Friedrich-University Bamberg, Germany, for her published dissertation entitled *Textilien und weitere organische Materialien aus Grab 58 von Trossingen (Lkr. Tuttlingen). Analyse und kulturräumliche Interpretation selten erhaltener Grabausstattungs-elemente einer um 580 n. Chr. datierten Männerbestattung* (german

dissertation with extended english summary: Textiles and Other Organic Materials from Grave 58 of Trossingen Cemetery (Lkr. Tuttlingen). Analysis and Historico-cultural Interpretation of Rarely Preserved Grave Furnishing Elements in a Male's Burial dated 580 AD). The dissertation (doi: 10.20378/irb-93534) is available free online: <https://fis.uni-bamberg.de/handle/uniba/93534>

**Mikkel Johansen Nørtoft** was awarded the PhD degree in May 2024 at the University of Copenhagen, Denmark, for his dissertation entitled *Ranks to Riches, Bust to Posh: Modelling Wealth and Inequality in the Czech Corded Ware Culture*. The dissertation (<https://www.academia.edu/121879941>) is based on articles, and the first two can be found here: A New Framework for Quantifying Prehistoric Grave Wealth in <https://journal.caa-international.org/articles/10.5334/jcaa.86> and An update on the Corded Ware culture: Formation and spread, social aspects, human-canid relations, and tooth and shell status items in the book *Power, Gender, and Mobility: Aspects of Indo-European Society* <https://press.uchicago.edu/ucp/books/book/distributed/P/bo248106928.html>

**Gwendoline (Greta) Pepper** was awarded the PhD degree in August 2024 at the University of York, United Kingdom, for her dissertation entitled *Following a Thread: Tracing Technology and Techniques Along the Silk Road*.

**Jenni A. Suomela** was awarded the PhD degree in April 2024 University of Helsinki, Finland, for her dissertation entitled *Plant Fibre Identification Methods in Research of Heritage Linen Textiles* in the discipline of craft science.

# General Information

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## Guidelines for Authors

The *Archaeological Textiles Review* aims to provide a source of information relating to all aspects of archaeological textiles. Material from both prehistoric and historic periods and from all parts of the world are covered in the ATR's range of interests.

1. Contributions are accepted in English.
2. Contributions may include articles or project reports as finished works or accounts of research in progress. These may cover any research or activities related to archaeological textiles from recent excavations or in museums and galleries. Projects may encompass technology and analysis, experimental archaeology, documentation, exhibition, conservation and storage.
3. News contributions may include announcements and reviews of exhibitions, seminars, conferences, special courses and lectures, or queries concerning the study of archaeological textiles. Bibliographical information on new books, announcements about awards, and completed PhDs are also welcome.
4. The authors' guidelines can be found at [www.atnfriends.com](http://www.atnfriends.com). Please check the current guidelines as they are updated regularly.
5. All submissions are to be made in electronic text file format (preferably Microsoft Word) and are to be sent electronically.
6. Illustrations should be electronic (digital images or scanned copies at 600 dpi resolution or higher). Preferred format is TIFF (maximum size is 17.4 x 21.6 cm). Illustrations should be sent as separate files and not embedded in text. Colour images are welcome. Only illustrations with cleared copyrights, permission for internet publication, and full credit information as required by copyright holders can be used.
7. All contributions are double-blind peer-reviewed by invited specialists.
8. The editors reserve the right to suggest and make appropriate alterations in the wording of manuscripts sent for publication.

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