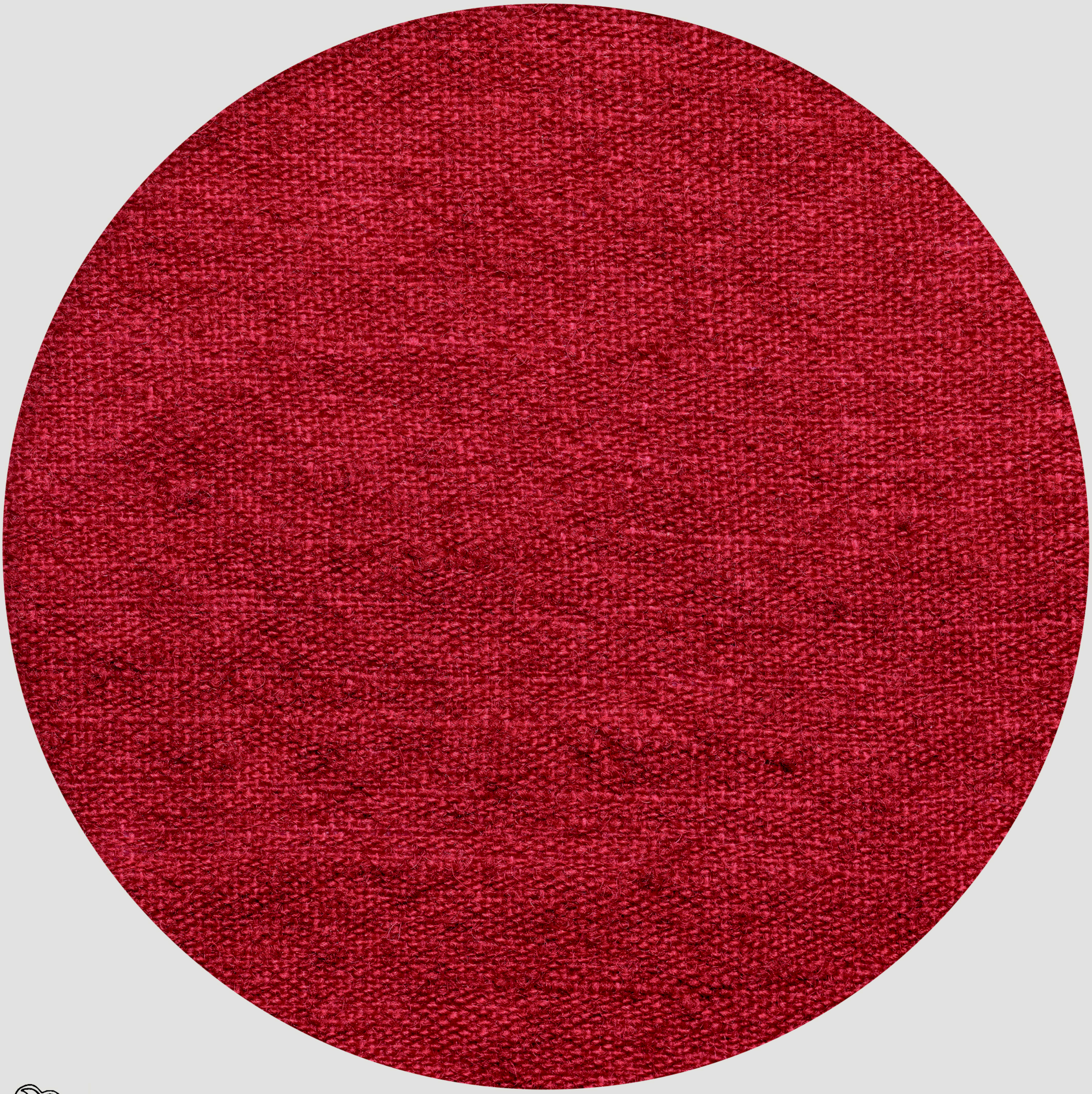
FROM ANALYSIS TO RECONSTRUCTION

Ulla Mannering &
Charlotte Rimstad



Fashioning the Viking Age 2

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Fashioning the Viking Age
This publication is the second of the volumes, describing the process and results of the research and outreach project Fashioning the Viking Age.

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Content

1. Introduction

In the Viking Age, much of the population lived and worked as farmers, fishermen and craftsmen in small scale communities that depended on self-sustainability. In these small groups, clothing, textiles and skin production were an integrated part of agriculture and an important outcome of food production. It is exactly these materials, related to the cloth culture, that were in focus in the project, Fashioning the Viking Age.

Viking Age society was divided into different hierarchical segments defined by family structure, gender, status and profession and this structure is also visible in textile and skin production (Andersson Strand 2015). Textiles were needed and produced in many different qualities and for different purposes: clothing, the household, for warfare, transport and trade. Glass beads, gold, silver and silk played an important part in the construction of clothing as well as in the display of status and wealth. Such commodities were traded from the south, most likely in exchange for slaves, and fur from wild animals like beaver, fox and sable that were hunted in the northern regions of Scandinavia and Russia (Kovalev 2001; Vedeler 2014; Mannering 2015). The Fashioning the Viking Age project has used its analysis of all such data to create a new and clearer perception of Viking Age clothing production.

Fashioning the Viking Age was funded by the VELUX FOUNDATIONS and based at the National Museum of Denmark in close collaboration with the Centre for Textile Research at the University of Copenhagen and Land of Legends in Lejre (Mannering 2018; 2021). The project core staff comprised the project leader, archaeologist and Research Professor, Ulla Mannering, the project coordinator, archaeologist and Postdoc., Charlotte Rimstad, both from the National Museum of Denmark, archaeologist and Associate Professor, Eva Andersson Strand, Head of the Centre for Textile Research at the University of Copenhagen, and archaeologist Ida Demant, Leader of the Textile Workshop in the Land of Legends in Lejre. The project consisted of three parts, all focusing on different aspects of Viking Age textile resources, production and clothing that together provide a new visual and tactile understanding of Viking Age textile production and clothing design which can be used for outreach purposes in teaching institutions, museums and the media as well as research.

Project Part 1, Viking Age Textile Production, focused on the reconstruction of textile tools which were subsequently used to produce replicas of known, archaeological textile finds from Hedeby in Schleswig. These textiles represent different textile qualities, and it is exactly this variation that the first part of the project aimed to explore.

Project Part 2, Viking Age Male and Female Clothing, focused on the production of two full-size outfits, representing a high-status male and female, based on the preserved textile fragments from two Danish Viking Age burials. The present report documents the reconstruction process based on the analyses of the selected archaeological finds as well as the decisions and data relevant to produce the final outfits (fig. 1.1). The process took almost two years, and besides the core project members, it involved several specialist researchers, and craftspeople, whose invaluable skill and commitment has contributed to the finished result. A workshop with our Nordic experts on Viking Age textiles and clothing from the two cultural history museums in Oslo and Stockholm as well as many discussions with local and international experts have helped us reach the results presented here.

Project Part 3, Viking Age Clothing Catalogue, focused on collecting different sources for Viking Age textile tools and production, textiles and clothing, whether they be archaeological, iconographic, written or other sources. The results of Project Parts 1, 2 and 3 are presented in separate volumes. Likewise are the many fibre analyses made by Irene Skals. We hope that this data can help and inspire others to work with textile reconstructions, as all good reconstruction always depends on the raw material. All dye analyses made by Ina Vanden Berghe are published in an article (Vanden Berghe et al. 2023).

◄ Fig. 1.1: The finished outfits in the Viking Age exhibition, The Raid, at the National Museum of Denmark.

Photo: Charlotte Rimstad

2. The two Viking Age burials

The overall textile design of the two reconstructed outfits is based on data extracted from two well-known Danish Viking Age burials in Jutland. These are Bjerringhøj, situated in Mammen, near Viborg, and Hvilehøj, situated near Randers (fig. 2.1). The burials are dated to the late 10^{th} century AD. The grave goods in the burials clearly show that the deceased belonged to the elite of Viking Age society, but this is not the reason why they were chosen for reconstruction. The choice was based on the fact that these two burials contain some of the largest and most complete textile fragments recorded from any Danish Viking Age context. Usually, textiles in Viking Age contexts are fragmented – if present at all – and poorly preserved, so the information about textiles and garment types is in general very limited (Bender Jørgensen 1986; Rimstad 2009). The fortunate preservation conditions in Bjerringhøj and Hvilehøj have ensured that a significant range of the textile types and decorative features used in the Viking Age are preserved in these two graves. The presence of silk fabrics and tablet-woven bands in silk, gold and silver threads as well as precious fur emphasizes the high status of these individuals, and makes them clearly different from the everyday clothes known from, for instance, the settlement and harbour area in Hedeby (Hägg 1984; 1991; 2015). The two final outfits should therefore not be seen as examples of typical Viking Age outfits, but rather as the exceptional capacity and skill of Viking Age textile craftsmanship.

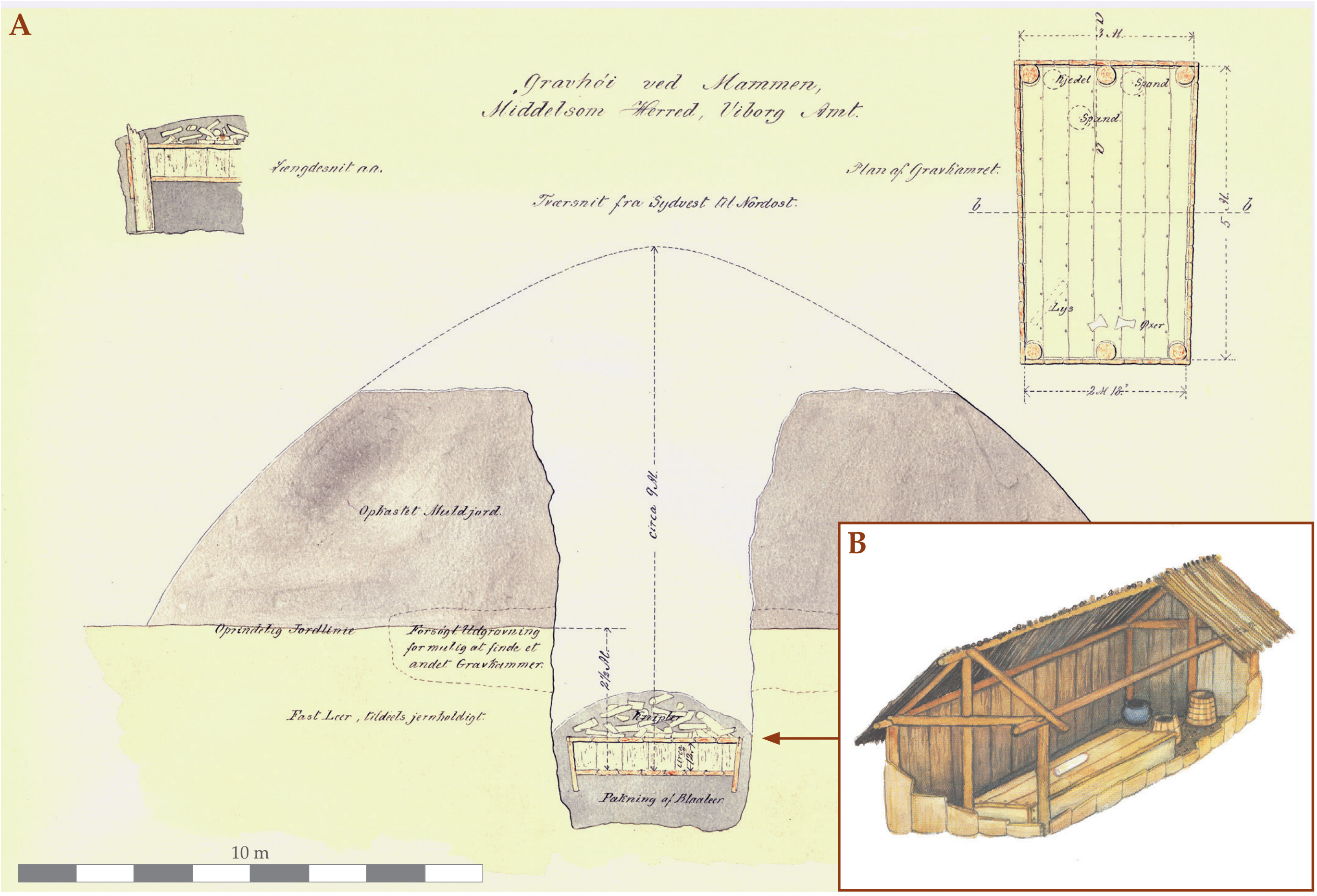
► Fig. 2.1: The locations of Bjerringhøj and Hvilehøj in Denmark.

Illustration: Mads Lou Bendtsen

Bjerringhøj

The Bjerringhøj burial, also known as the Mammen burial, was discovered in 1868 by local farmers, who wanted to remove the burial mound as they needed soil to fill a nearby lowland (Iversen et al. 1991). The burial was constructed with a wooden coffin placed inside a roofed wooden chamber in a large mound (fig. 2.2). It contained exceptional Viking Age grave goods, including two iron axes, one with silver inlay, a bronze bowl, two wooden buckets, a large candle of beeswax, several well-preserved textiles and ten small keyhole-shaped figures of silver and gold foil. The grave is interpreted as that of a male, based on the few preserved human bones as well as the grave goods. Although the human bones were handed in to the National Museum of Denmark, only a preliminary examination was executed and later the bones disappeared in the museum´s collection. It was not until the *Fashioning the Viking Age* project started to examine other Viking Age textile finds that it was discovered that the bones had been misplaced with the find from Slotsbjergby on

Zealand (Rimstad et al. 2021). A recent anthropological examination of the bones has confirmed that they most likely belong to a male, but unfortunately, the preservation is not good enough to make a certain identification using DNA analysis.



Furthermore, there is no jewellery or other clear archaeological gender markers except for the axes preserved in the grave. Due to the crude and unprofessional excavation, the precise location of the textiles is unknown, meaning that there is no certainty as to how the different textile fragments were situated or related. Neither can we be sure that all the textiles derive from clothing. The burial is dated by dendrochronology to AD 970-971, the later part of the Viking Age (Andersen 1991) which has recently been confirmed by a 14C-dating (table 2.1).

▲ Fig. 2.2.A: Section of the Bjerringhøj burial mound. B: Reconstruction of the Bjerringhøj burial.

Illustration A: Frits Uldall 1868
Illustration B: Ursula Seeberg 1991

Location	Sampled material	Sample size	AAR no.	Dating (calibrated)
Bjerringhøj C135a, Fragment 5	2/1 twill, wool	C. 30 mg	32148	892-993 AD (95.4% probability)
Bjerringhøj C145	Bones from the lower part of the body. Sample from tibia joint (fragment already broken off) + a fragment of the fibula, which was cut off	C. 400 mg	32149	885-992 AD (95.4% probability)
Hvilehøj C4280d	Tabby, wool	C. 30 mg	32146	950-1029 AD (95.4% probability)

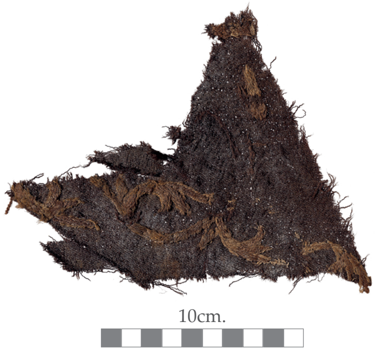
◄ Table 2.1: 14C-dating results of the samples taken from Bjerringhøj and Hvilehøj. All samples are dated to the later part of the Viking Age. Samples were taken by Bente Philippsen and processed by Marie Kanstrup from Aarhus University.

The textiles from Bjerringhøj were analysed and published in 1950 (Hald 1950; 1980) and again in 1991 (Østergård 1991). In the 1991 publication, the textile fragments together with an illustration of Canute the Great in the "Liber Viate" manuscript from AD 1031 were used as the basis for a full reconstruction of a Viking Age magnate male outfit (Munksgaard 1991; Bender Jørgensen 1992) (fig. 2.3). Ever since, this reconstructed outfit has been and still is used in Viking Age exhibitions at the National Museum of Denmark and lately also abroad. Motifs from the embroidered textile (C135a) were placed symmetrically in this outfit, according to modern aesthetics, on two different garments, while very little or no attention was paid to the original relationship of the motifs. In the new reconstruction, it is primarily the archaeological data that has dictated the design of the male outfit.

► Fig. 2.3: The previous reconstruction of the Mammen magnate outfit from 1991.

Photo: Lennart Larsen

Table 2.2 provides an overview of textile and skin/fur finds from Bjerringhøj, which have been included in the new reconstructed male outfit. The finds are ordered by museum number. The burial further contained a few other textiles and details that are not included in the outfit and therefore not presented here.

Museum no. and size	Technique & material	
Bjerringhøj C135a 64 fragments C. 1 m² preserved	**2/1 twill** With embroideries Wool	
Bjerringhøj C135b 1 fragment 135 x 105 mm	**Open tabby** Wool (padding)	
Bjerringhøj C135c 6 fragments C. 1 m² preserved	**Tabby** Wool	
Bjerringhøj C135d 1 fragment 195 x 30 mm	**Tabby** Wool	
Bjerringhøj C136a 2 fragments 330 x 15 mm in all	**Tablet weave** Wool	

◄ Table 2.2: The textiles and skin/fur fragments from Bjerringhøj used in the male outfit.

Photo: Roberto Fortuna

► Table 2.2 Continued: The textiles and skin/fur fragments from Bjerringhøj used in the male outfit.

Photo: Roberto Fortuna

Museum no. and size	Technique & material	
Bjerringhøj C136b 1 fragment 133 x 14 mm	**Tablet weave** 14 mm wide Silk, gold/silver lahn with silk core	
Bjerringhøj C136c 3 fragments 448 x 14 mm	**Braid** Wool	
Bjerringhøj C137 2 pendants a) 200 x 74 mm b) 218 x 73 mm	**Tabby** Silk **Naalbinding** Silk, gold/silver lahn with silk core **Tablet weave** 10 mm wide Silk, gold/silver lahn with silk core **Tabby** Wool (padding)	
Bjerringhøj C138 2 wrist cuffs 28 mm tall, 253 mm (outer diam.), 206 mm (inner diam.)	**Tabby** Silk **Tablet weave** 14 mm wide Silk, gold/silver lahn with silk core **Open tabby** Wool (padding)	

Museum no. and size	Technique & material	
Bjerringhøj C139 2 complete rouleaus 162 x 30 mm each	**Tabby** Silk **Samite** Silk **Tabby** Wool (padding)	 10cm.
Bjerringhøj C140, fragment 1 1 fragment 115 x 35 mm	**Samite** Silk	 10cm.
Bjerringhøj C140, fragment 2 1 fragment 295 x 45 mm sown together of two different textiles	**Samite** Silk	 10cm.
Bjerringhøj C142 2 fragments of a leather strap C. 135 x 15 mm	**Leather** Calf	 10cm.
Bjerringhøj C143 2 pieces of fur C. 90 x 50 mm	**Fur** Beaver	 10cm.
Bjerringhøj C145 Human tibia bone with textiles in situ on ankle	**Open tabby** Wool **Tablet weave** 8 mm wide Silk, gold/silver lahn with silk core	 10cm.

◄ Table 2.2 Continued: The textiles and skin/fur fragments from Hvilehøj used in the female outfit.

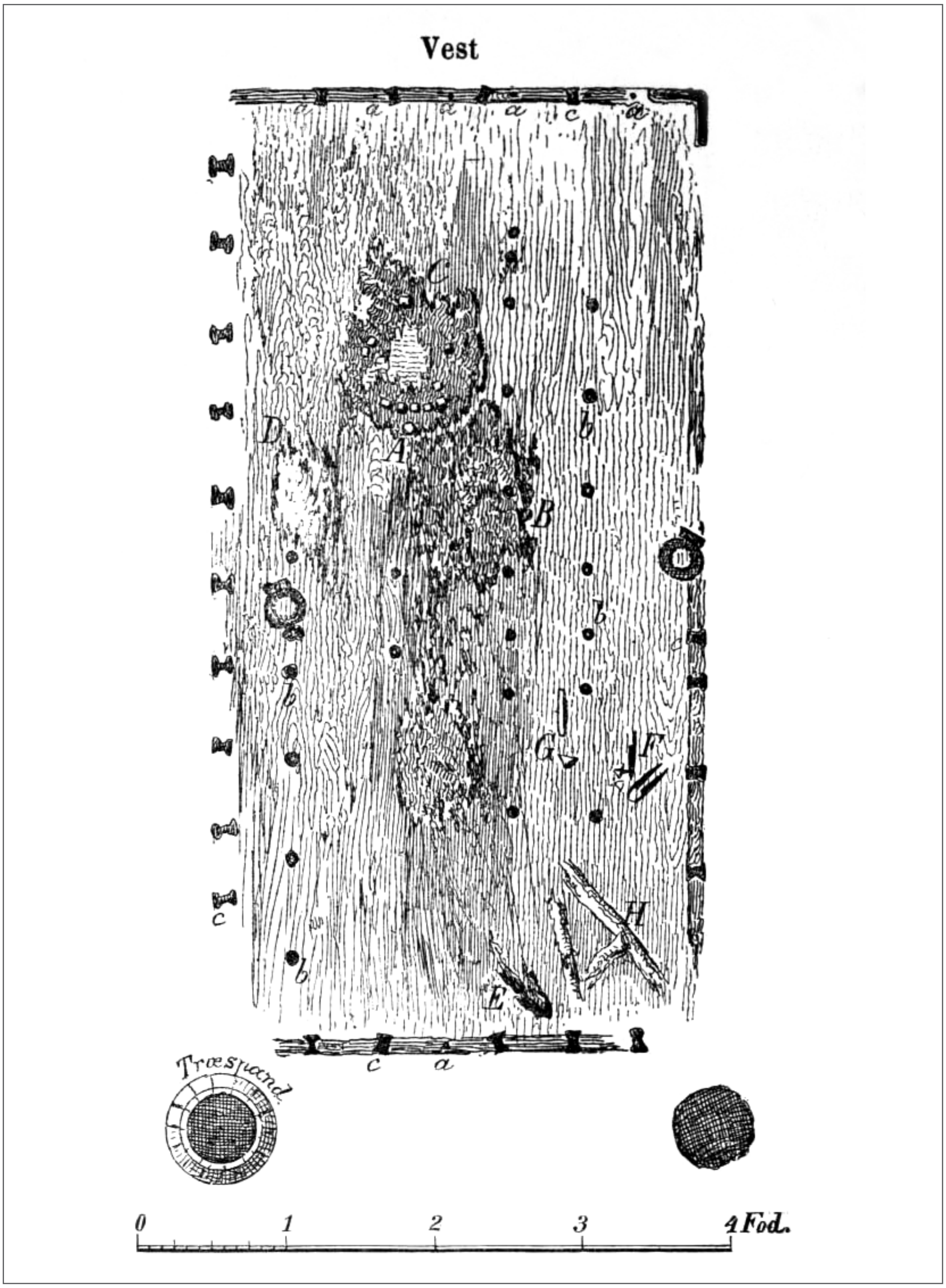
Photo: Roberto Fortuna

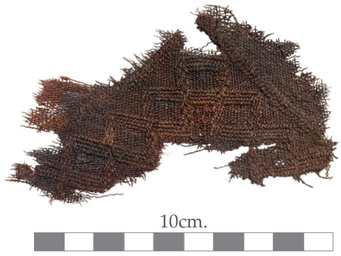
Hvilehøj

The female burial from Hvilehøj was excavated by the National Museum of Denmark in 1880 (Engelhardt 1881), fig. 2.4. The woman was placed in a wagon bed in a mound, and the grave is dated to the late 10th century based on the presence of coin of Otto I (AD 936-962). The dating was recently confirmed by a 14C analysis (table 2.1). The grave goods consisted of a wooden bucket, a wooden casket, a spindle whorl, a pair of scissors, two knives, a whetstone, fragments of one or possibly two mirrors, a bronze bowl, as well as several well-preserved textiles and a bead necklace. No dress fibulae or other dress related accessories were found that could be connected to the clothing construction of a female dress, for example the well-known Viking Age oval brooches. The burial has until now not been fully analysed or published, nor have the textiles in the grave ever been reconstructed (Hald 1980; Hedeager Krag & Ræder Knudsen 1999; Ræder Knudsen 2005; Hedeager Krag 2005; 2018).

► Fig. 2.4: Plan of the Hvilehøj burial.

Illustration: Magnus Petersen 1881



Museum no. and size	Technique & material	
Hvilehøj C4280a 6 fragments C. 20 x 30 cm	**Tabby with woven-in pattern wefts** Wool	
Hvilehøj C4280b, C4280c, C4280c extra C4291b (22 fragments) C. 760 x 17 mm	**Tablet weave** 17 mm wide Silk, gold/silver lahn with silk core	
C. 200 x 8 mm	**3/1 twill** Silk, silver lahn with silk core	
C. 100 x 10 mm	**Samite** (weft-faced compound twill) Silk	
20 x 20 mm	**Tabby** Silk	
110 x 8 mm 12 fragments	**2/1 twill** Wool rolls (padding)	
	Fur Beaver Squirrel	
Hvilehøj C4281 100 x 65 mm (largest fragment)	**Skin** Goat	

◄ Table 2.3: The textiles and skin/fur fragments from Hvilehøj used in the female outfit.

Photo: Roberto Fortuna

3. The analyses

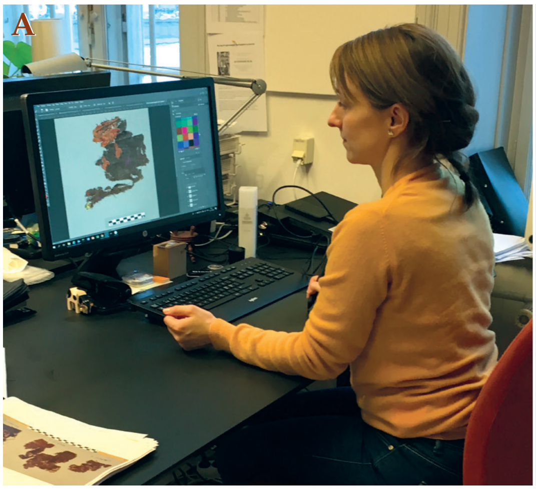
Before the reconstruction processes could begin, it was essential for the project that all the original finds were thoroughly analysed. This included not only analysis of textiles, fibres and fur/skins, but also the analyses by various specialists and experts of other grave goods related to the outfits, such as jewellery and remains of human bones. Using a pre-designed report template, reports were written for all types of analysis. Data from most of these reports is incorporated in the following while the more detailed reports on tablet weaving, fur making, shoe making and bead production are presented in separate chapters.

All textiles from Bjerringhøj and Hvilehøj went through technical analysis by Ulla Mannering and Charlotte Rimstad (fig. 3.1). The recording parameters were: size of the fragment, fibre type, yarn diameter, number of threads per cm, twist direction and twist angle as well as the recording of functional elements such as stitches. Some of the more composite textile fragments were recorded with special stratigraphic analyses, such as X-ray or CT scanning in order to understand the layer sequence. The samite silk fragments were analysed by Irene Skals and Åse Eriksen, who also wove the reconstructed silk textiles. The complete textile catalogues will be published in an anthology presenting the two graves (Mannering & Rimstad, forthcoming b). As already mentioned, during the recording process, it was discovered that the human bones labelled Slotsbjergby (C9166) in fact derive from the Bjerringhøj burial. Therefore, the analysis of the textiles attached to these bones was included in the reconstruction although they came in at a later stage when the reconstruction process had already started and decisions about the overall design could not be changed. Further, analyses of the tablet-woven bands were carried out by Lise Ræder Knudsen and Marie Wallenberg, who also participated in the reconstruction process.

In order to map and match the many embroidered 2/1 twill fragments from Bjerringhøj, a special method was used to detect the specific motifs and their relationships. Great effort was put into puzzling the pieces together in the most optimal and realistic way. For this part, each fragment was photographed in high resolution by Roberto Fortuna from the National Museum of Denmark. The photos were taken with light coming from above as well as beneath the fragments, so that empty stitch holes were revealed. Afterwards, the images were edited in Photoshop by Charlotte Rimstad, who outlined all the patterns with colour codes (different from the original colours) that enabled the different motifs to be separated (fig. 3.2). After this process, it was possible to join some of the fragments and arrive at a whole new understandings of the overall embroidery design. The same method was used for recording and designing the woven-in cross patterns on the tabby textile from Hvilehøj.

► Fig. 3.1.A: Charlotte Rimstad and Ulla Mannering in the textile laboratory, analyzing the textiles from Bjerringhøj. B: Taking out samples for fibre analysis.

Photo: The National Museum of Denmark

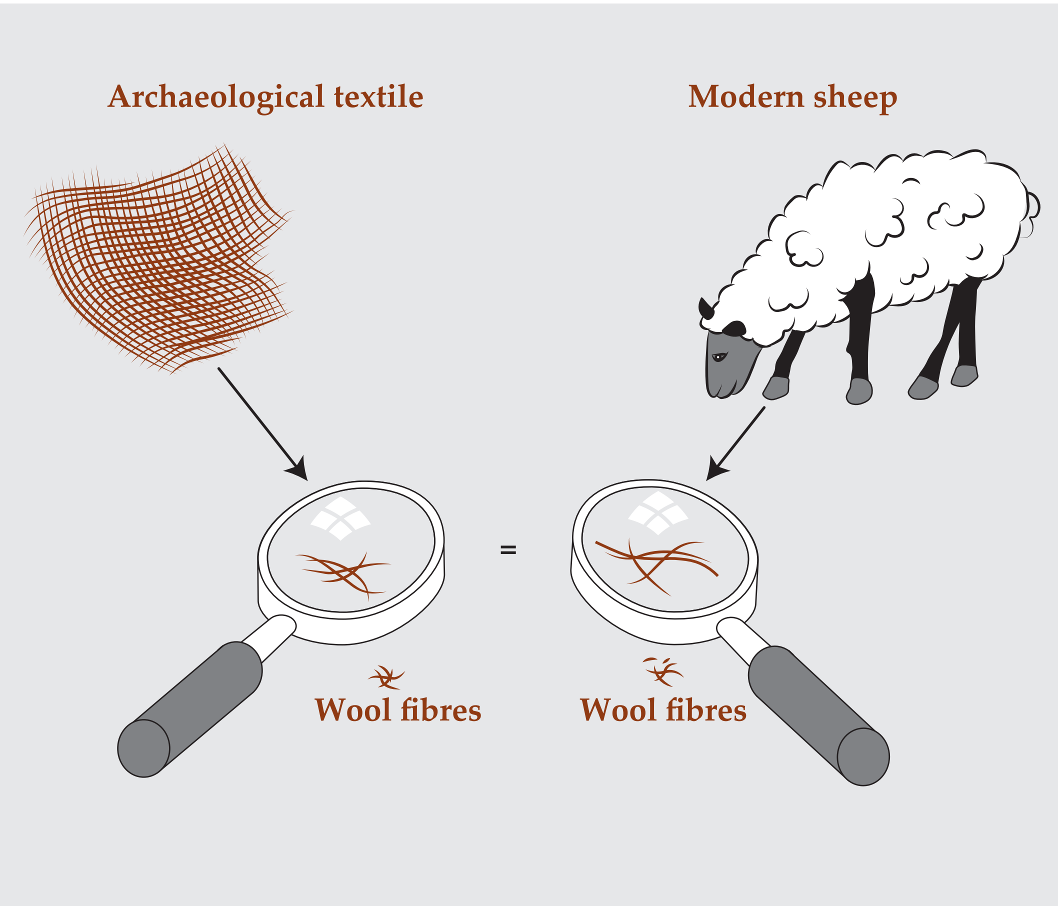


◀ Fig. 3.2.A: Charlotte Rimstad drawing the embroidery patterns from Bjerringhøj in Photoshop.
B: C135a, fragment 5 with the motives highlighted digitally.

Photo A: Ulla Mannering.
Photo B: Roberto Fortuna, with Charlotte Rimstad´s highlighted colours

Fibre analyses

The texture and visual appearance of any textile is completely dependent on the choice of raw material. It is impossible to produce a luxury textile with low quality raw materials or a soft textile with coarse fibres. Further, the preparation of the fibres will significantly influence the look and properties of the textile, depending on how parallel the fibres lie and how much air it is possible to "store" in the yarn. In a Viking Age context, combing was the most common way to prepare the wool fibres for spinning, a technique which made it possible to give the yarn a very high twist angle. Irene Skals oversaw taking samples from the original textiles for fibre analysis as well as conducting the analyses. In the fibre analysis, the proportion of fine fibres (below 25 microns), medium fibres (between 25 and 40 microns) and coarse fibres (above 40 microns) were determined for each yarn in the textiles, and this data was used in order to find a wool quality that came as close to the original finds as possible (fig. 3.3).



◀ Fig. 3.3: The principle of finding modern wool that resembles the Viking Age wool on fibre level.

Illustration: Charlotte Rimstad

The fibre content in each yarn can thus be used to characterize the wool preparation in general, but also differences in the production of each textile. Based on a comparison of the fibre content in warp and weft yarns respectively, the different fibre combinations seen in the Bjerringhøj and Hvilehøj textiles can be grouped as follows:

Fibre combination 1: warp and weft have similar fibre contents
- *1a: large content of fine fibres*
- *1b: large contents of medium fibres and few coarse fibres*
- *1c: large contents of medium fibres and several coarse fibres*

Fibre combination 2: warp and weft have different fibre contents
- *2a: warp has large content of coarse fibres and weft has large content of fine fibres*
- *2b: warp has large content of medium fibres and weft has large content of fine fibres*

The fibre analysis results of the textiles to be reconstructed are presented in table 3.1. Based on the comparative fibre analyses of modern sheep breeds, Spelsau wool was found to be the best match to the ancient samples and all handspun textiles in the reconstructed garments were produced using this wool type (for more details see Skals 2023).

Based on the fibre analysis, it can be deduced that the construction of the wool textiles from Bjerringhøj and Hvilehøj were conceived very differently from the outset, representing very different work processes which each, in their own way, expressed the desire to produce textiles with different visible features. The choice of wool materials used for the clothing reconstructions are explained in connection with each item. Based on the design and time scale, we knew from the beginning that we would not be able to match the wool exactly, but the details are given for inspiration in connection with future reconstruction projects. Regardless, a great effort was put into getting a proper feel and drape into the textiles so that they represent the tactility of an original Viking Age textile in the best way possible.

► Table 3.1: The fibre combinations recorded in the different textiles chosen for the reconstructions.

Find	Museum no.	Wool textile	Fibre type
Bjerringhøj	C135a	2/1 twill with embroidery	1c
Bjerringhøj	C135b	Open tabby (padding)	1b
Bjerringhøj	C135c	Tabby	1b
Bjerringhøj	C135d	Tabby	1c
Bjerringhøj	C136a	Tablet-woven band	2a
Bjerringhøj	C136c	Braided band	1c (one sample)
Bjerringhøj	C138	Open tabby (padding)	1b (one sample)
Bjerringhøj	C145	Open tabby (padding)	1b
Hvilehøj	C4280a	Tabby with woven-in weft pattern	2a
Hvilehøj	C4291	2/1 twill rolls (padding)	2a

Dye analyses

Some, but not all, of the textiles from Bjerringhøj and Hvilehøj burials have previously been tested for preserved dye stuffs. In the 1940s, Margrethe Hald conducted dye analyses on some of the textiles (Hald 1980) and Penelope Walton Rogers likewise carried out dye analyses on the Bjerringhøj textiles in the late 1980s (Walton 1991). The Hvilehøj tabby textile was further tested in 2001 at the request of Anne Hedeager Krag (2010; 2018). For the *Fashioning the Viking Age* project Irene Skals took more than 60 samples from the Bjerringhøj and Hvilehøj textiles for new dye analyses. These were sent to Ina Vanden Berghe at the KIK-IRPA laboratory in Brussels (Vanden Berghe et al. 2023). Here, the method of HPLC (high performance liquid chromatography) was used to test the chemical compounds of the dyes, and when compared to a reference database, interpretations of specific dye stuffs could be made (Vanden Berghe et al. 2009). An overview of the results is presented in tables 3.2 and 3.3. As some of the silk textiles and tablet-woven bands from Bjerringhøj are so intact that taking samples would likely damage the objects, sampling was avoided if older analyses were available. This is the case for the identification of madder in the narrow edge on C135a fragment 64, of woad/indigo in the leopard motif on the same fragment and in the open tabby C135b, and of lichen in the tablet-woven band C136b, the silk tabby in the pendants C137, and the sewing thread of the samite silk with heart decoration C140 fragment 2.

Museum No.	Hald 1950	Walton 1991	Vanden Berghe et al. 2023
C135a, 2/1 twill	Not tested	No dye detected	Luteolin yellow, clubmoss
C135a F64, red extra edge	Not tested	Madder	Not tested
C135a F64, selvedge	Not tested	Madder	Not tested
C135a F64, leopard's belly	Not tested	Woad/indigo	Not tested
C135a, F64, small masks	Not tested	Not tested	Tannin
C135a, other embroidery yarns	Not tested	No dye detected	(Luteolin, clubmoss, woad/indigo)
C135b, open tabby	Not tested	Woad/indigo	Not tested
C135c, tabby	Not tested	No dye detected	Luteolin yellow, clubmoss
C135d, tabby	Not tested	No dye detected	Madder, tannin
C136a, tablet weave, outer warp	Not tested	No dye detected	No dye detected, (tannin)
C136a, tablet weave, central warp	Woad	Not tested	Indigotin, tannin
C136a, tablet weave, weft	Not tested	Not tested	Tannin, (woad/indigo)
C136b, tablet weave	Not tested	Lichen purple	Not tested
C136c, braided band	Not tested	No dye detected	Madder, tannin
C137, tabby silk	Not tested	Lichen purple	Not tested
C139, rouleaus, tabby silk	Not tested	Not tested	No dye detected, (tannin)
C139, rouleaus, samite silk	Not tested	Not tested	Madder, tannin
C140, F1, samite warp	Not tested	Not tested	Madder (tannin)
C140, F1, samite silk weft	Not tested	Not tested	Madder, cochineal
C140, F2, samite silk with hearts, warp + weft	Not tested	Madder?	Madder,
C140, F2, sewing thread	Not tested	Lichen purple	Not tested
C145, 2/1 twill	Not tested	Not tested	Luteolin, clubmoss
C145, tablet weave	Not tested	Lichen purple	No dye detected, (tannin)

◄ Table 3.2: Overview of the dye analysis conducted on the Bjerringhøj textiles selected for reconstruction.

Brackets indicate dyes at trace level

Museum No.	Hald 1950	Krag 2018	Vanden Berghe et al. 2023
C4280a, F5, tabby warp	Not tested	Not tested	Kermes, (clubmoss)
C4280a, F5, tabby weft	Not tested	Not tested	Kermes, clubmoss
C4280a, F5, pattern threads	Not tested	Not tested	No dye detected
C4280b F10, tablet weave	Not tested	Not tested	(Woad/indigo)
C4280b, F14, tabby	Not tested	Not tested	Madder
C4280b, F16, 3/1 twill	Not tested	Not tested	Madder, woad/indigo
C4280b, F17, 2/1 twill strap	Not tested	Not tested	Kermes, madder, clubmoss
C4280b, brown thread	Not tested	Woad/indigo	Not tested
C4280c, wool rolls	Woad?	Not tested	(Madder)
C4280c, tablet weave	Woad?	Not tested	Woad/indigo
C4280c, samite	Not tested	Not tested	Madder
C4280c, tabby warp	Not tested	Not tested	Kermes
C4280c, tabby weft	Not tested	Not tested	Kermes, (woad/indigo)
C4280c, pattern threads	Not tested	Not tested	(Woad/indigo)
C4291, red thread	Not tested	Kermes	Not tested

◄ Table 3.3: Overview of the dye analysis conducted on the Hvilehøj textiles selected for reconstruction.

Brackets indicate dyes at trace level

The results of the dye analyses showed the presence of red dye stuffs of several kinds. Madder (*Rubia tinctorum*) is the most common dye stuff, found in both Bjerringhøj and Hvilehøj. This is no surprise as the madder plant was supposedly growing in the Danish habitat in the Viking Age, as seen in Viking Age York (Hall & Kenward 2004), and therefore could have been acquired locally. The more exotic dye stuffs, kermes (*Kermes vermilio*) and cochineal (*Porphyrophora*), would have been imported from other areas of Europe, e.g., the Mediterranean area and further east. However, it is impossible to say, whether it was the dye stuff, the dyed yarn, or the whole textile which was imported. Because of their material and technique, it is most likely that the two silk samite textiles from Bjerringhøj (C140, fragment 1 and fragment 2) were dyed in their production areas. Earlier studies have shown that red dyes tend to be better preserved than other dye stuffs (Ringgaard 2018), so the preservation conditions likely also have an impact on the large amount of red dye results coming from the two graves.

Indigotin is also relatively commonly detected, and the source of indigo was most likely woad (*Isatis tinctoria*), which could be grown locally. Although woad is not a native plant in the North European environment, finds of woad seeds at the Ginderup settlement in Denmark, dated to the Early Roman Iron Age (AD 1-200), confirms that the plant already at an early stage was grown in this area (Jessen 1933). Apart from the already detected indigo in the embroidery yarn of the leopard's belly (C135a fragment 64), indigotin was found in trace level in some of the bird motif as well as in the acanthus leaves. Here it is tempting to think that the blue dye stuff would have been combined with a non-preserved yellow dye stuff in order to create a green colour. Indigotin was likewise found in the tablet-woven wool band (C136a), especially in the central warp threads. In Hvilehøj, indigotin was identified in the tablet-woven silk band and also in the 2/2 twill of wool, which is not included in the outfit (Vanden Berghe et al. 2023).

The first dye analysis report came out with careful estimations on some of the dye stuffs, especially the yellow colours (luteolin and flavonoids) in the textiles. The result for the ground weave of the 2/1 (C135a) twill was ambiguous, as it firstly was interpreted as no dyes detected and only flavonoids on a trace level. Decisions for the reconstruction of the kirtle were made on the basis of these results. Later, new samples from the same weave found on the human bones, proved the textile to indeed have been dyed with a yellow luteolin source. Luteolin was also detected in the embroidery yarn of the big masks (C135a, fragment 2). The tabby C135c from Bjerringhøj at the other hand clearly contained flavonoids and it was decided to use this textile for the male trousers. No yellow dyes were found in the tested textiles from Hvilehøj.

Clubmoss (*Lycopodium sp.*) was detected in several instances. In the samples from Bjerringhøj it was detected with luteolin and in Hvilehøj together with kermes, confirming its use as a mordant. Different types of club mosses are known, and many of these aluminium-rich plants are indigenous to Denmark and were also used in earlier periods, such as in the Lønne Hede textiles dated to the Roman Iron Age (Demant et al. 2021).

The overall look of the two outfits is thus dominated by different colours. In the Bjerringhøj outfit primarily yellows for the ground weaves and different types of red for decorative textiles are found, whereas the Hvilehøj outfit is largely dominated by the red kermes in the ground weave, while the other colours such as blue and purple are found in the subtle, but important details of the decorative bands.

Fur and skin analyses

Several types of analyses were conducted on the fur and skin items from the two graves in order to identify the species and the tanning methods (fig. 3.4). Luise Ørsted Brandt took samples from both graves for Zooarchaeology by Mass Spectrometry (ZooMS) (Brandt & Mannering 2020), of which nine samples were further subjected to species identification by Peptide Mass Fingerprinting (PMF) and Liquid Chromatography Tandem Mass Spectrometry (LC-MS/MS) (Brandt et al. 2022). When possible, Anne Lisbeth Schmidt sampled hair from the fur items for species identification, which were analysed by light microscopy on cross sections and longitudinal mountings. The result from this analysis is summarised in table 3.4.

◄ Fig. 3.4: Analyses of fur in the textile laboratory, conducted by Ulla Mannering, Luise Ørsted Brandt, Anne Lisbeth Schmidt and Theresa Emmerich Kamper.

Photo: Charlotte Rimstad

Museum no.	Use	Sample	ZooMS	PMF result	LC-MS/MS)	Overall conclusion
Bjerringhøj C142	Strap	Skin	*Bovid/cervid*	-	-	Sheep, goat/ deer
Bjerringhøj C143	Fur	Hair	-	*Castor*	-	Beaver
Bjerringhøj AdC143	Fur	Hair	-	*Castor*	*Castor (canadensis)**	Beaver
Bjerringhøj C150	C135d	Hair	-	*Bovidae / cervidae*	-	Sheep
Hvilehøj C4281, id. no. A	C136a	Skin	*Capra hircus*	-	-	Goat
Hvilehøj C4281, id. no. B	C136c	Skin	-	-	-	Goat / reindeer
Hvilehøj C4281, id. no. C	C138	Skin	*Capra hircus / Rangifer tarandus*	-	-	Goat / reindeer
Hvilehøj C4280c	Fur	Hair	-	Closest match to *Castor*	-	Beaver
Hvilehøj C4280b, fragment 11	Fur	Hair	-	*Castor*	-	Beaver
Hvilehøj C4273-97, fragment 19	Fur	Hair	-	*Castor*	*Castor (canadensis)**	Beaver
Hvilehøj C4273-97, fragment 1	Wool roll	Hair	-	*Bovidae / cervidae*	*Ovis Aries*	Sheep
Hvilehøj C4273-97, fragment 60	Fur	Hair	-	Closest match to *Castor*	*Sciuridae* (probably *Sciurus vulgaris*)	Red squirrel
Hvilehøj AdC4291, fragment 12	Fur	Hair	-	*Castor*	-	Beaver
Hvilehøj C4273-97, E	?	Skin	*Bos taurus*	-	-	Cattle
Hvilehøj C4273-97, F	?	Skin	*Equus*	-	-	Horse

◄ Table 3.4: Results of the ZooMS and PMF analyses of the skin/fur objects from Bjerringhøj and Hvilehøj.

* Sequences from European beaver (Caster fiber) were not available in the reference database. The sample was therefore assigned to Northamerican beaver (Castor canadensis)

Theresa Emmerich Kamper conducted microscope analyses in order to determine the tanning methods of the fur and leather objects. All the preserved leather with the hair removed in Bjerringhøj and Hvilehøj burials share a set of similar characteristics, which include a well-defined, compact structure of collagen fibres within the dermis. The fibres have a dull lustre, textured surface, and a full cross section. These characteristics in combination with the minimal stretch seen in the high-stress areas, very square edges and no light translucence or reactivity to ultraviolet light, indicate that these items are most likely made from vegetable tanned leather. Theresa Emmerich Kamper also identified the shoe from Hvilehøj (C4281) as a hair-on object.

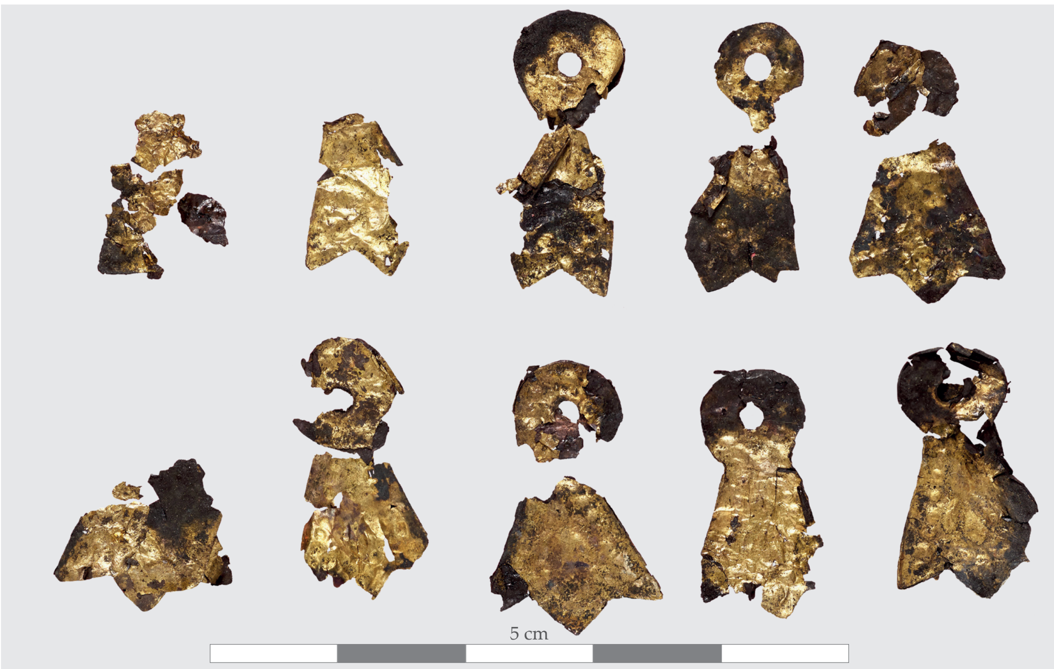
In contrast, the skin/dermal component of the fur pieces from the same burials has nearly completely degraded. It is not in a state of preservation where either macroscopic or low magnification microscopic analysis is possible. However, this lack of preservation is diagnostic in its own right, and indicates that the skin pieces were originally treated differently from each other most likely by using multiple tannage technologies. It is probable that the fur items were processed using an oil/fat tanning technology, although alum tanning is also a possibility and a technology known during this time period. These technologies do not have the same resistance to bacterial attack as seen with vegetable tannage when interred in wet preservation environments. Altogether the analyses determined in general that the leather objects, including the Hvilehøj shoe, were vegetable tanned, while the other fur objects were fat tanned. For more details about the tanning methods (see chapter 8).

Metallographic analyses

Arne Jouttijärvi conducted a visual analysis of the ten, keyhole shaped gold pendants from Bjerringhøj (C141) in order to determine their production method (fig. 3.5). The pendants were most likely produced with two layers of metal foil, one of silver and one of gold. The top gold foil layer is slightly larger than the silver layer, and the overhang is bent around the silver layer and kept in place mechanically or by means of an organic, unidentified glue. The shape of the pendants varies slightly, indicating that they were produced and decorated individually, probably by hand instead of using a stamp (fig. 3.6). The textile analysis of the embroidered 2/1 twill textile from Bjerringhøj revealed stitch holes in a shape and size that is identical to the gold pendants, indicating a possible attachment to this textile or as a copy of the shape in the embroidery design. Torben Sode made two replicas of the pendants to be used for outreach purposes, but not to be attached to the outfit.

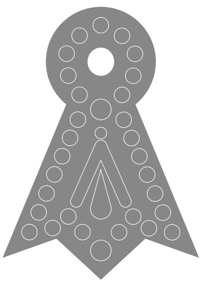
► Fig. 3.5: Gold foil pendants from Bjerringhøj (C141).

Photo: Roberto Fortuna



▼ Fig. 3.6: Schematic ideal illustration of the gold-foil pendants from Bjerringhøj.

Illustration: Mads Lou Bendtsen



Bead analysis

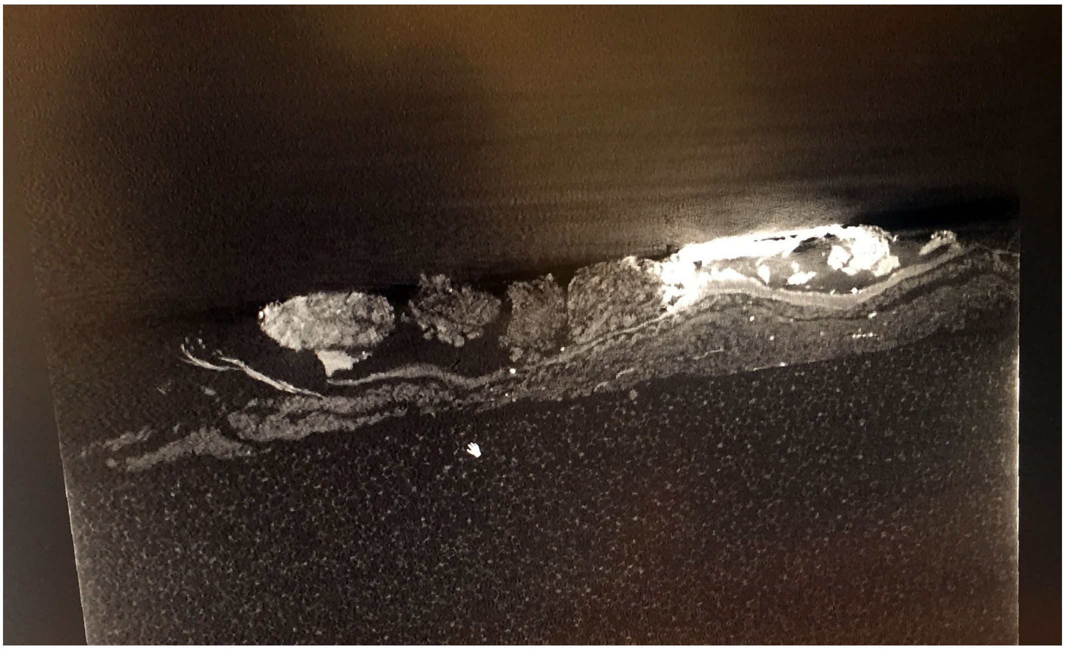
The bead necklace from Hvilehøj (C4278) (fig. 3.7) was analysed by Ulla Lund Hansen and Torben Sode, who also made a reconstruction of its design. During the analysis, it was discovered that besides the already known and well-preserved white, green, blue, and yellow glass beads in combination with the amber and mountain crystal beads, and the silver coin, the necklace also contained several gold-foil beads. Altogether, this exclusive combination of beads created a beautiful decoration that must have been placed in a row on the chest of the deceased. No remains of the bead string were found, and the necklace could have been sewn onto the front of the garment (see chapter 6 & 10).

◄ Fig. 3.7: Beads found in the Hvilehøj burial (C4278).

Photo: Roberto Fortuna

CT scanning

CT scanning was used to extract more information from the multi-layered textile and fur pieces with metal threads from Hvilehøj (C4280c) (fig. 3.8). Carsten Gundlach carried out the CT scanning at the Technical University of Denmark (DTU). The analysis clarified and confirmed the sequence of C4280c, consisting of textiles (2/2 twill and tabby) at the lowest level, then fur and on top the 2/1 twill wool rolls (padding) next to the two tablet-woven bands. Unfortunately, the analysis did not reveal if the wool rolls had been covered by another non-preserved textile, as seen in the case of Bjerringhøj.



◄ Fig. 3.8: The CT scanning of fragment C4280c from Hvilehøj.

Photo: Carsten Gundlach

XRF analyses

Michelle Taube carried out XRF-analyses (X-ray Fluorescence Spectroscopy) on several of the objects from Bjerringhøj and Hvilehøj. This is a non-destructive analysis technique used to determine the elemental composition of materials. Four of the ten gold pendants (C141) were tested, showing that they consist of a silver back plate with a top gold foil. Copper was detected in the pendants from either the gold or the silver. The detection of mercury may either come from the painted background on which the pendants are mounted, or as a result of a fire-gilding. Zinc was also detected, but most likely came from the painted background.

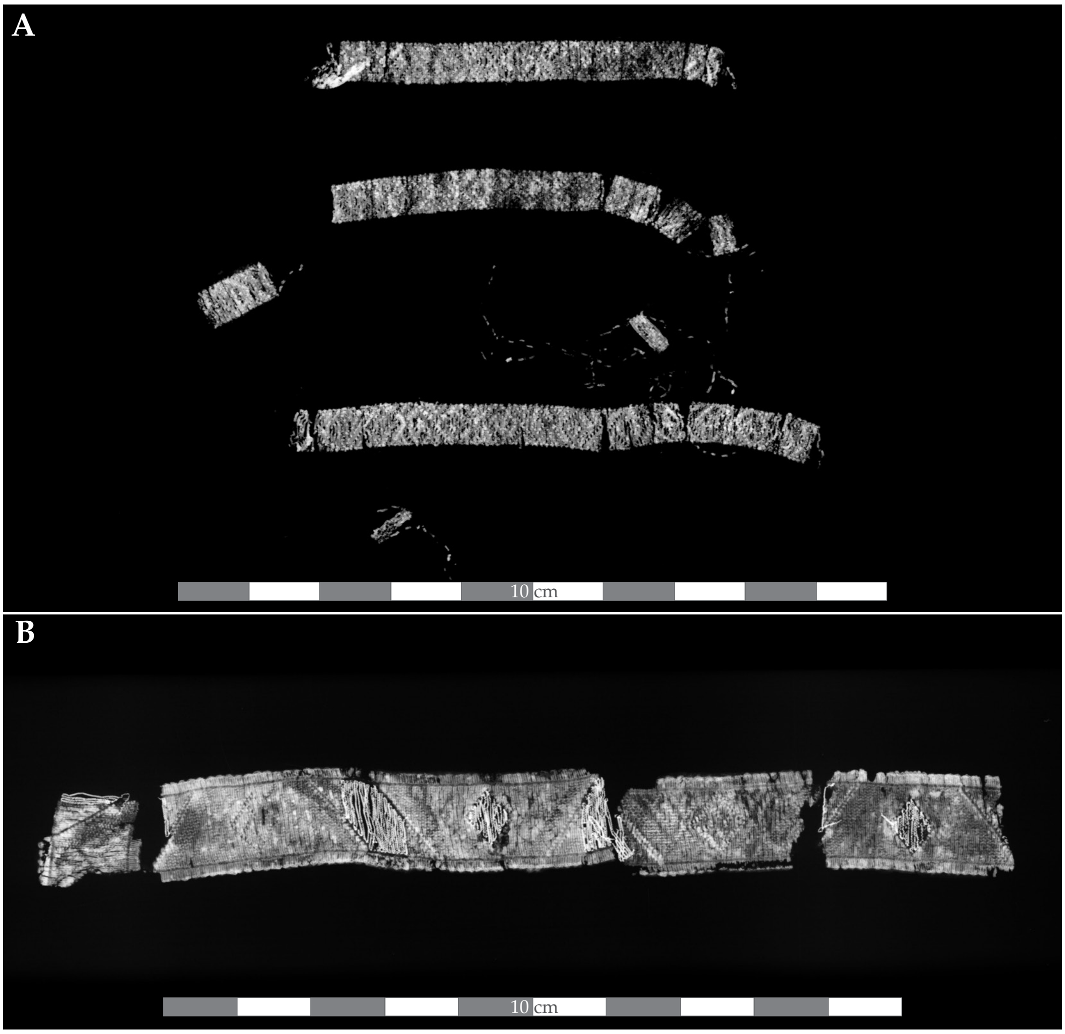
The XRF method was also used on a few of the textile fragments i.e., the 2/1 twill with embroideries from Bjerringhøj C135a (fragment 7 and 9). In these textiles, a lot of iron was detected as well as large amounts of copper in both ground weave and embroidery yarns. As most of the copper was detected in the embroidery yarns, it may possibly derive from the dyeing process, perhaps from dyeing in a copper-alloy container. No tin was detected in any of the tested textiles, so a contamination from the bronze cauldron in the burial can be excluded. The tabby textile from Bjerringhøj C135c (fragment 3 and 4) was also tested. Here, very little copper was detected, but a lot of zinc, which could not be readily explained, but may come from the wool itself.

X-ray

X-ray analyses were performed by Signe Nygaard and Michelle Taube. X-ray was primarily used to verify the presence of metal threads in the textiles, such as the tablet-woven bands from Bjerringhøj (C136b and C145) (fig. 3.9) and Hvilehøj (C4280c). These X-ray photos were an important tool in helping Lise Ræder Knudsen and Marie Wallenberg recreate the patterns of the many different tablet-woven bands in the two graves.

► Fig. 3.9: X-ray images of the tablet-woven bands from Bjerringhøj.
A: C145.
B: C136b.

Photos: Signe Nygaard & Michelle Taube



Osteological analyses and CT scanning

The rediscovered human bones from Bjerringhøj were analysed by Marie Louise Schjellerup Jørkov and compared to the original description of the bones from Bjerringhøj (fig. 3.10). This analysis concluded that there is a significant match between the two (Rimstad et al. 2021). Chiara Villa also CT scanned the bones at the Department of Forensic Medicine, University of Copenhagen, using a CT scanner SIEMENS SOMATOM DEFINITION with a pixel size of 0.71. This was primarily done in order to see the density of the bones, and to determine the possibility for conducting a DNA analysis in the future.

◄ Fig. 3.10.A: Marie Louise Schjellerup Jørkov analysing the human bones from Bjerringhøj.
B: CT scanning the bones.

Photo: Charlotte Rimstad

4. The reconstruction and design process

Archaeological textiles are often small, poorly preserved and hard to interpret for non-experts. When the textile fragments come alive in a reconstruction, the shape, colour, visual and tactile effects are more readily understood.

The reconstruction of any kind of garment will involve many considerations and decisions. First, the purpose must be addressed – why reconstruct at all? To help answer this question, a key model was developed by Land of Legends in Lejre, dividing different kinds of reconstructions into A, B and C models (Demant & Batzer 2015).

An A-model aims to get as close to the original textile as possible, in terms of materials, techniques, processes, and tools. For the reconstruction of a Viking Age garment, this includes combing the wool, spinning on a hand spindle, and weaving on a warp-weighted loom. The fibres of the original textiles must be analysed before the reconstruction process can begin as it demands a quality comparable to the original find. The yarn or the finished textile should then be dyed with natural dyes. The A-model can be used in a research-based production, enabling observations of labour intensity, functionality of tools as well as use and sourcing of raw materials.

A B-model is less time-consuming to produce and therefore also cheaper in terms of production. The focus here is on the garment shape and visual details, so it is possible to cut corners in the production processes. The yarn can be machine-spun, but dyed with natural dyes. The weaving can be done on a modern loom, or machine-woven fabrics can be used. Details, like hand-sewn seams and tablet-woven bands, can be added. This model is often used when more garments are produced, but when the functionality and visual appearance should still come close to a research-based design.

The C-model focusses exclusively on shape, colour and materials. The garments are sewn from machine-woven textiles and non-visible seams are also sewn on machine. Visible seams are still handmade, just as the fabrics are dyed with natural dyes. This model is useful when a large-scale production of garments is demanded, and quantity goes before quality (see also Brøns-Pedersen 2021).

For the design of the male and female outfits, it was decided to use the textiles and materials identified in the Bjerringhøj and Hvilehøj burials to the largest extent possible. In this way, the majority, but not all, textiles and fur/skin objects in the two graves were included in the reconstruction process. For the overall design, a B-model was chosen as there were too many different textile and garment types that needed to be reconstructed within the timeframe of the project. However, it quickly turned out that several of the required fabric qualities were not available in any fabric stores and thus had to be produced within the project. In these cases, a matching wool was selected, and the yarn was then either hand spun, spun on a spinning wheel, or a machine-spun yarn was given extra twist on a spinning wheel in order to match the very hard-twisted threads known from the Viking Age. Fibre analyses of the original finds were compared to the yarns selected for the reconstructions. In this way, fibres and other materials used for the reconstructions match the originals, whereas the production processes in most cases were optimized by using modern tools.

As the textiles and fur/skin objects from Bjerringhøj and Hvilehøj are so fragmented and only contain few construction details, such as seams and signs of reuse or repair that can be related to the design of the original garments, it was decided to use known contemporary Scandinavian and more or less complete clothing finds as inspiration for the design and pattern for the outfits. Fibre analyses guided the drape and feel of the textiles and the best match between original fibre and reconstruction was aimed at. The dye analyses guided the selection of colours chosen for the many different clothing items. When no dye results were available, the choice of colour was based on the best match with the overall design, adjusted to colors that could have been present under the specific preservation conditions. Particularly for the Bjerringhøj burial, it was decided to rely on the dye results from previous projects, as the completeness of some of the items made invisible sampling impossible.

◄ Fig. 4.1: Materials used in the discussion on the colors for the embroidery yarns.

Photo: Charlotte Rimstad

5. The male outfit

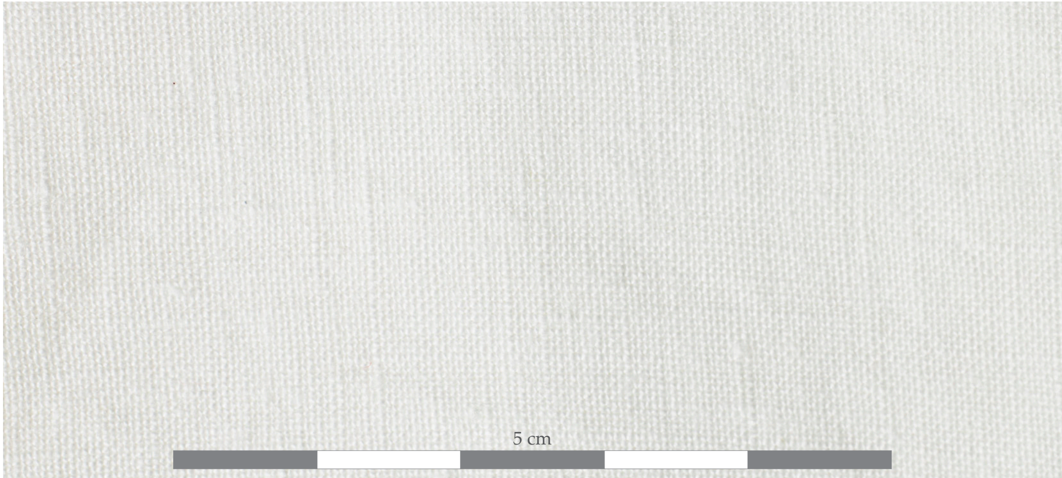
For the male outfit, it was decided to make both outer garments and undergarments. The male outfit includes the following items: A linen tunic, a wool kirtle, a belt in wool and silk, a pair of trousers with a braided tie string, two silk wrist cuffs, a fur caftan and a pair of leather boots. No headwear was made for the outfit. For the size of the outfit, it was decided to match a body height of c. 183 cm, which is more than the 173 cm average height of men in the Viking Age (Sellevold et al. 1984, 226). However, it was deemed important that a man of average, modern height would be able to wear the outfit for outreach purposes. The male outfit is based on the measurements presented in table 5.1. The male model is Mads Dengsø Jessen.

► Table. 5.1: The body measurements used for the male outfit.

Male model body part	Measurement
Height	183 cm
Back length from shoulder to floor	158 cm
Shoulder width from middle of neck to end of shoulder	23 cm
Circumference around the chest	105 cm
Circumference around the waist	93 cm
Circumference around the pelvis	99 cm
Circumference around the backside	102 cm
Arm length from shoulder to wrist	64 cm
Inside legs	80 cm
Foot length	27.7 cm

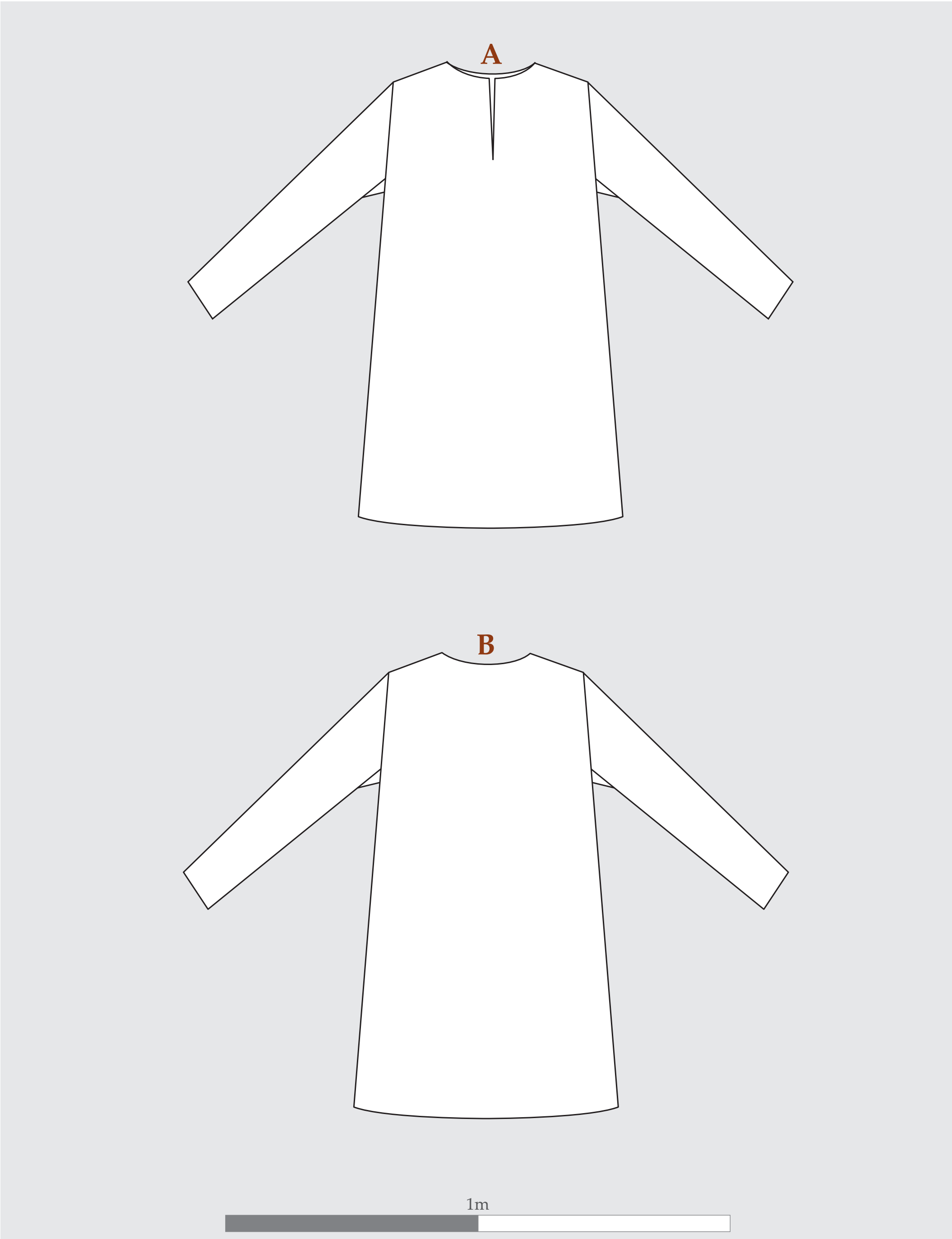
Linen shirt

No traces of undergarments were found in the Bjerringhøj burial, but since there is other evidence for the use of a linen shirt worn underneath a wool kirtle (Falk 1919; Mannering 2017a), it was decided to produce a shirt for the male outfit. Although we could have used the pattern of the Viborg shirt dated to AD 1050 (Fentz 1998), it was decided to base the pattern on the simple design of traditional shirts, which was created by Ida Demant (see also Andresen 1974). In general, this garment was not designed to be seen, but to make the outfit more comfortable for the model to wear. A linen fabric was acquired from Historical Textiles in Stockholm. The fabric is made of 0.3-0.5 mm thick z-twisted machine-spun yarn in both directions and woven in tabby with 22/18 threads/cm (fig. 5.1). The white linen was not dyed. The shirt was sewn by Birgitte Kjelstrup and the pattern is seen in fig. 5.2.



► Fig. 5.1: Photo of the linen cloth, used for the shirt.

Photo: Ulla Mannering



◄ Fig. 5.2: Pattern for the linen shirt.

Illustration: Line Maria Mørch

Kirtle

The kirtle is a well-known garment in the Viking Age (Østergård 2004, 124) and the fabric chosen for this garment is the 2/1 wool twill with embroidered motifs (C135a). The technical details relating to this textile can be seen in table 5.2.

Textile C135a	Colour	Twist direction	Twist degree	Yarn diameter in mm	Thread/cm	Fibre
64 fragments in 2/1 twill C. 1 m2 preserved	Brown Traces of luteolin yellow	z/s	30-40°/ 30-40°	0.3-0.4/0.3-0.6	20-24/16-18	Wool 1c
Reconstruction	**Colour**	**Twist direction**	**Twist degree**	**Yarn diameter in mm**	**Thread/cm**	**Fibre**
2/1 twill	Light grey	z/s	30-40°/ 30-40°	0.3-0.5/0.3-0.5	20/15	Spelsau wool

◄ Table. 5.2: Technical details of the original textile chosen for the kirtle and the reconstructed textile.

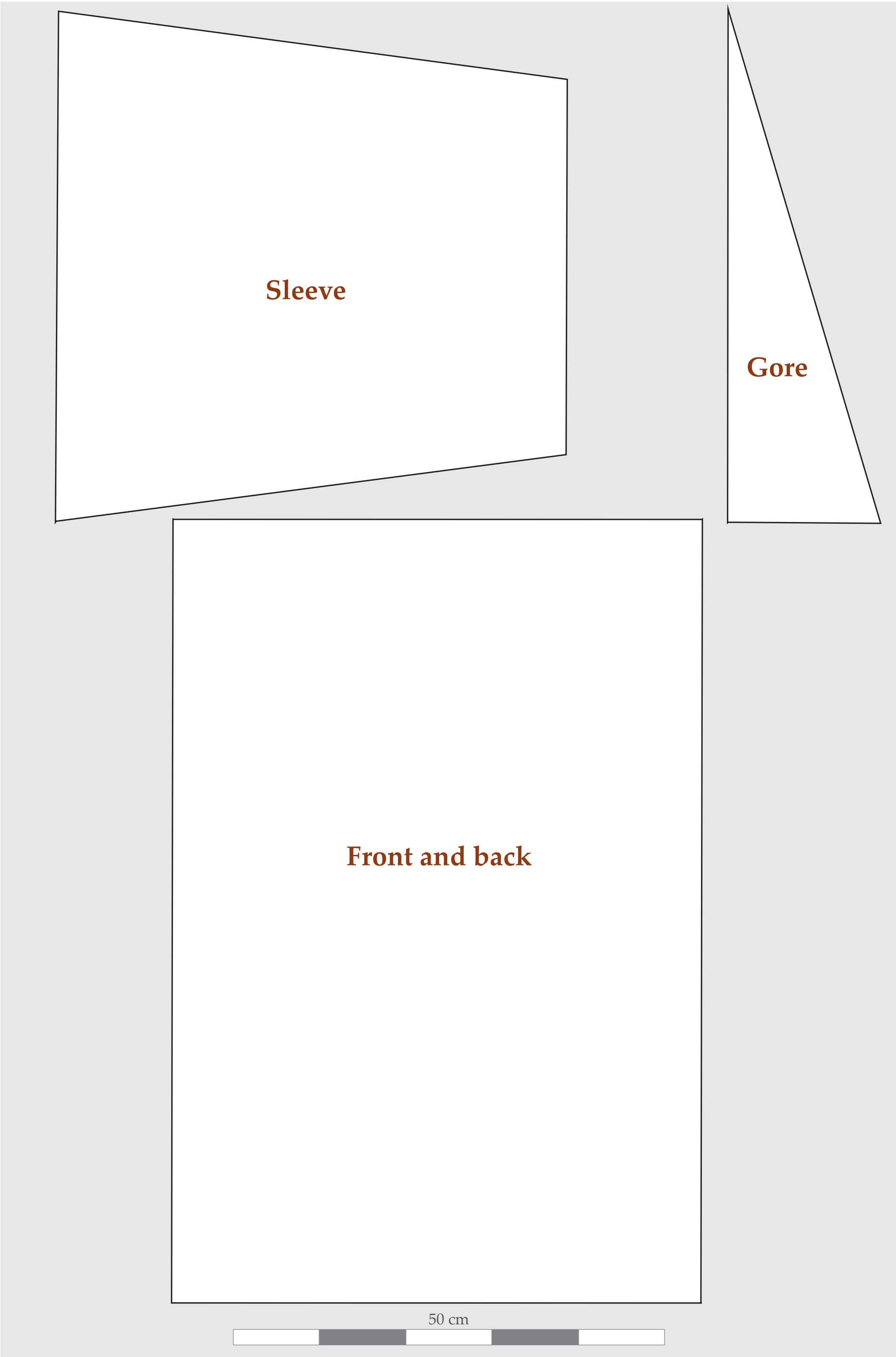
The kirtle pattern

Before the spinning and weaving of the 2/1 twill textile could begin, it was necessary to work out an exact pattern for the kirtle in order to calculate fabric size and how much yarn was needed for the weaving. Only one of the 64 fragments of the 2/1 twill from Bjerringhøj indicates that this textile was used for a garment and how it may have been constructed. This piece (C135a fragment 64) measures 26 x 19.5 cm (fig. 5.3.). At the upper cut-off edge, a line of regularly placed stich holes are likely to be the remains of a dissolved seam. The right edge has remains of a now 7 cm long selvedge. The left side has been folded diagonally to the thread direction and stitched down. This hem is fragmented and measures 10 x 1 cm today. The hem is decorated at the outer edge with a beaver trim of a 0.7 cm wide tabby-woven band created as a combination of 8 z-twisted and 3 S2z-plied red yarns in the warp and a similar red plied yarn used for the weft. The band is linked to the outer hem edge via the weft and is thus created in one workflow directly at the hem. The whole of C135a fragment 64 is interpreted as the remains of a left-side garment front piece with parts of a V-shaped neckline as well as the preserved shoulder and sleeve seams. This is the piece that most clearly and convincingly documents that the 2/1 twill was reworked into a garment at some point, and it also shows the care and craftsmanship of the execution of the secondary reuse.

► Fig. 5.3: C135a fragment 64 with the secondary made neck-opening, the hearth-shaped faces and the back part of the lepard

Photo: Roberto Fortuna.

There are two well-preserved kirtles from Denmark which could be used as a model or pattern for this garment, namely the Moselund and Kragelund finds, dated to AD 1150-1155 and AD 1045-1155 respectively (Hald 1980, 39 and 41; Østergård 2004, 124). Further, the Skjoldehamn find from Norway dated to AD 995-1029 and the Bernuthsfeld tunic from Germany, dated to AD 680-774 (Gjessing 1938; Schlabow 1976; Løvlid 2009; Mannering 2017a) are relevant finds for comparison with the Bjerringhøj grave, but none of these exactly match the details seen in C135a fragment 64. Each of the mentioned garments have varying details, but because we did not want to cut to muchin the embroidered textile,



◄ Fig. 5.4: Pattern for the kirtle.

Illustration: Line Maria Mørch

it was decided to use a simple design with large body parts, a V-shaped neck-opening, a straight shoulder seam, straight added sleeves in one piece, and side gores, but no mid-gores (fig. 5.4).

Adapted to the size of the live model, the pattern was constructed by Ida Demant so that the different parts could be cut out from the fabric, with almost no waste. The front and back consist of two rectangles, 100 cm x 63 cm, including allowances. The sleeves were made of two rhombic-shapes approximately 60 cm at the widest and 22 cm at the narrowest (wrist) end. The elongated triangular pieces, cut off while shaping the sleeves, were used for the side gores. The width of the sleeves then corresponded to the width of the front and back pieces, and the gores have approximately the same length as the sleeves. In this way, the fabric was woven in a width matching the width of the front and back pieces, and the length matching the length of the front, back, the two sleeves and a little extra for allowances. All in all, this added up to 63 x 400 cm of fabric, and for this approximately 10,350 metres of z and s-twisted yarns were needed (table 5.3).

► Table. 5.3: Calculations of the amount of yarn needed for the weaving of the kirtle.

2/1 twill	Threads / cm	Width in cm	Length in cm	Shrinkage of 7% in cm	Loomwaste in cm	Yarn length in cm	Number of threads	Yarn length in metre	Total yarn length in metre
Warp/z-twist	18	63	400	28	70	498	1,213	6,041	10,355
Weft/s-twist	16	63	400	4,4	-	67.4	6,400	4,314	

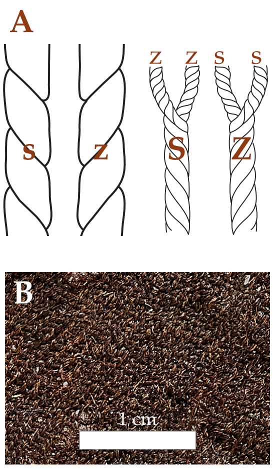
The dye analyses of the original 2/1 twill had at first glance very ambiguous test results (14152/01-02), with only traces of benzoic acid derivatives and flavonoids. Given that the reconstructed fabric was to have embroideries on the surface, it was therefore decided that the natural white or light greyish yarn for the ground weave should not be dyed. At a later stage, beyond the point where the design plan could be changed, new dye analyses of the 2/1 twill textile attached to the rediscovered human bones from Bjerringhøj (C145, but previously recorded under C9166) turned out to contain secure traces of luteolin (14152b/03-04). This result could be due to the fact that the small textile fragments on the bones had not been cleaned or exposed to light as much as the rest of the Bjerringhøj textiles during their more than 150 years in the museum. The presence of luteolin indicates that the ground weave was originally yellow and not white. However, the process of making the kirtle was already too far on to change the colour decisions.

The most important technical parameters of the 2/1 wool twill are the high twist degree of the threads and the high number of threads per cm which are responsible for the visual appearance and tactility of this textile. However, the use of combined yarn twist directions is just as influential, and this is a feature almost unknown in modern textile production. Together with the twill lines, the different yarn twist directions (z/s) provide a more vibrant surface and a visual appearance that cannot be simulated by other means (fig. 5.5, fig. 5.8).

At first, it was considered whether a modern machine-spun yarn could be an option. Could we find a single-spun yarn which was available in both twist directions, and which could be given the extra twist needed? Experienced hand weavers know that s-twisted yarns are very difficult, if not impossible, to buy commercially. Another way to cut corners could be to use a two-ply worsted such as Kampavillalanka 36/2. The fact that it is two-ply would not be visible from a distance but would definitely deviate from our overall desire and aim to use the craft knowledge available in the archaeological data. Therefore, it was decided to create yarns according to the original requirements of a z-twisted warp and a s-twisted weft, this was spun by Signe Vind using a spinning wheel. The fibre analysis showed a warp and weft yarn similar to each other, with a large content of medium fibres and several coarse fibres (fibre combination 1c) and based on this result it was decided to use wool from Spelsau sheep which had in fact grazed on fields close to Bjerringhøj in Jutland. The wool fleece was first washed in warm water with a mild detergent to remove the grease. The fibre preparation took place using a double rowed hackle and a wool comb. At first, the wool fibres were placed on the hackle (ripple), before most of the outercoat hairs were removed. With the handheld comb and sideways strokes, the fibres were transferred to the comb. The process was repeated three times, before the wool was pulled out as a sliver. When spun, the fibres were drafted from the end of the slivers for spinning. Combing the wool for warp and weft for test samples and fabric took 45 hours in total. A comparison between the original fibres and the yarn for the reconstruction showed that the latter ended up with too few coarse fibres. This shows how difficult it can be to match the fibres precisely in a reconstruction, even though they seem to match at the beginning, because the sorting can alter the final fibre content dramatically. Nevertheless, the feel of this textile is estimated to be almost similar to the original (see Skals 2023).

▼ Fig. 5.5.A: The principle of spinning a thread in the s or z direction and plying two threads in the opposite direction.
B: The diagonal twill lines of the 2/1 twill (C135a)

Illustration: Line Maria Mørch
Photo: Roberto Fortuna



◄ Fig. 5.6: Yarn for the kirtle spun by Signe Vind.

Photo: Signe Vind

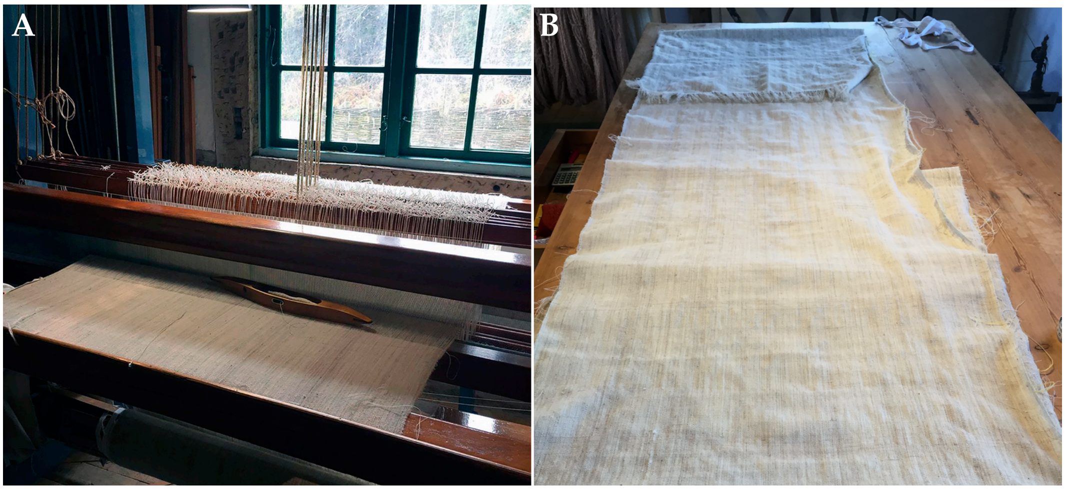
Spinning and weaving tests
In order to test the capacity and weaveability of the wheel-spun yarn, several yarn spinning tests and test weavings were made. A first sample of yarn was delivered by Signe Vind and analysed with a Dino-Lite microscope by Charlotte Rimstad. The test showed that the diameter of the yarn matched the original, however the twist degree was too low. The yarn was then tested on a small rising-shaft loom. The weave was set up to be woven with 21 threads/cm in the warp, using a 70/10 reed with 3 threads per slot. The yarn did stick a bit in the weave and needed help to be separated during weaving. There was some fibre fluff sticking out of the threads, but otherwise they appeared to be strong. However, it was only possible to beat in 12 wefts per cm when using the s-twisted weft yarn, as opposed to the desired minimum 16 threads per cm. The warp yarn, that was slightly thinner was also tested as weft, but with the same result. Altogether, based on the spinning test and the Dino-Lite microscope analysis, it was concluded that in order to be weaveable, the warp yarn needed a higher twist degree. In theory, this should also reduce the amount of fluff in the yarn. Further, the problem of the density of the weft was solved by letting the warp be more open, with only 18 threads/cm, using a reed 60/10 with 3 threads per slot. Without doubt, this weaving process seemed promising. The twill pattern in a 2/1 twill is only seen on one of the sides, the other will appear with a tabby-like weaving structure and after a few attempts of changing sheds in the right order, it became clear that it was easiest to weave with the tabby side upwards. Weaving in this manner further meant only lifting one shaft at a time. However, the disadvantage is that mistakes made by skipping a shed are not detected while weaving, in contrast to when the fabric is woven with the twill side facing upwards.

Signe Vind delivered a second batch of yarn with more twist added and afterwards, a second sample was set up on the rising shaft loom using 72 warps which gave a width of approximately 15 cm. This width was in fact too narrow for a proper test of the weaving process, but it was important to economize with the costly hand-spun yarn. The warp was set up again with 21 threads/cm (reed 70/10 with 3 threads per slot). However, it was still not possible to beat the weft to more than 11-13 threads/cm. This time, the test piece was woven with the twill side facing up, but this test weave resulted in many broken warp threads, and thus the weaving of the sample was abandoned after only 7 cm of weaving.

The third weaving sample was created using the rest of the warp from the second sample, which was set up with only 18 threads/cm (reed 60/10 with 3 threads per slot). It was now possible to beat the weft to approximately 14-16 threads/cm by supplementing the batten with the reconstructed iron weaving sword. Using the batten alone, the weft could only be beaten into 12-14 threads/cm. After washing the sample, it was clear that the finished fabric would shrink approximately 7% lengthwise, but only a little in the width. Based on the knowledge obtained from the test-spinning and weaving, it was decided to produce a z and s-twisted yarn with a high twist that could be used in the latter setup. Further, it was estimated that the density in the single yarn textile could develop into a more accurate thread count with resting and washing. Including the yarn for the test samples, Signe Vind spun in total 11,356 metres of yarn on a spinning wheel, weighing 946 g. This took approximately 94 hours (fig. 5.6).

Weaving the kirtle fabric
The fabric was woven by Ida Demant during December 2019 and January 2020 on a modern counter-march loom (fig. 5.7). After the warp was made, beaming was done with the assistance of Ulrikka Mokdad. Threading the heddles was done on six shafts. Only three are necessary for a 2/1 twill, however, when the number is doubled, more space is allowed for the warp threads to pass through the heddles. The warp was kept tight during weaving, as it was deemed the most efficient method when opening the sheds and beating in the weft. After weaving the first 10 cm, it became clear that despite the higher twist and more open warp setup it would be a very slow weaving process, resulting in many broken warp threads. In order to solve this problem, it was decided to glue the warp, a process in which Marie Wallenberg assisted. Inspired by Swedish sources from the 18th century (Kjellberg 1943, 382), a solution of bone glue was brushed onto the warp threads. An ordinary bone glue acquired at C. Flauenskjold A/S in Aalborg, dissolved 1:20 in hot water was used. This

solution improved the weaving process immensely, and it was now possible to weave up to 15 cm per working day. However, there were still many broken warp threads, which had to be replaced. In the beginning, the glue was primarily brushed once onto the warp behind the heddle-shafts. As an experiment, it was decided to brush the glue on to the part of the warp between the fell and the heddles as well. This further improved the process, and made it possible to weave up to 25-30 cm per working day with far fewer broken warp threads. The glue doubtless reinforced the yarn, but also made it evident how much wear the reed causes to the threads. A layer of fine glue dust was forming on the floor under the loom, and not least on the edge of the beater, below the warp.



◄ Fig. 5.7.A: Weaving the kirtle fabric on a couter-march loom.
B: The finished fabric for the kirtle, off the loom.

Photo: Ida Demant

The finished weave was cut off the loom in February, 2020. Before the fabric could be washed, the broken warp threads had to be fastened. This was done in March 2020. Afterwards, Anne Batzer washed it in her bathtub where first it was left to soak in lukewarm water with a little mild wool soap, in order to dissolve the glue that was still present between the fibres. Then it was rinsed until the water was clear, rolled in towels and left to dry. The finished fabric measured 455 cm on the loom, and the remaining loom ends 53 cm. After washing, the fabric had shrunk to 410 cm in length, which is equivalent of the estimated 7% as registered on the test samples (table 5.4). The width was almost the same, which is typical for a warp-faced fabric. Altogether the appearance of the fabric is slightly rustic, with wavy lengthwise stripes. It is evident that some parts of the warp threads had shrunk more than others, but the feel is of a very light, but slightly stiff material. Before it was cut into the different pattern pieces the surface was gently smoothened with a steam iron. The difference between the original textile, C135a, and the reconstruction is seen in fig. 5.8.

◄ Fig. 5.8.A: Close-up of the 2/1 twill weave (C135a)
B: The reconstructed 2/1 twill for the kirtle.

Photo: Charlotte Rimstad.

► Table. 5.4: Measurements of the reconstructed kirtle fabric

Reconstructed fabric	Length in cm	Width in cm
On the loom	455	69
Cut off the loom	443	69
After wash	410	68
Shrinkage in total	7%	0%

The embroidery design

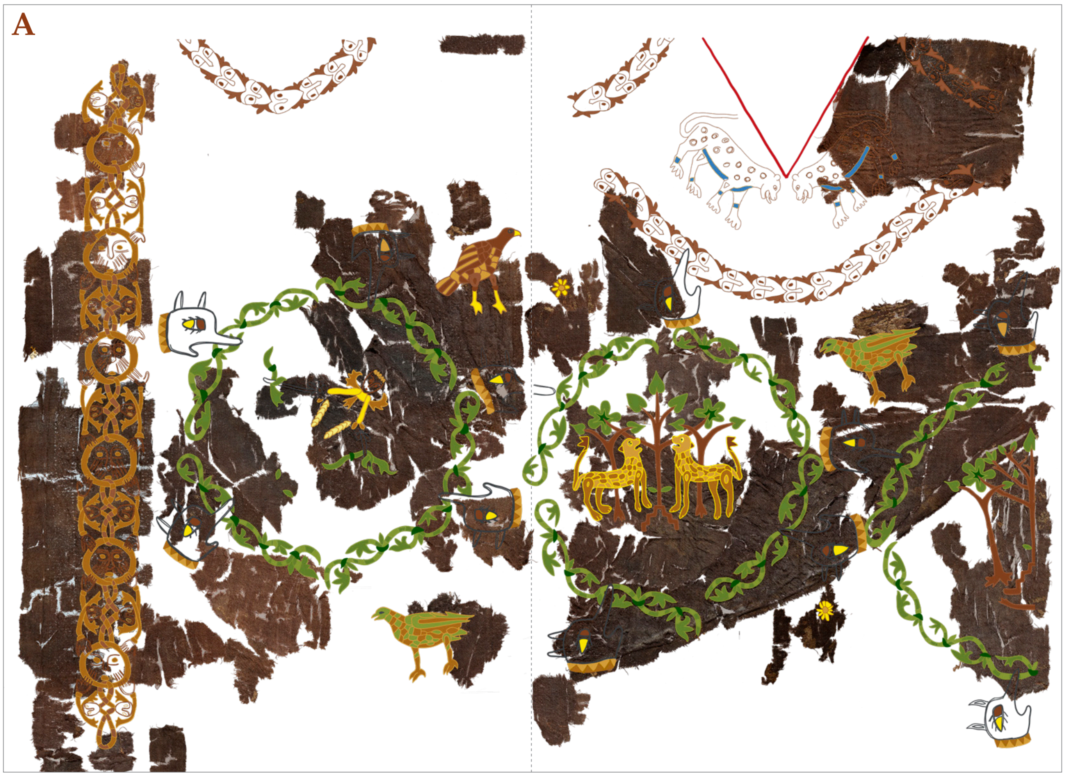
The 64 fragments of the embroidered 2/1 twill fabric represent approximately 1 m² preserved fabric. It is thus likely that large parts of this fabric were either not preserved in the grave or not recovered during the looting of the grave in 1868. The embroidery design was studied both on the original finds and using high resolution images in Photoshop. A 2/1 twill fabric has diagonal lines that are useful as a guideline for the orientation of the textile fragments, which can only turn in one of two directions, either upwards or downwards, according to the twill lines. Moreover, some of the fragments (C135a, fragment 1 and 64) have selvedges that guided their position further, although the original width of the fabric could not be determined. The largest fragments that could be put together were used as a starting point for the reconstruction of the overall embroidery design and the smaller fragments were then added. In this way, Charlotte Rimstad managed to digitally fit all fragments to a rectangular shape, which could then serve as front and back piece of the kirtle. As mentioned, the original fabric has clear signs of reuse (fragment 64), while other fragments (fragment 43 and 57) had been repaired with silk yarn for unknown reasons (fig. 5.9). Therefore, we suggest that at some point in its primary use, it functioned as a large decorative fabric, which was turned into a garment in a secondary use – perhaps only prior to the burial. The embroidery design should therefore be able to embrace both the first and the second stage of use. The reconstructed design was created to fit onto the front and back pieces of the kirtle while no embroidery was placed on the sleeves (fig. 5.10). This is, of course, not the only way that the original design could have looked, but it is our best suggestion at the moment.

A repeated pattern with rings of acanthus leaves (fig. 5.11) and a central motif began to take shape as the pieces were jigsawed together. It thus became clear that if placed like this the rings were not placed symmetrically on a line, but rather a little staggered. The acanthus plant ornament is a well-known, but little studied, motif in Late Iron and Viking Age iconography (Skibsted Klæsøe 1997). The ornament often occurs for instance on trefoil brooches which in Scandinavia are mostly linked to female contexts. The acanthus leaves are generally seen as a Carolingian trademark, adopted into Scandinavian jewellery around the second half of the 9th century (Skibsted Klæsøe 1997, 83). As such, the acanthus vines in the Bjerringhøj embroidery represent a well-known motif which has local comparisons and inspiration in contemporary jewellery but may also symbolize a direct link to high-status spheres in Viking Age society. For more detailed discussion about the embroidery motifs see Mannering & Rimstad forthcoming a.

▼ Fig. 5.9: Examples of silk stitches on C135a fragment 43 and 57.

Photo: Charlotte Rimstad

Other special motifs are the large animal heads which are seen in profile each with one



◄ Fig. 5.10.A: The placement of the original textile fragments with the final embroidery design.
B: The final embroidery design without the original textile fragments.

Illustration: Charlotte Rimstad

large eye, eye lashes, a long nose, an open mouth without teeth and narrow, long ears. The animal is alternately biting into the acanthus rings and looking away from it. The head ends in a collar consisting of small interchanging and opposing triangles, which makes the motif easy to recognize even if it is not fully preserved (fig. 5.12). The animal is interpreted as a dog or wolf's head, and it is preserved on several different pieces with remains of at least 11 heads. The animal head was earlier described by Margrethe Hald as a bird and was turned upside down (Hald 1980, 105), but since the motif does not resemble the other birds, this interpretation is no longer plausible. The wolf plays a vital part in Nordic mythology, the most famous being the Fenris wolf, and the fact that the embroidered wolf

► Fig. 5.11: C135a fragment 7 with embroideries of acanthus vines.

Photo: Roberto Fortuna

► Fig. 5.12.A: C135a fragment 5 with embroideries of a wolf's head.
B: Theillustration of the wolf-head design.

Photo: Roberto Fortuna
Illustration: Charlotte Rimstad

A

B

has such a clear collar could indicate a link to this narrative. Also, in the Nordic animal styles there are numerus decorations with beasts depicted on a vast range of materials that can be interpreted as wolves (Høilund Nielsen 2002). So this seemingly sweet looking animal head, dog or wolf, can be seen as a strong symbol of power that dominates in the Bjerringhøj embroidery.

Large felines are also visible on the embroidered textile. Two of these animals are placed as a central motif inside one of the acanthus vine circles (C135a, fragment 35). Both animals have tails that bend upwards and are seen in profile facing each other. Between the two animals is a step-like feature which can be interpreted as a stylized tree (fig. 5.13). As the heads of the four-legged animals are missing or poorly preserved, their exact species cannot be determined, but based on the feet and tails they are possibly lions.
Another slightly different looking feline, but of a similar size, is found on C135a fragment 64 (see fig. 5.3). The head and front part of the animal is not preserved but based on the dotted belly it is interpreted as a leopard. Large felines, especially lions, are motifs which occur on many different artefacts and may thus be inspired by similar feline-like depictions seen on other sources, such as jewellery or foreign silk textiles (Gärtner & Ulriksen 1997; Schrenk 2004; Hedeager Krag 2010, 25). The inspiration, found in these exotic sources, is further underlined by the symmetrical position of the lions around a tree-like feature. As such, lions are a well-known motif in the Nordic animal styles and not at all foreign to Nordic iconography in this period (Skibsted Klæsøe 2002). Whether it should be interpreted as a motif with strict Nordic roots or also containing Christian connotations is open for debate, but it is tempting in this context to see these animals as symbols of power, just like the other depicted animals, that possibly had a specific meaning and relation in the embroidery.

◄ Fig. 5.13: C135a fragment 35 with two four-legged, mirrored animals, around a tree.

Photo: Roberto Fortuna

► Fig. 5.14.A: C135a fragment 8 with embroidery of a short-legged bird.
B: C135a fragment 6 of a long-legged bird.

Photo: Roberto Fortuna

Two different types of birds are depicted on various pieces of the textile, though they are not fully preserved. The first kind has short legs and may be some kind of waterfowl, a pigeon or a chicken. The other bird has longer legs, more pronounced thighs and sharp pointed claws (fig. 5.14). This is most likely a bird of prey, such as a falcon or an eagle. In general, birds are a well-known motif in Scandinavian Iron Age iconography, for instance as bird-shaped brooches or as decorations on weapons and figurines (Skibsted Klæsøe 2002; Vang Petersen 2005). The ravens, Hugin and Munin, are known to be the birds of Odin, but goddesses are also connected with birds (Arwill-Nordbladh 2013). In a Viking Age context, hunting birds and birds of prey can be seen as motifs signalling high-status, wealth and prestige.

Several of the embroidered fragments contain motifs of two different human faces, placed on top of each other. In one of the motifs there are arms and hands linking the faces (fig. 5.15). According to how most of these pieces fit together, it is likely that the largest motif was placed along the left selvedge of the fabric. As there are no signs that these faces were also placed next to the right selvedge in a symmetrical manner this is neither reflected in the reconstruction. On a different fragment, the beginnings of two, separate rows of much smaller, triangular or nearly heart-shaped human faces are visible (see fig. 5.3). These faces are simpler in their construction with the faces placed on top of each other, with acanthus-like leaves filling out the spaces between their pointed cheeks. The fact that two differently designed faces are present underline the great variety in the overall embroidery design. Faces very similar to the ones depicted on the Bjerringhøj textile are a well-known motif in contemporary Viking Age iconography (Helmbrecht 2011; Kastholm et. al 2017). Although they are often interpreted as representations of Odin, depictions of the human face in general cannot be seen representing one deity alone and come from a long tradition with many connotations (Helmbrecht 2011, 417-418).

◄ Fig. 5.15: C135a fragment 1 with face large embroideries.

Photo: Roberto Fortuna

All in all, the embroidery patterns seem to be an interesting, yet confusing mixture of inspiration taken from Nordic iconography and exotic motifs, although the overall impression of motifs and their execution points towards a Nordic production place.

As it is obvious that large parts of the embroided fabric have not been preserved, missing parts in the embroidery design had to be filled in. These parts were designed using inspiration from other embroideries of the period. The Bayeux Tapestry (AD 1070s) was especially useful as inspiration for the many missing heads of birds and cat-like animals (Rud 1988). Some embroidery motifs could unfortunately not be clearly deciphered, and the reconstruction is therefore primarily based on the clearly visible parts. Likewise, the motifs placed on the back of the kirtle are the less clear ones. It is possible that a whole new and more complicated design would emerge, if all the empty stitch holes were used and included in the pattern design. This is an interesting task for the future.

Recreating the embroidery yarn

Coming from the same modern Spelsau wool as the ground weave, the S-2z plied embroidery yarn was spun and plied on a spinning wheel by Signe Vind. The spinning of the 374 g of embroidery yarn took 82 hours. The dye analyses of the many embroidery yarns (14152/03-18) gave very few results, except for traces of indigo, benzoic acid derivatives, unknown components, and one example of flavonoids. Most of these components are considered to be contamination. Although the embroidery yarns today have different shades of yellow and brownish colours, it is likely that they were dyed in different colours originally and that the lack of clear result is primarily due to poor preservation conditions. Therefore, it was decided to use dye sources that would in theory be less likely to survive poor preservation, such as greenish, brown and yellow dyes (Ringgaard 2018). In general, clear red and blue colours were avoided as they should have left traces in the dye analysis, if present. One exception was the belly of the leopard motif (C135a, fragment 64), which in the analysis from 1991 had proved to be dyed with indigo (Walton 1991, 140). All the dyeing of the embroidery yarns was done by Anne Batzer. In total 300 grams of the hand-spun and plied yarn was plant dyed in 10 different colours (table 5.5, fig. 5.16).

► Fig. 5.16: The yarn colors made for the reconstructed embroideries.

Photo: Charlotte Rimstad

Colour	Estimated g	Used g/m
Light brown	55.75 g	24.84 g/ 99.36 m
Medium brown	48.22 g	5.17 g/19.64 m
Dark brown	43.15 g	13.05 g/47.55 m
Blue	4.92 g	0.88 g/3.03 m
Light green	4.92 g	22.54 g/100.73 m
Medium green	26.17 g	17.73 g/ 86.75 m
Dark green	3.31 g	3.31 g/11.41 m
Sunny yellow	9.03 g	5.81 g/22.58 m
Medium yellow	61.85 g	16.10 g/64.40 m
Grey	17.13 g	10.3 g/35.52 m
Total	**274.45 g**	**119.73 g/490.97 m**

◄ Table. 5.5: Estimated and used amount of hand spun and plied embroidery yarn (S-2z) needed for the kirtle fabric.

To make the embroidery, the cut out front and back pieces of the kirtle were delivered to Fria Gemynthe together with 1:1 prints of the final design as well as enlarged prints of the original textiles so every stitch and detail could be studied and copied when necessary for the overall design. In preparation, Fria Gemynthe had made an embroidery test using a matching machine-spun yarn in order to calculate how much yarn would be necessary for each motif. The calculation turned out to be a problem as the weight and filling of a machine spun yarn does not match that of a hand-spun yarn. The calculation of how much yarn was required for each of the 12 different colours was therefore rather uncertain, with amounts from only 4-5 grams (dark green and blue) to 61 grams (medium yellow). It eventually turned out that much less was actually used.

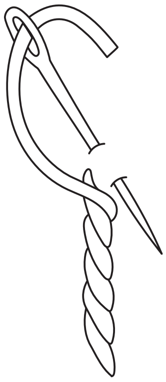
The motifs were at first transferred onto a water-soluble stabilizer fabric using a blue water-soluble pen. The stabilizer fabric was then stitched together with the ground weave, using preliminary tailor basting stitches both horizontally and vertically on the entire surface. Then the material was inserted into an embroidery frame, which was deemed necessary in order to place each element correctly, and according to the overall scheme. The work began from the middle and continued towards the edges, first by creating the outline and then filling in the motives (fig. 5.17). The stiches used in the original embroidery resemble what we in modern terms call stem stitches and as Margrethe Hald puts it, they were "slightly heavy and clumsily executed" (Hald 1980, 104). Close-set lines of stiches make the outline, and the motifs are then filled in with the same type of stitch. One would imagine that it would take the same number of stiches to fill out the motifs in the reconstruction as in the original, but the variations in the thicknesses of the hand-spun yarns sometimes made it necessary to add more stitch-lines. Fortunately, this did not affect the overall impression of the embroidery. The embroidery frame kept the ground weave taut, while the stiches were added. This should also prevent it from being pulled in afterwards. However, the tension of the yarns – both in the fabric itself and the rather heavy embroidery yarn – compared to the yarn of the ground weave, did pull it in and made waves in the fabric.

When the embroidery was finished, the tailor basting stitches were removed, and the fabric soaked in clean lukewarm water for few minutes to dissolve the stabilizing fabric. The water was then carefully squeezed out and the wool fabric rolled in a towel. The next day, the damp piece of embroidered fabric was removed from the towel and blocked on a large wooden board covered in an old wool plaid, where it was left for a week, slowly drying into shape. Later, when the kirtle parts were sewn together it was given a light pressing, but it was otherwise decided to let it be, as one must expect the slight wavy effect would have been the same in the Viking Age. Fria Gemynthe spent 95 hours embroidering the front piece with all its motifs. Fewer motifs were planned for the back, so it took only 79 hours; that is 12 and 10 working days of 8 hours respectively. Only 119 grams of yarn were used for the entire embroidery. Altogether, the rather random distribution of the motifs gives a hint of how it may have been executed in the Viking Age, when the overall planning and controlling of the pattern would have been different to today. Further, it cannot be ruled out that several embroiderers with different degrees of skills worked on the original.

Finishing the kirtle

► Fig. 5.17.A: The reconstructed embroideries in the making.
B: The principle of the stem stich used in the embroidery.

Photo: Charlotte Rimstad
Illustration: Line Maria Mørch



The final sewing and finishing of the garment were performed by Birgitte Kjelstrup, using a plied wool thread taken from the production of the ground weave. There are no seams preserved among the 2/1 twill textile fragments from Bjerringhøj to show how it was stitched together. The small stitches of silk thread in fragments 43 and 57 seem to be repair stitches (see fig. 5.9). Therefore, the choice of seams had to be based on other finds and rational conclusions. Among the textile fragments preserved from the Viking Age, such as Hedeby and the Frisian settlement Elisenhoff (also in Germany), there are several finds to choose from (Hägg 1984, 149-152; Hundt 1981). For this kirtle it was decided to use a flat felled seam (see fig. 6.7), which is represented in both find groups. It is a very stable and solid type of seam, which is very useful for handwoven fabrics with a tendency to fray.

The decision to make a V-shape neck opening is based on C135a fragment 64 (see fig. 5.3, 5.4).

As mentioned before, this fragment has part of a V-neck opening with a red narrow-woven band decorating the outer edge, which was added after the hem was cut, folded backwards and hemmed. Part of the leopard's tail is visible on the back of this fold, and demonstrates that the neck opening was cut into the finished embroidery design. The narrow red band was made by Ida Demant using a machine-spun yarn dyed with madder by Anne Batzer. This colour was already identified in 1991 (Walton 1991, 140). The edge was created using a rigid heddle with space for 17 threads. A single twisted yarn was used for the warp threads, woven with 6-7 wefts per cm. The edge has a final width of 0.5 cm (fig. 5.18). Rigid heddles are not preserved from the Viking Age. The earliest examples known from Northern Europe are found in Bergen in Norway and are dated between AD 1170 and 1193 (Behr 2000, 105). However, rigid heddles were widely known in the Roman world, so it is not impossible that this tool could have been used in the process.

The garment with all its many details was finished in early October 2020, almost one year after the work had begun (fig. 5.19). Five different craftspeople, a spinner, a weaver, a dyer, an embroiderer, and a seamstress, plus several craft experts helping and advising, had been involved in the process of creating this beautiful garment.

Trousers

The only indications of legwear in the Bjerringhøj burial are a few textile fragments still found in situ on the human bones. At the right ankle, remains of two wool rolls and a narrow tablet-woven band were found. This is interpreted as decoration on a trouser leg, meaning that the trousers went down to the ankle.

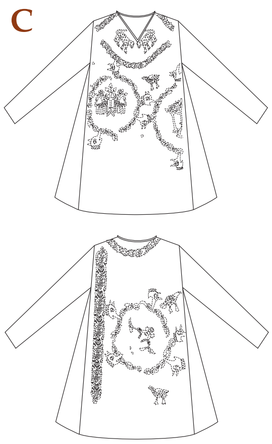
The trousers pattern

◄ Fig. 5.18: Close up of the kirtle neck opening with the red woven edge.

Photo: Roberto Fortuna

► Fig. 5.19.A: The reconstructed kirtle, front.
B: Back.
C: Schematic illustration of the kirtle (Top: front. Bottom: back)

Photo: Roberto Fortuna.
Illustration: Line Maria Mørch



As there were no other certain traces of the trousers, the pattern for them had to be based on another find. The choice fell on the trousers from the Norwegian Skjoldehamn find, dated to AD 995-1029, which are also decorated with bands placed around the ankle (Nockert & Possnert 2002; Løvlid 2009, 109-110). The Skjoldehamn find was discovered in 1936 and the textiles were analysed and published in 1938 (Gjessing 1938) and again in 2009 (Løvlid 2009). Dan Halvard Løvlid's research was accompanied by a new suggestion for how to reconstruct the find. Though well preserved, the Skjoldehamn trousers are fragmented in the parts that are vital for understanding the pattern and it is difficult to get a clear picture of how they were constructed. In collaboration with Lone Brøns-Pedersen, the available published information was evaluated and compared to the construction of other ancient trousers and the current suggestion developed.

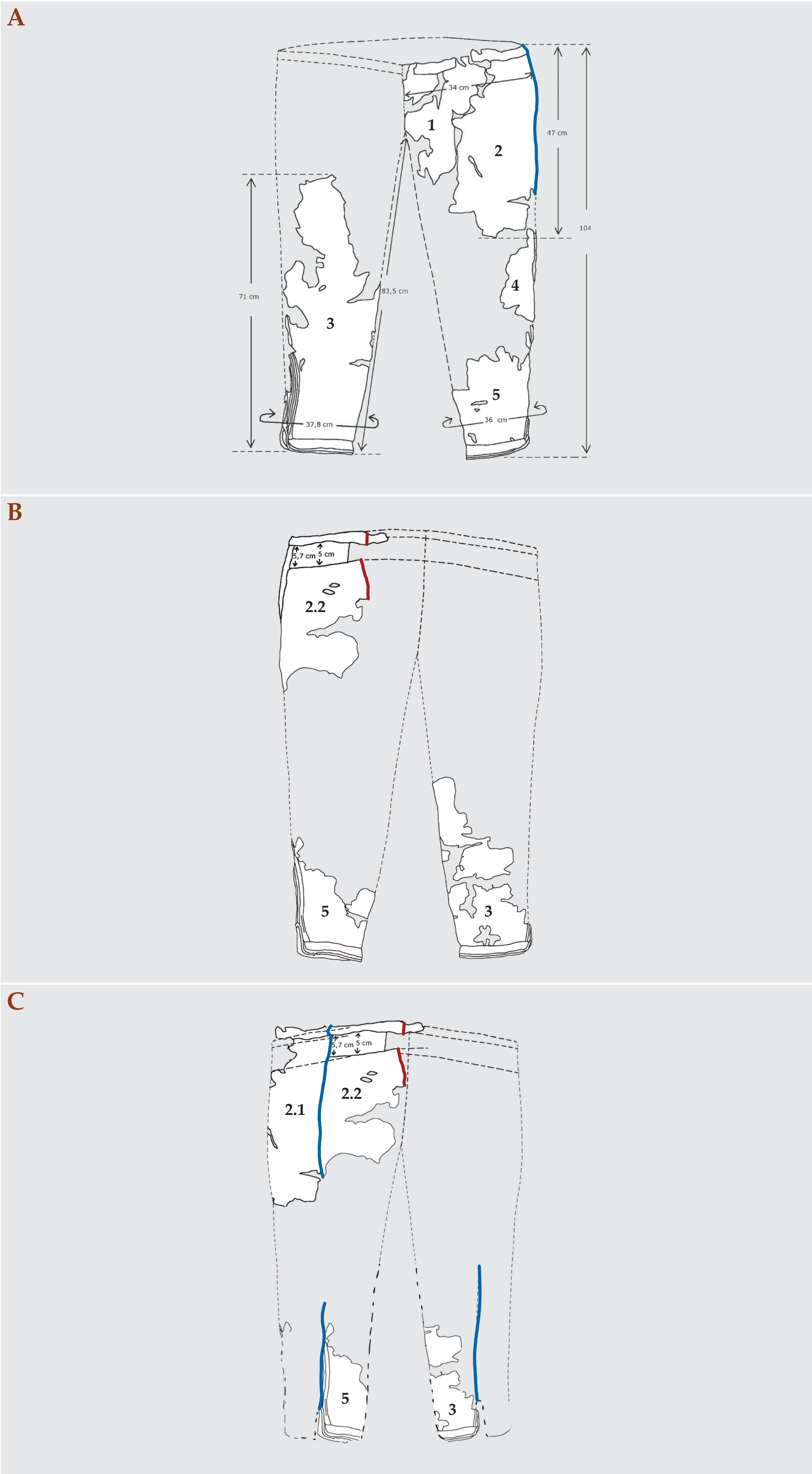
In Gutorm Gjessing's interpretation, the trousers are made of two pieces of fabric, one for each leg, folded around the legs forming a tube with the seam placed at the sides. The two pieces are joined in the crotch and the elaborately trimmed slits, found at the end of the seams are placed on the outer side of the legs (fig. 5.20a-b). There are several arguments against this reconstruction plan. This construction does not have any parallels in any well-established prehistoric trousers pattern (eg. Schlabow 1976). In general, most preserved prehistoric trousers have the main seam turned towards the inside of the legs (Meedom 1984), which allows for shape and space for the buttocks and the crotch. This detail is not accounted for in Gjessing's reconstruction and cannot be compensated for by extra width. When Løvlid re-examined the find, he observed a selvedge in fragment 2 (fig. 5.20 marked with red), which Gutorm Gjessing did not observe (Løvlid 2009, 107). This discovery opens for a different placing of the pieces, creating something more similar to other known trouser patterns. Fragment 2 consists of two parts (2.1 and 2.2), joined by the seam (marked with blue), which Gutorm Gjessing interpreted as a side seam. From seam to selvedge, 2.2 is only 19-21 cm wide, a size that would fit well as a piece covering the buttocks. Thus, Gutorm Gjessing's side seam becomes then in our reconstruction a vertical seam at the back of the left trouser leg and the selvedge will be part of the equivalent back seam (fig. 5.20c).

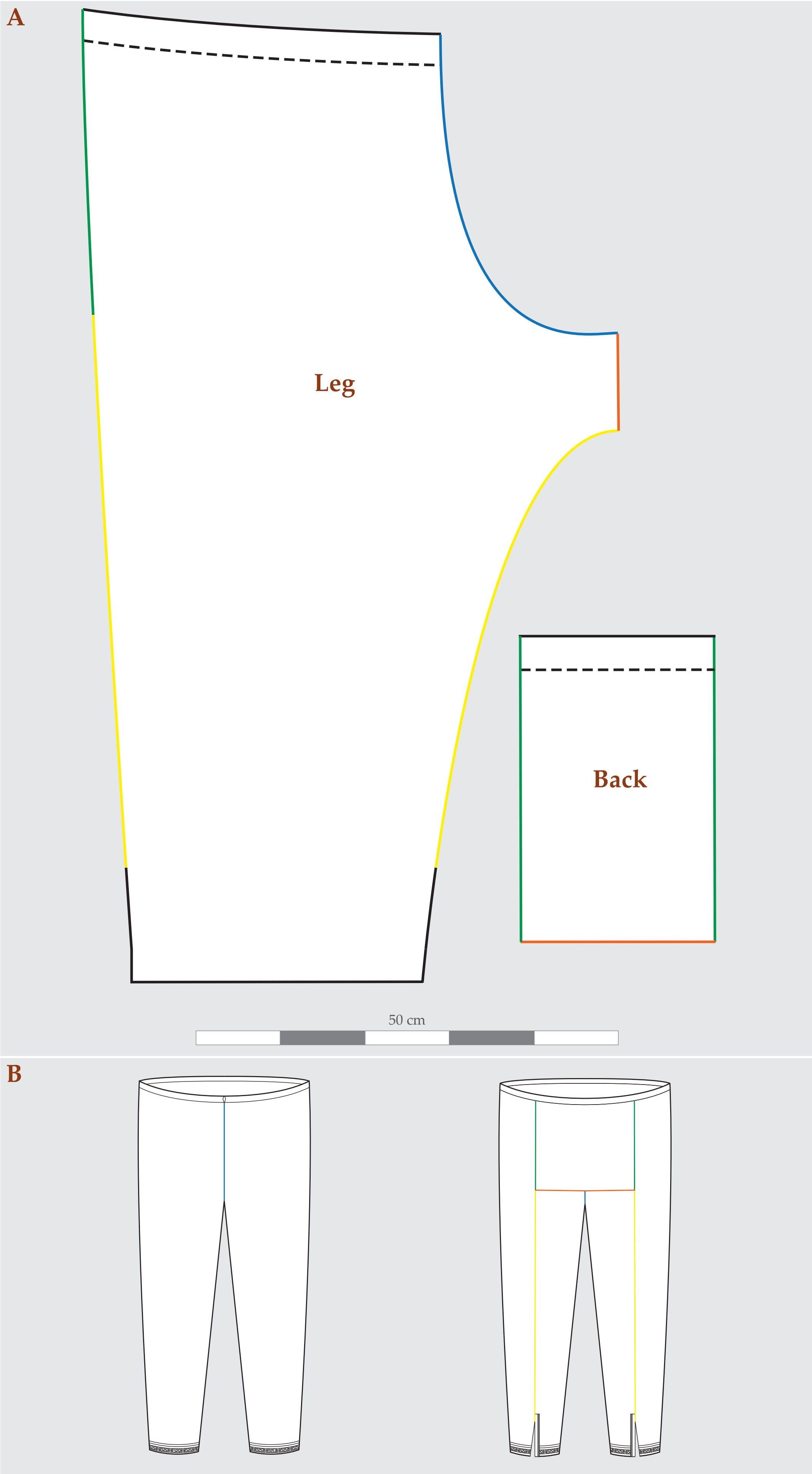
At the front part of the trousers, we decided to add a crotch arc. This is known from the Thorsberg and Damendorf trousers dated to the early part of the 3rd century AD (Schlabow 1976, 76; Möller-Wiering 2011, 41). Extra fabric was added to create space between the legs and the back square, as the wearer would otherwise not be able to move. Here we copied the shape seen in the Thorsberg trousers (Möller-Wiering 2011, 52). Alternatively, the back square could be cut in a different way to allow for such space, but no sources were found for such a design. Our interpretation resulted in a fitted pair of trousers that match the elaborate shirt and kirtle, and which are still based on reliable archaeological sources (fig. 5.21).

► Fig. 5.20: Gutorm Gjessings interpretation of the Skjoldehamn trousers.
A: The front.
B: The back.
C: The new interpretation.

Red line marks the selvedge.
Blue line marks the seam.

Illustration: After Løvlid 2009, modified by Charlotte Rimstad & Mads Lou Bendtsen





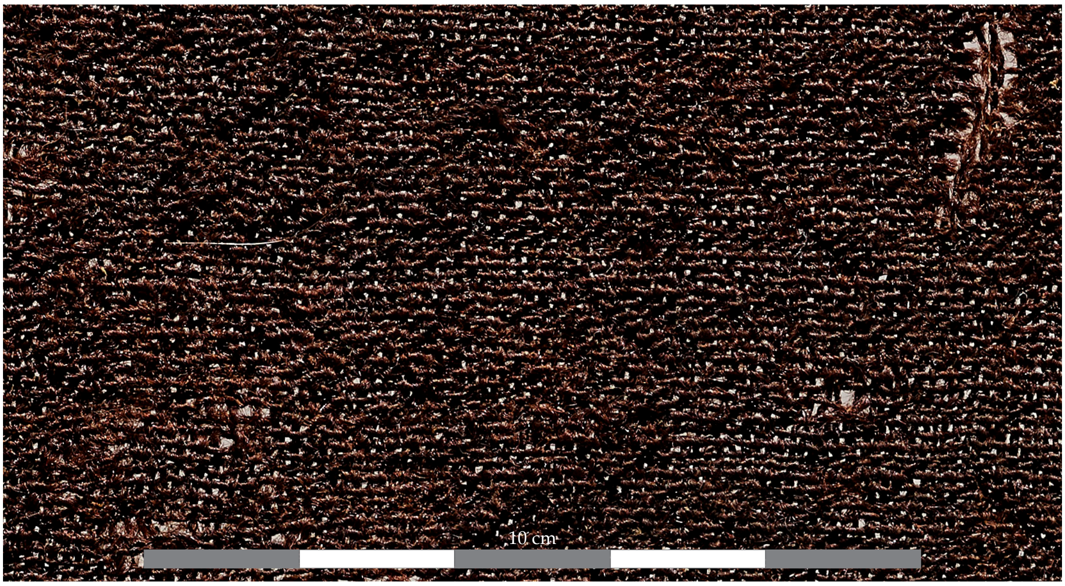
◄ Fig. 5.21.A: The pattern of the trousers based on the Skjoldehamn find.
B: The final design of the reconstructed trousers.

The colors, shows corresponding edges, that are stiched together in the final pair of trousers.

Illustration: Line Maria Mørch

Weaving the trouser fabric

It was decided to use a reconstruction of the wool tabby from Bjerringhøj (C135c) as the main fabric for the trousers. Although almost 1 m² of this textile is preserved, it has no seams or traces of sewing that indicate its original use. The weave has z-twisted yarns in both thread directions and although the warp and weft directions are unknown, the warp has most likely the hardest twist and most threads per cm (table 5.6). Luckily, the characteristics of this textile are so common that it was decided to use a machine spun and machine woven cloth obtained from Kjellerup Væveri. Unlike the original, this fabric is made from a plied yarn, S-2z, but the thread density of was in a range comparable to the original textile and its overall appearance was deemed satisfactory. More important, the original fabric has an interesting, crimped surface which makes it look a bit like a diamond twill, despite being a tabby (fig. 5.22). This special surface was obtained in the modern fabric by machine washing it and leaving it to dry. The dye analysis of the Bjerringhøj tabby (14152/19-20) showed traces of flavonoid, which could indicate the presence of a yellow colour. It was thus decided to make the trousers yellow. Anne Batzer dyed the fabric using weld as the dye source, before it was cut into pieces and sewn (fig. 5.23).



► Fig. 5.22: Textile C135c with a visible crimp pattern.

Photo: Roberto Fortuna.

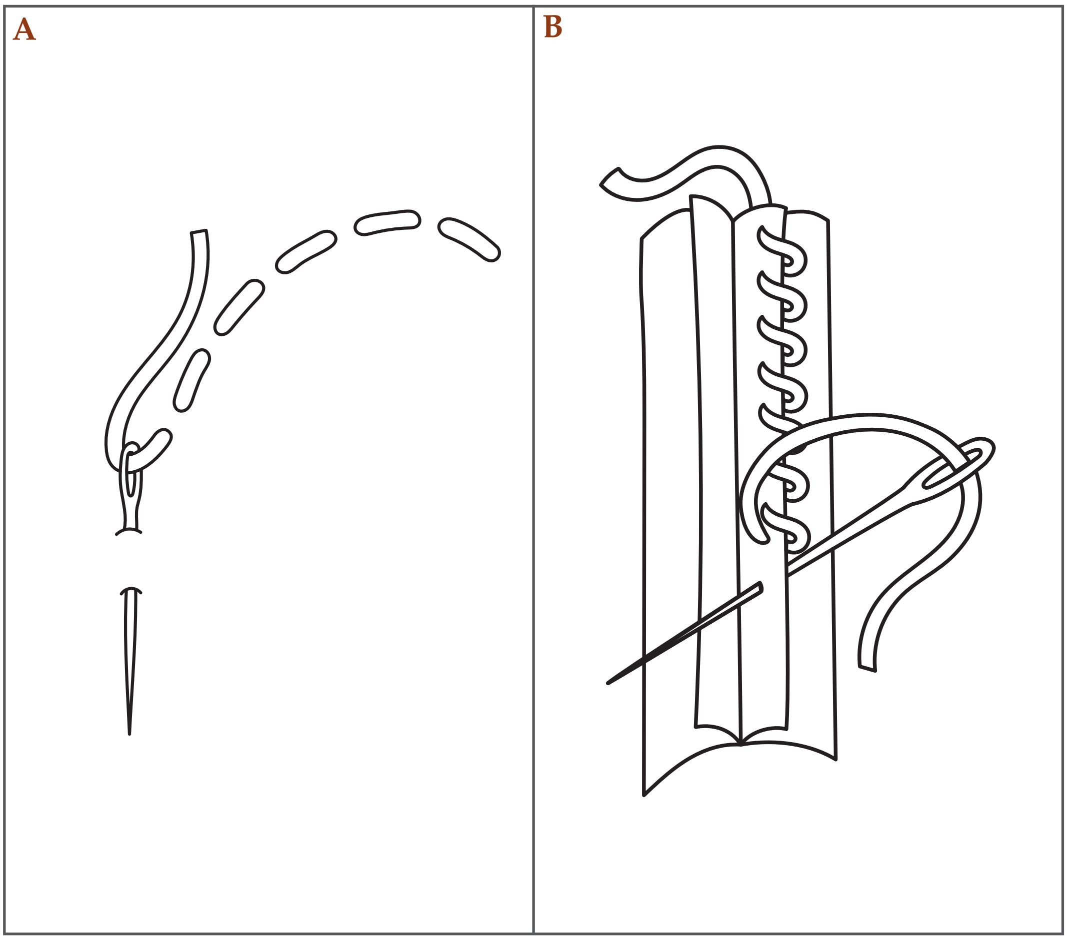
► Table. 5.6: Technical details of the original textile chosen for the trousers and the reconstructed textile.

Textile C135c	Colour	Twist direction	Twist degree	Yarn diameter in mm	Thread/cm	Fibre
6 fragments in tabby	Dark brown	z/z	40-50°/ 40-50°	0.3-0.5/0.4-0.5	14-16/12-14	Wool
	Flavanoids					1c
C. 1 m2 preserved						
Reconstruction	**Colour**	**Twist direction**	**Twist degree**	**Yarn diameter in mm**	**Thread/cm**	**Fibre**
Tabby	Yellow	S2z	20°/20°	0.5-0.6/0.5-0.6	15/15	Wool
			Ply: 30°			

The main seams of the trousers were hand sewn by Ida Demant, using the stitch types known from the Skjoldehamn trousers (Løvlid 2009, 108). A similar, but simpler, flat felled seam is known from Old Norse garments (Østergård 2004). The seams of these examples are described as made from the front, with the allowance of the upper piece folded over the lower piece and then stitched with fine running stiches in the fold. When the allowance is stitched down with overcast stitches, the seam is barely visible on the front. However, when this seam is made in practice, it is much easier to place the two pieces front to front and make the running stitches directly through both layers (fig. 5.24a). Afterwards the allowance is pressed to one side and stitched down with overcast stiches (fig. 5.24b).

◀ Fig. 5.23.A: Lone Brøns-Pedersen showing the reconstructed trousers.
B: Close-up of the fabric.

Photo: Ida Demant



◀ Fig. 5.24.A: The principle of running stiches.
B: The principle of overcast stich.

Illustration: Line Maria Mørch.

The ankle back slit

In the ankle area of the legs, the Skjoldehamn trousers have a decoration and a slit which, in our interpretation, was placed at the back of the trouser leg. This detail was included in the reconstructed Bjerringhøj trousers by combining the wool rolls and the narrow tablet woven band recorded on the Bjerringhøj bones (C145) as well as the two padded silk rouleaus (C139).

► Table. 5.7: Technical details of the original textile chosen for the trouser decorations and their reconstructions.

Textile	Colour	Twist direction	Twist degree	Yarn diameter in mm	Thread/cm	Fibre
C139, piece 1 Tabby 16.2 x 1.5 cm	Light brown No dyes detected	z/unspun	40-50°/ 40-50°	0.3-0.5/0.4-0.5	14-16/12-14	Silk
C139, piece 2 Samite (weft faced compound twill) 16.2 x 1.5 cm each	Light brown Madder and tannin	z/unspun	30°/-	0.2/0.3	c. 17 binding and 14 double main warps/ c. 15 double passes (at least 2 wefts)	Silk
C139, padding Tabby padding	Greyish	z/?	40°/?	0,6/?	Unknown	Wool
Reconstruction Tabby	Rose Cochineal	Unspun	-	0.2/0.2	35/30	Silk
Reconstruction Samite	Dark red Madder	Unspun/ S plied, 2 unspun	Ply: 20°	0.2/0.6	Warp: 45 ends per cm, 15 binding warps, 30 inner warps (1:2) Weft: 13-15 passes per cm (2 wefts)	Silk (gummed for warp, degummed for weft)
Reconstruction Padding	White	S2z/S2z	20°/20° Ply: 30°	0.5-0.6/0.5-0.6	15/15	Wool

▼ Fig. 5.25: The rouleaus, C139, made of silk tabby and samite.

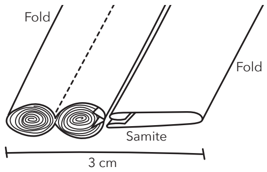
Photo: Roberto Fortuna

The two identical and fully preserved rouleaus, measuring 16.2 x 3.0 cm, are made of two padded rows of a silk tabby, sewn together with a double layer of silk samite (table 5.7, fig. 5.25). Through very small holes in the outer fabric, it is possible to see the padding fabric which is a quite coarse wool tabby made in z-twisted yarn. No dye samples could be taken from this textile, but the greyish colour indicate that it could originally have been blue. As the preserved rouleaus are not attached to any other textile and no sewing stitches are visible, their original function is still unknown. In the reconstructed outfit from 1991, they were used to decorate the slit in the neck opening of the wool tunic. Here we propose a different use and have placed them vertically along the back slit in the leg of the trousers.

Åse Eriksen used a treadle loom to hand weave a silk tabby and samite which could also be used in the reconstruction of the other Bjerringhøj silk items (see specifications in the section about the belt). The dye analysis of the rouleaus detected madder and traces of tannin (14152/57-58) in the samite, and the reconstructed textile was therefore dyed with madder in a dark red colour by Anne Batzer. As no dyes were detected in the silk tabby (14152/56) it cannot be ruled out that this textile originally may have been white or undyed. Nevertheless, it was decided to use the same rose colour as for the silk tabby used in the pendants (C137). In 1991 this textile was identified as dyed with lichen (Walton 1991, 140).

To reconstruct the two identical rouleaus, two 4 x 17.5 cm large pieces of the pre-dyed silk tabby were folded in half and hemmed. A row of running stitches was placed c. 7 mm from the fold, thus dividing the piece into two tubes. Padding made from a tightly rolled-up wool fabric was pulled through each tube. The padded silk tabby and a folded and hemmed pre-dyed samite piece of the same size were then sewn together along their hems (fig. 5.26). The two reconstructed rouleaus were sewn onto the inner edge of the lower 16 cm long vertical slit in the trousers' back seam with the padded area turned inwards.

A



▲ Fig. 5.26.A: Schematic illustration of how the padded tabby is attached to the samite textile in the rouleaus.
▼B: The reconstructed rouleaus.

Photo: Irene Skals
Illustration: Line Maria Mørch

B

The ankle cuffs

A number of narrow and tight rolls made of a fine wool tabby textile were found still in situ around the right ankle bone belonging to the Bjerringhøj find (C145) and as loose pieces in the same box (table 5.8, fig. 5.27). The three preserved rolls measure respectively 17, 11, and 4,5 cm in length and are 0.8 cm in diameter. Based on these data, it can now be confirmed that the square textile C135b which until now had an unknown function, is a fourth unfolded example of one of these rolls (fig. 5.28). With a size of 13 x 10 cm, it has a similar length to the other rolls and had it still been rolled up, it would have had an identical width too.

The fibre analysis performed by Irene Skals has further strengthened this interpretation by showing that the various wool textile rolls are made from an identical wool quality. A previous dye analysis has shown that this textile was dyed blue, probably with woad, but when used as a padding, the colour was not visible and thus not important for its function. Further, underneath the lowest roll on the right ankle bone, a small fragment of a tablet-woven band with silver threads was found (see fig. 5.27), and more pieces of the same tablet-woven band were found as two loose fragments, measuring 14 x 0,7 cm and 60 x 7 mm respectively. The shortest piece still has the shape of a half circle from sitting around the ankle bone. The tablet-woven band is made with two outer silk tablet warps, and wefts of silk and silver threads, creating a geometrical pattern. The band is unique in its construction, but the design resembles the other tablet-woven bands from Bjerringhøj (C137, C138).

► Fig. 5.27: The right tibia bone from Bjerringhøj, with two preserved wool rolls and a tablet-woven band.

Photo: Charlotte Rimstad

◄ Fig. 5.28: The tabby C135b from Bjerringhøj, which must be a unfolded wool roll from the left ankle.

Photo: Roberto Fortuna

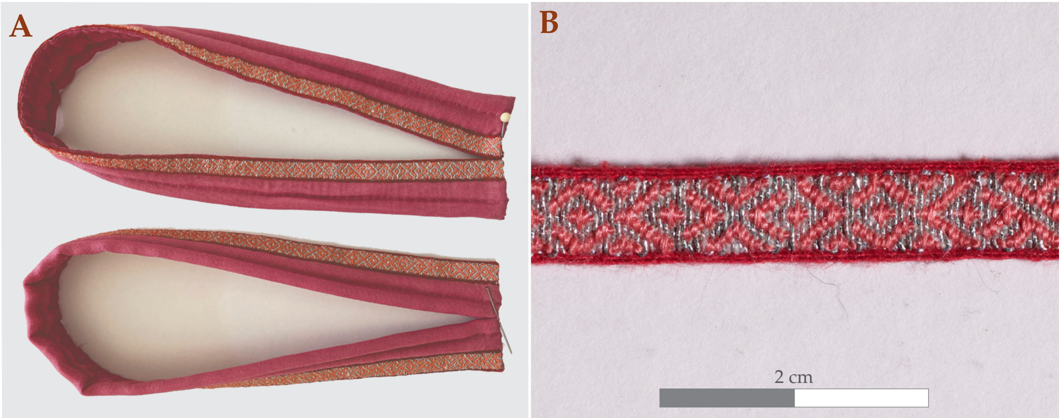
Altogether, this information was used to make a pair of padded ankle cuffs that were placed on the bottom of the trouser leg and in this way meet with the padded ankle slit created by the rouleaus. The construction of the lower ankle cuffs was made in a similar manner to the wrist cuffs (C138) with one decorated and one plain section consisting of two padding rolls. No silk was found as coverage for the wool rolls on the bones, so it was decided to use the same rose silk tabby as used for half of the rouleaus as well as the wrist cuffs. To reconstruct the two identical ankle cuffs, two pieces of 7 x 40 cm of the pre-dyed silk tabby silk were folded in half along their length and hemmed along the long sides. Two rows of running stitches were then placed c. 0,7 and 1,5 cm from the fold, forming two tubes. Padding made from a tightly rolled up commercially acquired wool fabric was pulled through each narrow tube. A 0.8 cm wide tablet-woven band, made by Marie Wallenberg, was then attached to the plain area. The tablet-woven band was woven with 19 tablets using silver as well as rose and bright red silk threads (fig. 5.29). As the dye analysis did not detect any remains of dyes, it was decided to create the band in colours like the wrist cuffs. The ankle cuffs were subsequently sewn onto the bottom edge of the

► Table. 5.8: Technical details of the original textiles chosen for the ankle cuffs as well as the reconstructed textiles.

Textile	Colour/ dye	Yarn diameter in mm and twist direction	Thread/cm	Material
C145 Tabby padding 17 x 0.8 cm 4.5 x 0.8 cm 11 x 0.8 cm	Greyish/ Woad?	0.2/0.2 z/z 30-35°/ 30-35°	17-18/16	Wool
C135b Tabby padding 13 x 11 cm	Brown/ Woad	0.2/0.2 z/z 30-35°/ 30-35°	17-18/16	Wool
C145 Tablet-weave band 17 x 0.8 cm 8 x 0.8 cm 5 x 0.8 cm 2 x 0.8 cm	Dark brown No dyes detected	Warp edge: 0.2-0.3 mm, 2 ply Silk weft: 0.3-0.4 unspun Brocade weft: 0.3 mm/ (metal lahn) 0.3 mm	19 tablets 15 tablets/cm Edge: 2x2 tablets Pattern: 15 tablets Wefts: 28/cm	Silk Missing (vegetable) threads Silver lahn with silk core
Reconstruction Tabby silk	Rose Cochineal	0.2/0.2	35/30	Silk
Reconstruction Tablet-woven band, 19 tablets 80 x 0.8 cm	Rose and red	Red edges: 0,3 mm, 2 ply S2z White linen warp: 0,3 mm 2 ply S2z Red silk weft 210/2 Rose silk weft: 0,4 mm, 3 ply S3unspun Brocade weft: 0,3 mm/ (metal lahn) 0,3 mm	19 tablets 15 tablets/cm Edge: 2x2 tablets (4 threads in each tablet, Z orientated) Pattern: 15 tablets (2 threads in each tablet, alternating Z and S orientated) Wefts: 28/cm	Warp: Silk Nm 60/2 (edges) Linen Nel 110/2 (pattern) Weft: Silk Nm 210/2, Pipers silks Brocade weft: Silver thread no. 4 from Klöppelwerkstadt and floss silk from Pipers silks.

trouser legs with the padding turned upwards and the tablet-woven band below (fig. 5.30). The ankle cuffs ended up measuring 3 x 40 cm. The sewing of the reconstructed rouleaus and ankle cuffs was done by Irene Skals.

The Bjerringhøj excavation reports mention that some of the finders were expected to return a silver clasp found in the grave (Vellev 1991, 19-20). Unfortunately, this never happened which is why we only know that it existed, but not what kind of clasp it was or where it was placed in the burial. It was decided to acquire a pair of silver clasps with spiral ends at Torben Sode's shop, Vikingbead.dk. These were sewn onto the edge of the bottom of the trouser legs to close the slits. This construction is not based on a direct archaeological parallel, but on similar constructions of ankle cuffs with clasps known from much older Early Germanic Iron Age textile finds (Nockert 1991).



► Fig. 5.29.A: The reconstructed ankle cuffs
B: Detail of the reconstructed tablet-woven band.

Photo: Irene Skals and Charlotte Rimstad

◄ Fig. 5.30: The reconstructed rouleaus and ankle cuffs, attached to one of the trouser legs.

Photo: Roberto Fortuna

The draw string

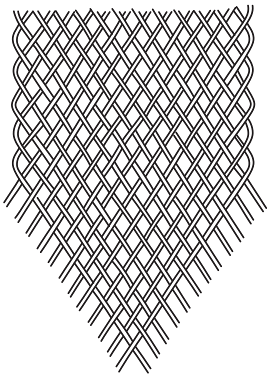
To keep the trousers in place around the waist it was decided to introduce a draw string pulled through the waist band just like in the Skjoldehamn trousers. In accordance with the original fragments from Bjerringhøj, it was decided to use a reconstruction of the braided band (C136c) (table 5.9, fig. 5.31) for this purpose. The dye analysis of the braided band (14152/27) showed the presence of madder and tannin, and the yarn must originally have been reddish-brown.

Textile C136c	**Colour/ dye**	**Twist direction**	**Twist degree**	**Yarn diameter in mm**	**Threads**	**Fibre**
Braided band in 3 pieces 44.8 x 1.4 cm	Dark brown/ Madder and tannin	S-2z	30° twist 30° ply	1.0	24	Wool
Reconstruction 150 x 1.4 cm	**Colour**	**Twist direction**	**Twist degree**	**Yarn diameter in mm**	**Threads**	**Fibre**
Braided band	Dark red Madder	Z-2s	30°-40°	1.0	24	Wool

◄ Table. 5.9: Technical details of the original textile chosen for the draw string for the trousers and the reconstruction.

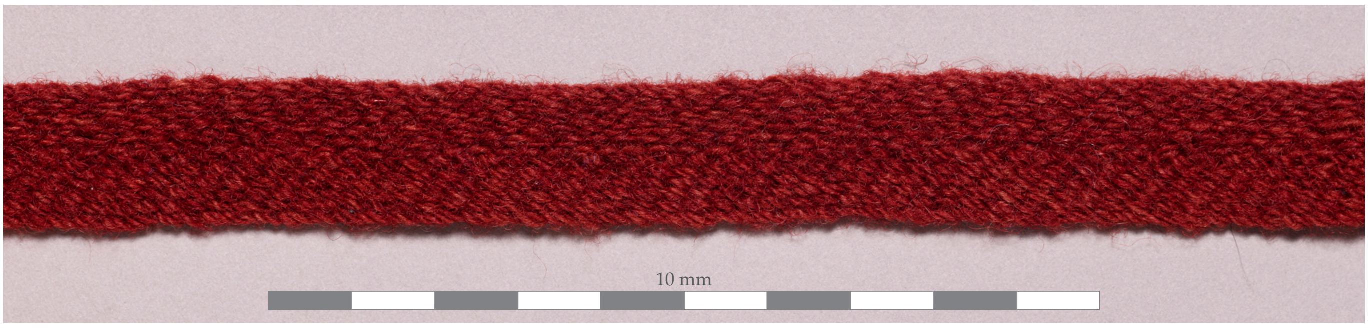
▲ Fig. 5.31.A: The braided band from Bjerringhøj, C136c. ▼B: A schematic Illustration of the technique.

Photo: Roberto Fortuna. Illustration: Line Maria Mørch



The original braid consists of 24 S-2z plied cords, each with a diameter of c. 1 mm. Three pieces of the band are preserved, each 1,4 cm wide, with a total preserved length of 44.8 cm. The technique of making the braided band was described by Margrethe Hald in 1950 (Hald 1980, 249). The yarn was plied on a spinning wheel using a machine spun yarn by Ida Demant and dyed in a deep red colour using madder and a tannin source by Anne Batzer. Marie Wallenberg braided the band to a length of 150 cm (fig. 5.32).

Finally, a pair of yellow trousers with leg decorations in silk fabric and a tablet-woven band could be added to the male outfit (fig. 5.33). The yellow fabric has the same crimped surface appearance as the original tabby fabric, but compared to the more accurate reconstruction of the kirtle textile it is clear that there is an important visual difference in the appearance between a hand-spun and hand-woven fabric and a modern machine woven textile. While the hard-twisted yarns in the original textile create a firm, stiffer and shiny surface, the soft and fuzzy textile used for the reconstruction gives the garment a shaggy appearance that was not intended and therefore unfortunately gives the trousers a less accurate look than the kirtle.



▲ Fig. 5.32: The reconstructed braided band.

Photo: Roberto Fortuna

◀ Fig. 5.33.A: The finished, reconstructed trousers, front
◀ B: Back.

Photo: Roberto Fortuna

Belt

A silk belt was constructed, for the outfit, combining three different preserved textiles: the two silk pendants (C137), a piece of silk samite (C140, fragment 1) and a piece of wool tabby (C135d) (table 5.10).

► Table. 5.10: Technical details of the original textiles chosen for the belt as well as the reconstructed textiles.

Textile	Colour	Twist direction	Twist degree	Fibre
C137 Tabby 20.0 x 7.4 x 0.2 and 21.8 x 7.3 x 0.2 cm	Light brown	0.2-0.4/0.3 z/z 35-40°/ 10-20°	28-30/25	Wool
Naalbinding Stitch variation: UOOO/UUOO F1	Greyish and golden	Metal thread: 0.3 mm Metal lahn width: 0.2 mm, S wound	-	Silver/gold lahn with silk core
Tablet weave 15 x 1.0 14.8 x 1.0	Greyish and golden	Warp: 0.3-0.4 mm, S2unspun Weft: 0.25 mm, unspun Brocade weft: 0.2 mm/(metal lahn) 0.1-0.2 mm, S wound	19 tablets 19 tablets/cm Edge: 2x5 tablets Pattern: 9 tablets Wefts: 30/cm	Silver/gold lahn with silk core
Tabby padding	Greyish	NA	NA	Wool
C140, fragment 1 Samite (weft-faced compound twill) 11.5 x 3.5 cm	Light brown Madder and cochineal	0.3/0.3 Lightly z/unspun 25-28°/-	C. 15 binding warps and 14 double main warps/13-14 double passes	Silk
C135d 19.5 x 3.0 cm	Light brown Madder and tannin	0.2-0.3/0.2-0.3 z/z 35-50°/ 35-50°	18-20/17-18	Wool
Reconstruction Tabby	Rose Cochineal	0.2/0.2 Unspun	35/30	Silk
Reconstruction Samite	Dark rose	0.2/0.6 Unspun/2 unspun Ply: 20°	Warp: 45 ends per cm, 15 binding warps, 30 inner warps (1:2) Weft: 13-15 double passes	Silk (gummed for warp, degummed for weft)
Reconstruction Tabby	Red	0.5-0.6/0.5-0.6 S2z/S2z 20°/20° Ply: 30°	15/15	Wool
Reconstruction Tablet woven band 1.0-1.1 x 100 cm	Pink (same as wrist cuffs C138)	Pink silk warp: 0.3 2ply, S2z Linen warp: 0.3 2ply, S2z Pink weft: 0.3 mm, lightly Z spun Brocade weft: 0.3 mm/(metal lahn) 0.3 mm	19 tablets Edge: 2x5 tablets, 2 tablets for the stave border in each side (4 threads in tablets, Z orientated) Pattern: 9 tablets (2 threads in tablets, alternating S and Z orientated)	Warp: Silk Nm 60/2 from The Handweavers Studio, London Linen, Nel 100/2 (stave border) Weft: Silk, Nm 60/2, split to 1-ply Brocade weft from Klöppel-werkstatt no. 4, gold and silver

The belt endings

The original pendants (C137) are triangular and consist of two silk tabby strips with a middle section of naalbinding (fig. 5.34). The two silk pieces are 2 cm wide and consist of a double layer of textile, measuring 5 x 25 cm and folded lengthwise, hemmed and attached to the outer rows of the naalbinding wedges. The outer, folded edge of the silk is trimmed with narrow blanket stitches. At the broad end, the pendants are finished with a tablet-woven band and below it, two horisontal, padded rows are present, the lowest was originally divided into seven smaller sections with a now disintegrated thread.

◄ Fig. 5.34: The pendants are made of silk with a middle area in naalbinding and a tablet-woven band below. (C137).

Photo: Roberto Fortuna

Nothing is known about the original use of the two silk pendants, also often termed "cape bands" due to their incomplete state. In the reconstructed outfit from 1991, they were used as bands to close the fur-lined wool coat. It has also been suggested that they should be interpreted as liturgical vestments such as the stole and maniple which are integrated parts of Roman Catholic religious practice (Ræder Knudsen 2007). Examples of this type of vestment are known from several more or less contemporary contexts often linked to the graves of saints or reliquary finds. On the other hand, most of these examples are made in completely different techniques to those of the present find, such as silk embroidery or tablet-weaving technique (Coatsworth, E. & Owen-Crocker, G. 2018). In this reconstruction, it was decided to use them as endings for a belt.

For the reconstruction, it was decided to produce a hand-woven silk tabby textile in undyed, white silk yarn that could also be used for the wrist cuffs and the rouleaus for the trouser legs. As the silk tabbies in the rouleaus, pendants and the wrist cuffs are all slightly different in their construction and do not represent the same textile, a textile with the 31 warps and 32 wefts per cm was produced on a treadle loom using a 52:10 reed. The material was an unspun, undyed silk 0.25 mm in diameter. The finished textile measured 50 x 200 cm and was woven by Åse Eriksen. The dye analysis from 1991 (Walton 1991) proved that the silk tabby used for the pendants was dyed with lichen, but as this dye stuff is not very light fast, it was decided to dye the textile with a more light-resistant dye substance. As lichen may result in many different colours within the rose to purple range, it was decided to make a rose colour using cochineal dyed by Anne Batzer. The same rose dye was also chosen for the rouleaus and the wrist cuffs, which made the dyeing process more efficient.

The area in naalbinding was carefully analysed. Each naalbound wedge is about 19.5 cm long and 3.8 cm wide at the widest end. It consists of 16 rows, each measuring 2-2.5 mm in width. The outer rows are 10.5 cm long, the next rows towards the centre are (estimated) 14 cm, 15 cm, 16.5 cm, 18 cm, 18.5 cm, 19 cm and 19.5 cm long respectively. The naalbinding is conducted in a very simple stitch, labelled UOOO/UUOO F1 also known as the Mammen stitch (fig. 5.35). The thread in the originals is 0.3 mm thick, made of a silk core wound with a flat silver lahn c. 0.2 mm wide. As a decorative pattern, at least seven small rectangles are made in a similar gold thread. The average measurement of each gold section is 20 x 4 mm. They cover two rows of stitches, but differ slightly in size and location on each pendant.

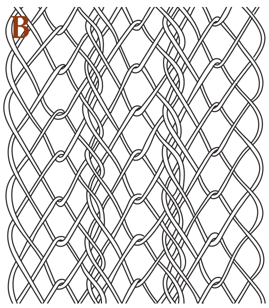
The gold and silver thread for the reconstruction was obtained from Klöppel Werkstatt (Gespinst 3) in Germany, and Lone Bjørnskov-Bartholdy created the naalbinding pieces (fig. 5.36). During the work, she discovered that handling the thread during the needle work created oxidation in the surface which made the piece black. Therefore, the work had to be done using gloves. This is an unforeseen side effect that must have applied to all work with silver threads in the Viking Age, but darkening of the silver threads can

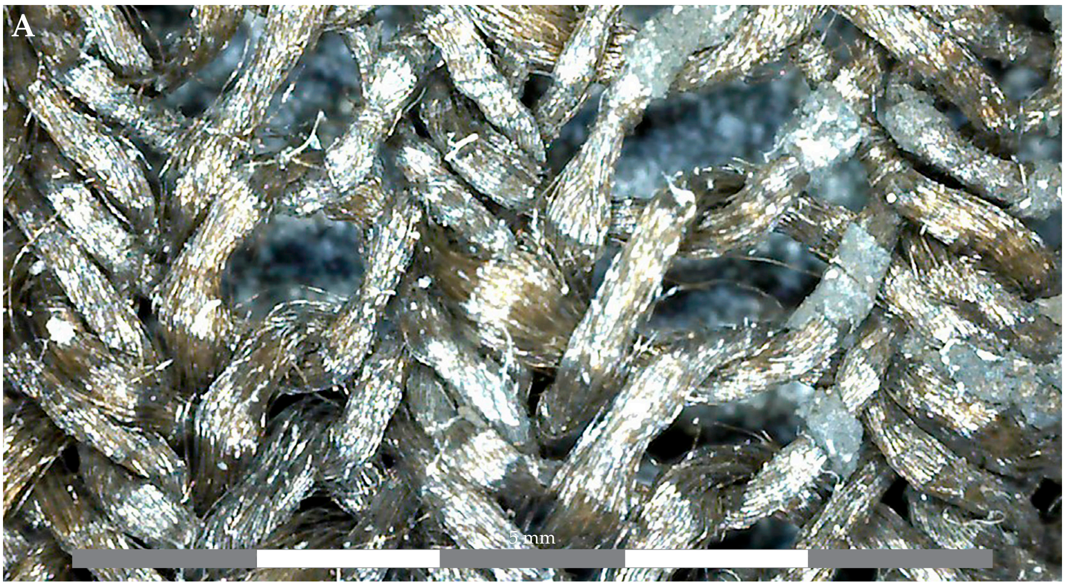
► Fig. 5.35.A: Detail photo of the naalbinding in the pendants, C137.

Photo: Charlotte Rimstad

▼B: The schematic illustration shows the technique.

Illustration: Line Maria Mørch, after Hald 1980





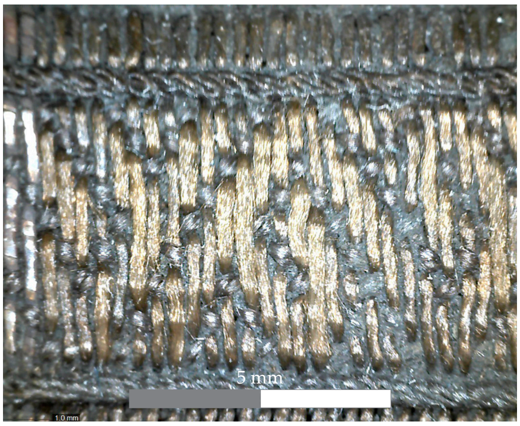
easily be polished away with a linen cloth. Based on high resolution photograps of the naalbinding, Lone Bjørnskov-Bartholdy first made a detailed template of each wedge with the total number of rows, stitches per row, and exact location of the gold sections. Then test bindings were made to calculate the production time and amount of material needed. This showed that c. 45 m silver, very little gold thread and 22 work hours were used for making each wedge. It was decided that 14 rows should be visible, in the finished pieces and two extra rows and two extra stitches in every row were added to allow space for the mounting onto the silk tabby sides. To start the first row, a simple pretzel shaped knot was made. In this, three loops were made in buttonhole stitch and from then on the Mammen stitch was used. It is further evident from the original that when changing to a new thread the two threads were simply tied with a knot, which was then hidden within the work.

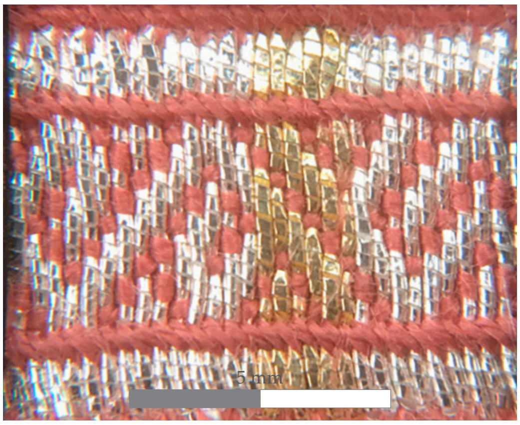
◄ Fig. 5.36: The making of the reconstructed area in naalbinding for the pendants.

Photo: Lone Bjørnskov-Bartholdy

The tablet-woven band on the pendants is 1 cm wide and has a repeated geometrical and diagonal meander-like gold and silver pattern made in a c. 0.25 mm thick thread with a 0.16 mm wide metal lahn wound around a silk core (fig. 5.37). It is visible on both sides of the pendants. The silver thread forms the weft for about 8 mm followed by 2-3 mm of gold thread in a repeating pattern. No dye analysis was made of the tablet-woven band, as they are too complete to sample. The reconstructed band was thus made to match the silk tabby trimming, the pendants, which originally was dyed with lichen. Therefore, a lichen-like rose colour was chosen for the commercially acquired silk yarn. The pattern and tablet weaving were made by Marie Wallenberg using metal thread obtained from Klöppel Werkstatt in Germany. Nineteen tablets were used for the band which was woven in a length of 1 m (fig. 5.38) (see chapter 7).

The two padded rows were filled with the same machine woven soft wool tabby fabric as used for the rouleaus and the wrist cuffs.





◄◄ Fig. 5.37: Detail photo of the tablet-woven band in the pendants.

Photo: Charlotte Rimstad

◄ Fig. 5.38: The reconstructed tablet-woven band.

Photo: Charlotte Rimstad

The belt part itself

Before the samite textile (C140, fragment 1, fig. 5.39) could be reconstructed, a new analysis of the textile was needed, as the existing description and analysis was too brief and lacking details (Østergård 1991, 125). The new analysis was conducted by Irene Skals using a stereomicroscope with an external light source and the CIETA terminology and standard for analysis of silk weavings (Strömberg 1967; Vial 1979) (table 5.10).

► Fig. 5.39: The silk samite, C140, fragment 1.

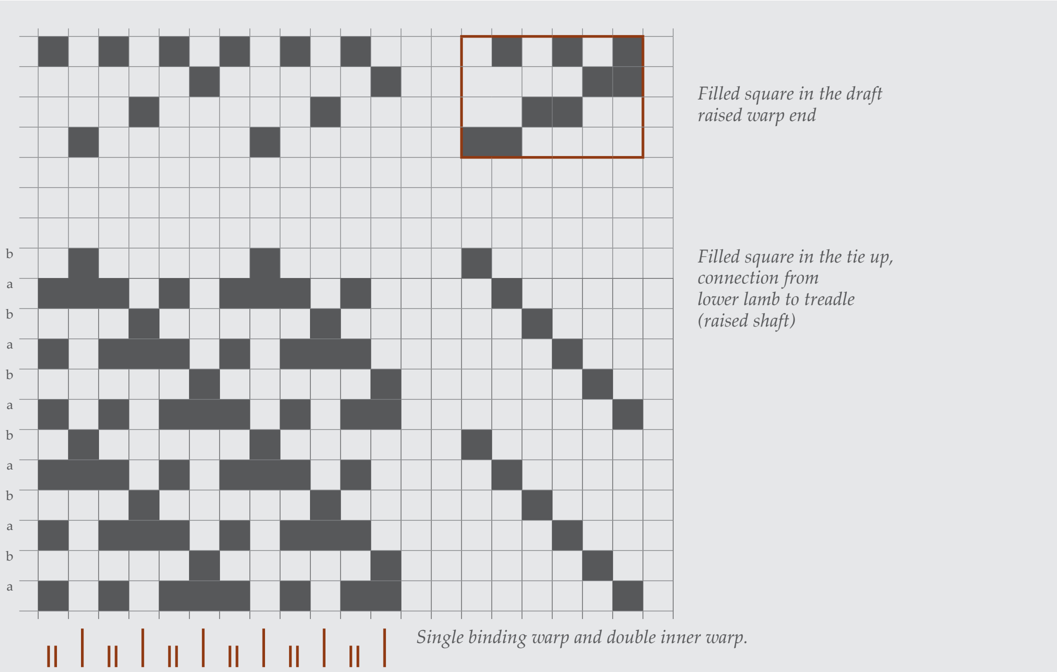
Photo: Roberto Fortuna

The silk weavings were made by Åse Eriksen using available silk yarn from different commercial sources. Yarn thickness and density was chosen to make the best possible match, but also to make the weaving feasible within the project timeframe. However, the yarn for the samite was a white machine reeled, plied yarn that cannot directly be compared with the original material.

The reconstruction was woven on a treadle loom in samite 1/2 S-directed twill with 45 warp ends per cm (15 binding warps and 30 inner warps (1:2)) using a reed 45:10 (fig. 5.40). The naturally coloured, reeled gummed silk yarn with almost no twist had a yarn thickness of 0.25 mm. The weave was constructed with 13-15 weft passes per cm in a doubled weft in a slightly spun degummed naturally coloured silk yarn, 0.3 mm in diameter. Åse Eriksen wove the textile measuring 20 x 150 cm which was also used for the reconstruction of the rouleaus placed on the trouser legs, and as well as on the female cape. The dye analysis of C140, fragment 1, identified madder in all three samples (14152/59-61), which in one of the weft samples was combined with cochineal. This indicates that there could originally have been a weak colour pattern in the textile, but as the pattern cannot be discerned today the textile was kept in a dark rose colour.

For the reconstruction of the wool tabby (C135d, fig. 5.41) a machine-woven wool tabby fabric from Kjellerup Væveri was used. It is the same fabric as used for the trousers. The dye analysis of the original wool tabby showed no dyes detected in one system (14152/21) and madder/tannin in the other (14152/22). We chose to use a finished fabric it was impossible to match the result of the differently coloured thread directions (possibly white in one direction, red in the other), resulting in the fabric being dyed completely in a dark brownish red colour. Anne Batzer dyed both the silk and wool textiles for the belt.

The belt was sewn together by Irene Skals by combining 5 x 134 cm long strips of the reconstructed dark rose silk samite for the front, and the dark brownish red wool tabby for the back (fig. 5.42). The belt measures 178 cm in total, including the pendants which are each 23 cm long.



◄ Fig. 5.40: Schematic illustration of the samite technique used for the reconstruction of C140, fragment 1.

Illustration: Åse Eriksen

▼ Fig. 5.41: The original wool tabby, C135d.

Photo: Roberto Fortuna

◄ Fig. 5.42: The finished, reconstructed belt.

Photo: Roberto Fortuna

Wrist cuffs

The two wrist cuffs from Bjerringhøj (C138, fig. 5.43) are almost perfectly preserved and could therefore be reconstructed more or less 1:1 (table 5.11). However, the original circumference (measured on the inside) of c. 21 cm was adjusted to 24 cm to fit the model. The width of an entire cuff is c. 2.8 cm. The silk cuffs are constructed of a silk tabby piece folded in half. In one side two rows of running stitch were placed c. 0,7 and 1,5 cm respectively from the fold. Paddings made at a tightly rolled up wool fabric were pulled through each tube. The two ends were sewn together and the tablet-woven band was attached. Thereafter the two hems were sewn together.

The silk tabby was woven on a treadle loom by Åse Eriksen, using white silk thread. No dye analyses were conducted as the completeness of the wrist cuffs made it impossible to take samples. Therefore, it was decided to use the rose silk fabric which was made for the pendants (C137) for the outer silk layer. For the padding the same machine-woven soft wool tabby fabric was used as for the rouleaus and the pendants.

The 1.4 cm wide band was woven with 33 tablets by Marie Wallenberg who also reconstructed the pattern. At first glance the two bands look similar, but actually they differ from each other, with small variables in each band. The metal thread is about 0.2-0.3 mm wide and made of a a silver or gold lahn wound around a silk core. It was not possible to make a dye analysis of the tablet-woven bands, so it was decided to produce them with silk in the same lichen-like rose colour as the silk tabby. A soumak thread was used in the originals to underline parts of the woven pattern and this thread seems a bit darker than the other yarns. For this reason, a red colour was chosen for the commercially acquired pre-dyed yarns (see chapter 7).

The cuffs were sewn by Irene Skals. The pre-dyed silk tabby was cut into pieces measuring 7 x 26 cm, folded in half and two rows of running stitches were placed c. 0.7 and 1.5 cm respectively from the fold, forming two tubes. Wool rolls were pulled through each tube. The short ends were then sewn together, and the tablet-woven band attached to the other side of the padded rings. Finally, the hem underneath the tablet-woven band was sewn together. An identical wrist cuff was made (fig. 5.44). The original wrist cuffs have no signs of stitches or stitch holes that could indicate that they were attached to a garment or another layer of textile. As they are so well-preserved, they were most likely worn as separate objects, but the construction indicates that they were produced within the same work tradition as the other padded objects in the Bjerringhøj find.

► Table. 5.11: Technical details of the original textiles chosen for the wrist cuffs and as the reconstructed textiles.

Textile **C138, 2 pieces**	**Colour/ dye**	**Yarn diameter in mm**	**Threads/cm**	**Fibre**
Tabby 25.3 (outer dia.)/20.6 (inner dia.) x 2.8 cm	Light brown	0.3/0.15 Unspun/z -/20°	24-25/36-38	Silk
Tabby (padding) 13 x 11 cm	Greyish	0.1-0,2/0.1-0,2 z/z 25°-30° Similar to C135b	17-18/16	Wool
Tablet-weave 25.3 x 1.4 cm 25.3 x 1.4 cm	Light grey and golden	Silk warp: 0.2-0.3 mm, S2unspun Soumak silk thread: 0.3-0.4, Z2unspun Brocade weft: 0.2-0.3 mm Metal lahn width: 0.1-0.2 mm, S wound	33-35 tablets 25.5 tablets/cm Edges: 7 and 6 (3/2 silk, 4 veg.) Pattern: 23 tablets (of 2 silk and 2 veg.) 30 wefts/cm	Silk Gold/silver lahn wirh silk core
Reconstruction	**Colour**	**Yarn diameter in mm**	**Threads/cm**	**Fibre**
Tabby	Rose	0.2/0.2 Unspun	35/30	Silk
Tablet-weave	Pink silk (based on lichen dye analysis from the loose band C136c) Dark red silk for soumak	Pink silk warp: 0.3 2 ply, S2z White linen: 0.3 2 ply, S2z Weft: 0.2 mm, lightly z spun Weft: 0.3 mm Lahn width: 0.3 mm	33 tablets Edges: 2 x 5 tablets. 2 tablets for the stave border in each side (4 threads, Z orientated) Pattern: 23 tablets (2 threads, alternating Z and S orientated) 27 wefts/cm	Pink silk (based on lichen dye analysis from the loose band C136c) Dark red silk for soumak

◄ Fig. 5.43: The two wrist cuffs, C138.

Photo: Roberto Fortuna

A

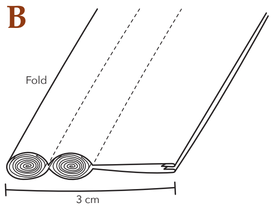
◄ Fig. 5.44.A: The reconstructed wrist cuffs.

Photo: Roberto Fortuna.

▼ B: Schematic illustration of how the wrist cuffs were made.

Illustration: Line Maria Mørch

B



Silk strip with heart decoration

A small irregular strip of silk samite also belongs to the Bjerringhøj burial (C140, fragment 2). It actually consists of two different kinds of samite sewn together, one is oblong with a broad and a narrow. It measures c. 29.5 x 4.5 cm (fig. 5.45). It has a pattern of small hearts, encircled by a diamond-shaped grid. The other piece is much smaller, measuring c. 3.5 x 3.2 cm, and it has a pattern which is difficult to identify. It is attached to the narrow end of the largest piece as an extension (table 5.12). Altogether the whole fragment measures 33 x 4.5. However, diagonal lines from a fold are found in the narrow end of the larger piece, clearly indicating that it was originally folded into a point at this end. The smaller piece was thus folded on to the back and not visible during use. It was therefore not reconstructed.

► Table. 5.12: Technical details of the original samite (C140 fragment 2) and as the reconstructed textile.

Textile C140, fragment 2	Colour/ dye	Twist direction	Twist degree	Yarn diameter in mm	Thread/cm	Fibre
Piece 1 Samite (weft faced compound twill) 29.5 x 4.5 cm	Light brown Madder	z/unspun	25-30°/-	0.2/0.2	26 binding and main warps/ 18 passes (of at least 3 wefts)	Silk
Piece 2 Samite (weft faced compound twill) 3.5 x 3.2 cm	Light brown					Silk
Reconstruction	**Colour/ dye**	**Twist direction**	**Twist degree**	**Yarn diameter in mm**	**Thread/cm**	**Fibre**
Samite	Rose	Unspun/ Unspun	-	0.25/0.25	Warp: 32 warp ends per cm. 16 binding warps: 16 inner warps (1:1) Weft: 36 passes (when three wefts in pass) and 42 passes (when two wefts in pass)	Gummed silk

The edges of the samite fragment are folded on three sides and remains of stitches in silk threads along the edges reveal that the piece was attached to something else during use, probably a garment. As in 1991, the dye analysis identified madder in all samples including the yellow weft in the small hearts (14152/62-64). The patterns of the original piece may thus have been composed of different red colours while it is not known if the red dye in the hearts represents a true colour or is the result of leaking dyes from the surrounding threads. Based on the present visual impression, it was decided to make a design with yellow hearts on a pink background and a dark red grid. Another possibility is that the fabric had white hearts on a red background. Åse Eriksen wove the fabric on a treadle loom using machine-spun industrially dyed silk threads (fig. 5.46). Irene Skals cut the fabric into shape and prepared the edges for stitching it on to a garment.

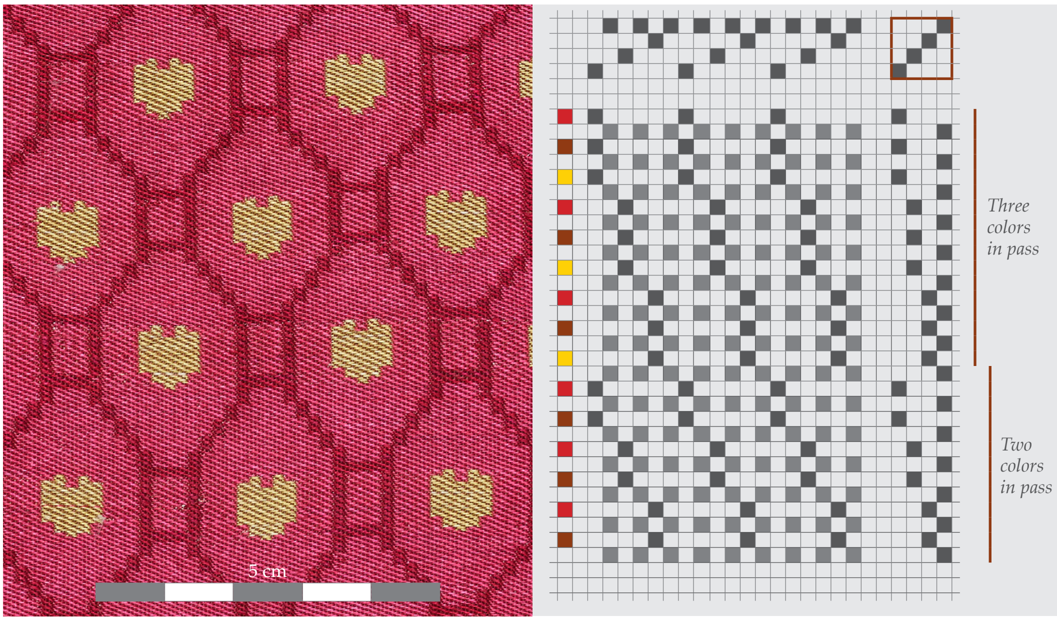
Seen in an archaeological perspective it is very likely that the silk strip represents a kind of token or a sign of status in Viking Age society (Vedeler 2014). It was decided to place the reconstructed samite on the right shoulder of the fur caftan, and in this way to ensure the best possible visibility in the final outfit. This attachment was done by Marie Wallenberg.

◄ Fig. 5.45.A: The samite piece with heart decoration.
B: Illustration of the pattern.
C: Reconstructed textile super imposed on the shape of the orginal.

Photo: Roberto Fortuna
Illustration: Charlotte Rimstad

► Fig. 5.46.A: The reconstructed samite with heart decoration.
B: Schematic illustration of the technique.

Photo: Roberto Fortuna
Illustration: Åse Eriksen



Tablet-woven band

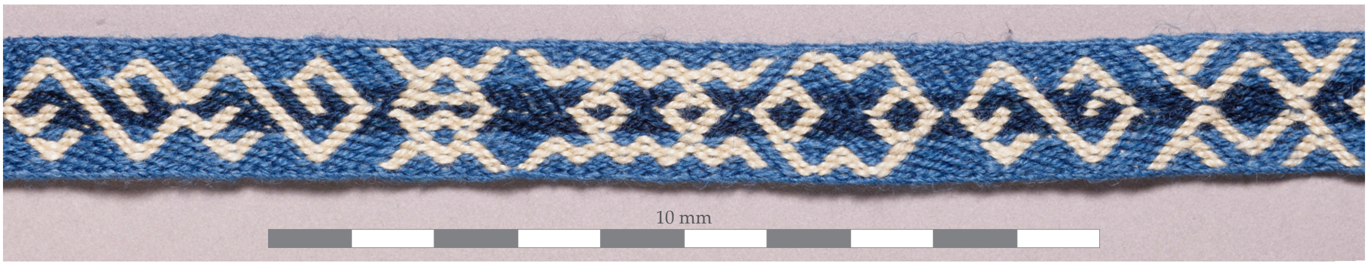
A tablet woven band made of wool was found as a loose piece in the Bjerringhøj burial (C136a). The band measures 1.5 cm in width and is preserved in two pieces with a total length of 33 cm (table 5.13, fig. 5.47). Unfortunately, the original use in the Bjerringhøj grave is not known (Ræder Knudsen 1991). It was decided to reproduce the band but leave it unattached to a specific garment. The dye analysis showed no dye result from the outer edge, an indigo/tannin dye in the central, longitudinal part, and only tannin in the weft (14152/23-26). The reconstructed band was therefore woven with a dark blue central part and lighter blue edges in wool and a white pattern created by a linen thread (fig. 5.48). The pattern was constructed by Lise Ræder Knudsen and the band was woven by Marie Wallenberg using 17 tablets to a length of 350 cm. (see chapter 7).

▼ Fig. 5.47: The tablet-woven wool band from Bjerringhøj, C136a.

Photo: Roberto Fortuna

► Table. 5.13: Technical details of the original tablet-woven wool band and the reconstructed band.

	Colour/ dye	Yarn diameter in mm and twist direction	Threads/cm	Fibre
Textile C136a Tablet weave 33 x 1.5 cm 3/1 double-faced broken twill	Dark brown Indigo in central part. No dyes detected in the edges.	Warp: 0.7, S2z Weft 0.6, S2z	17 tablets 12 tablets/cm Edge: 2x1 (wool) Pattern: 15 (2 wool, 2 veg. fibres in each tablet) Wefts: 10/cm	Wool
Reconstruction Tablet weave 350 x 1.5 cm 3/1 double-faced broken twill	Light and dark blue / white	Light blue warp: 0.7 mm, S2z Dark blue warp: 0.7 mm, S2z Linen warp: 0.7 mm, S2z Weft: 0.7 mm, S2z	17 tablets 12 tablets/cm Edge: 2x1 (wool) Pattern: 15 (2 wool, 2 veg. fibres in each tablet) Wefts: 10/cm	Warp: Wool Nm 20/2, dyed light blue with indigo from Historical Textiles, Sweden. Dark blue dyed by Tove Lodal, Denmark. Linen 16/2 Bockens lingarn. Weft: Same as light blue warp.



▲ Fig. 5.48: The reconstructed tablet-woven wool band.

Photo: Roberto Fortuna

Leather boots

The Bjerringhøj burial contained no traces of any footwear. However, for the reconstructed outfit, it was decided to make a pair of boots. These were based on shoe type 6 from the Hedeby, dated to the 10th century AD (Groenman-van Waateringe 1984, 26-27). The calfskin was vegetable tanned by Theresa Emmerich Kamper, resulting in a soft, but firm reddish leather. The boots were made in the shoe size of the male model and sewn by Espen Kutschera in Norway, who used flax thread for the seams (fig. 5.49). For more information, see chapter 9.

◄ Fig. 5.49: The reconstructed shoes for the male outfit.

Photo: Espen Kutschera

Fur caftan

Based on the few preserved fragments of fur in Bjerringhøj (C143, fig. 5.50), it was decided to produce an outer garment in fur for the outfit. The original description from the excavation mentions large layers of fur in the bottom of the grave, but most of this material seems not to have been brought to the museum. The pattern of the reconstructed fur garment is based on the caftans depicted on the gold-foil figures dated to the late Iron Age (Mannering 2017a). The pattern was constructed by Lone Brøns-Pedersen and first sewn in a mock-up and sized to fit the model. Based on the protein analysis conducted by Luise Ørsted Brandt, it was decided to produce this garment in beaver fur (table 5.14) (Brandt et al. 2022). The caftan is closed with a reconstruction of a leather strap (C142, fig. 5.51) combined with bone buttons. The button detail is not documented in the Bjerringhøj grave. The material for the straps was identified as de-haired sheep, goat, or deer skin according to the ZooMS analysis (Brandt & Mannering 2020; Brandt et al. 2022), but we chose to reconstruct the straps in the same calf leather as made for the shoes.

Theresa Emmerich Kamper oversaw the tanning and sewing of the garment. The beaver furs were imported from Canada and tanned by fat tanning (fig. 5.52). Both flax and sinew were used as sewing threads in order to test how they functioned. It was decided not to line the caftan and it can thus be turned inside out so the flesh side and stitching are visible. Altogether, the caftan is produced from 24 beaver skins. The hand tanning made the skins very soft and flexible. Although the fur is very thick and warm, it only weighs 1670 g. Due to the fat tanning method, the flesh side has a white colour. The straps were vegetable tanned and due to this tanning method, they obtained a reddish colour. The finished kaftan can be seen in fig. 5.51 & fig 5.52. For further details see chapter 8.

► Fig. 5.50: Beaver fur fragments from Bjerringhøj, C143.

Photo: Roberto Fortuna

Fur/leather	Original	Reconstruction
C142 Leather strap in two parts 13,5 x 1,3 cm, openings are 0,8 cm long	Sheep, goat or deer skin 1.25 mm thick	Vegetable tanned cattle leather
C143 2 pieces of fur, 9 x 5 cm More pieces in Ad C143 are preserved	Beaver	Oil/fat tanned Beaver fur

◄ Table. 5.14: Technical details of the original fur and skin objects and the reconstructions.

◄ Fig. 5.51: Leather strap in two parts from Bjerringhøj, C142.

Photo: Charlotte Rimstad

◄ Fig. 5.52: The tanned beaver furs hanging to dry.

Photo: Theresa Emmerich Kamper

► Fig. 5.51.A: The finished caftan, front.
B: Back.

Photo: Roberto Fortuna

◄ Fig. 5.52.A: The finished caftan inside, front.
B: Back, from inside.

Photo: Roberto Fortuna

6. The female outfit

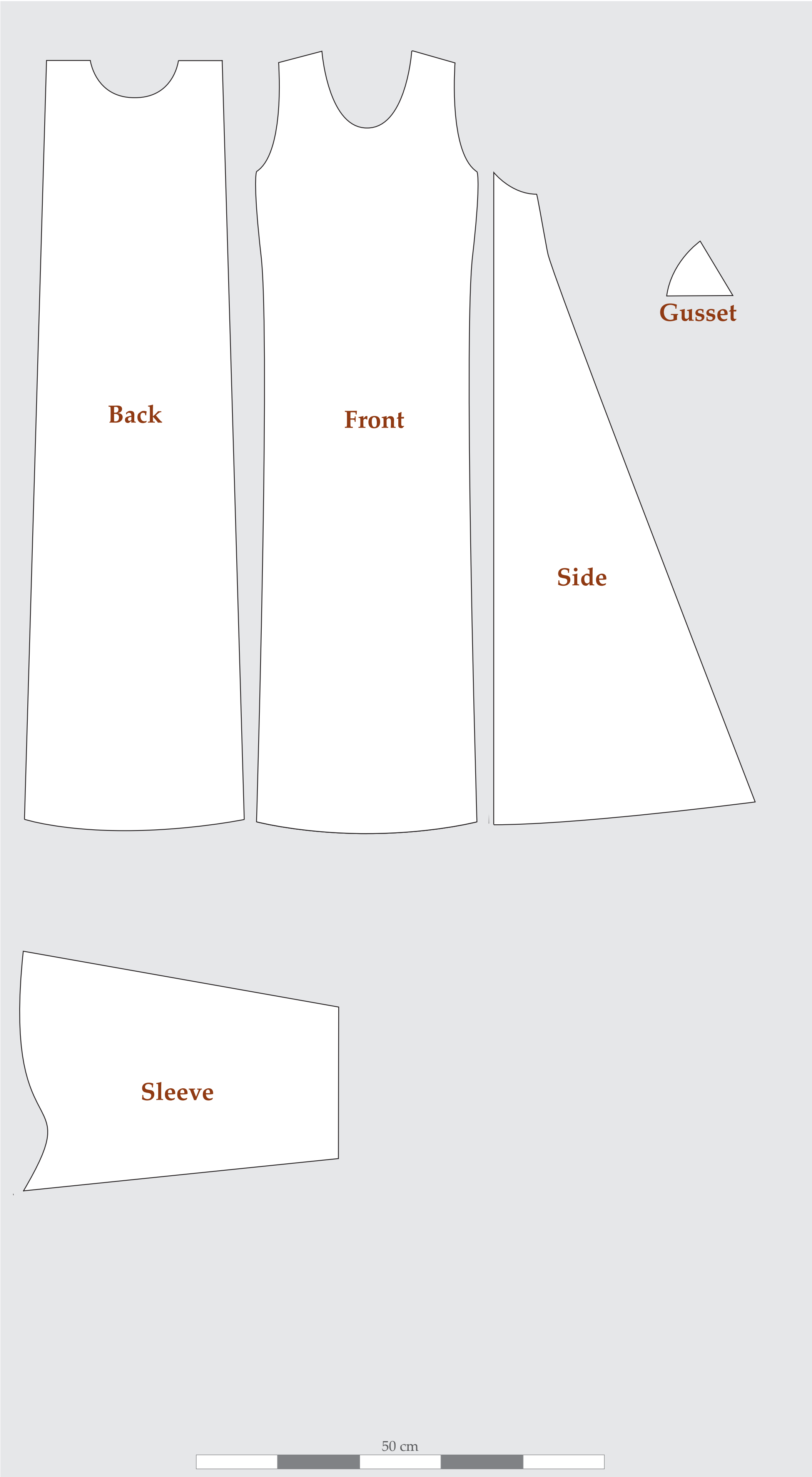
For the female outfit, it was decided to make both outer garments and undergarments. The female outfit includes the following items: a linen dress, a red wool tabby dress with decoration woven into the fabric, a marten fur cape with edges of beaver fur and decorations in padded red tabby silk, red samite, a purple 3/1 twill band and a tablet-woven band in blue silk, silver and gold threads as well as goat skin shoes with the fur still on. No headwear was made for thise outfit. For the size of the outfit, it was decided to match a body height of c. 165 cm, which is a little taller than the 158 cm average height of women in the Viking Age (Sellevold et al. 1984, 226). The female outfit is based on the measurements presented in table 6.1. The size model is Sigrid Mannering, while Ida Rebekka Mikkelsen is the model used for the photographs.

► Table. 6.1: The body measurements used for the female outfit.

Female model body part	Measurement
Height	165 cm
Back length from shoulder to floor	140 cm
Shoulder width from middle of neck to end of shoulder	19 cm
Circumference around the chest	87 cm
Circumference around the waist	70 cm
Circumference around the pelvis	83 cm
Circumference around the backside	98 cm
Arm length from shoulder to wrist	58 cm
Inside legs	77 cm
Foot length	24 cm

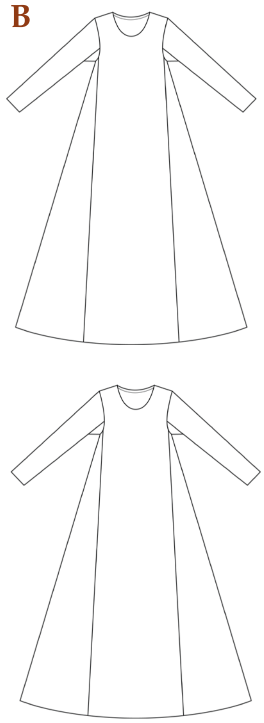
Linen dress

In the Hvilehøj grave, no traces directly linked to an undergarment were found. However, other archaeological sources suggest that a linen dress was a common part of female clothing (Mannering 2017a). The reconstructed undergarment is based on a simple design to fit underneath the wool dress and was not meant to be visible. The fabric was acquired from Historical Textiles in Stockholm, and it is machine spun and tabby woven with 24/24 threads/cm. The white linen was not dyed. A pattern based on the dress from Herjolfnæs in Greenland (D10581) dated to AD 1380-1530 (Østergård 2004) was constructed by Ida Demant and Lone Brøns-Pedersen. The hand sewing was done by Birgitte Kjelstrup. The pattern is seen in fig. 6.1.



◄ Fig. 6.1 Construction pattern for the undergarment and the dress.
B: Schematic illustration of the undergarment (Top: front. Bottom: back).

Illustration: Line Maria Mørch

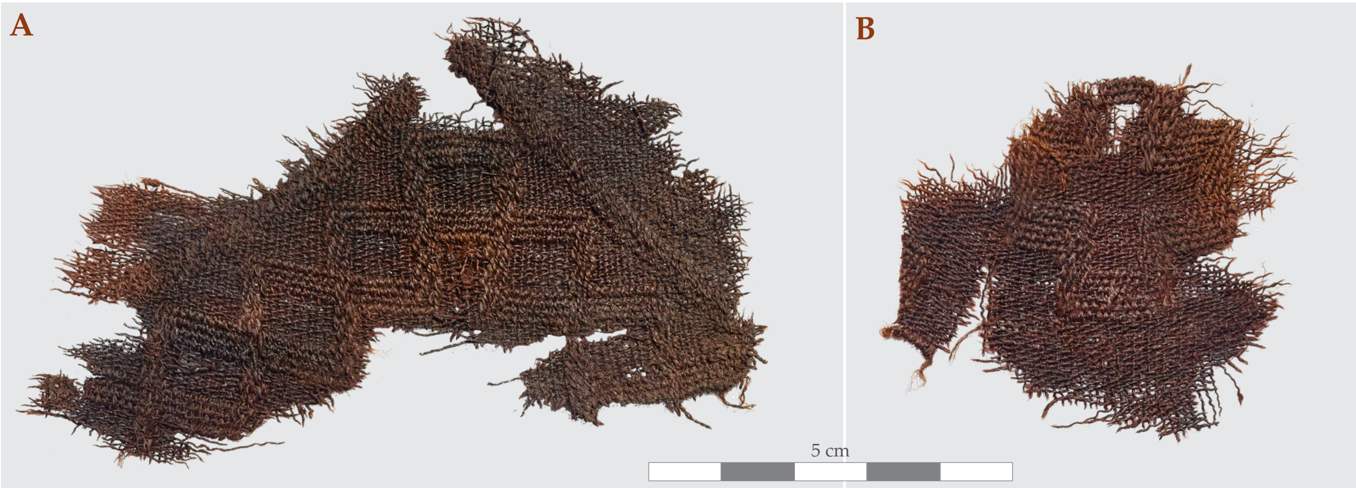


▼ Fig. 6.2.A: Fragment of the tabby from Hvilehøj with in-woven cross decoration (C4280a fragment 2).
B: (C4280a, fragment 8).

Photo: Roberto Fortuna

Wool dress

In the Hvilehøj grave, nine small textile fragments with a cross decoration woven into the fabric (C4280a) were found in the chest area of the buried woman (fig. 6.2). They are interpreted as part of her dress and consist of a tabby made of 0.3-0.4 mm thick and z twisted threads in both thread directions. There are c. 24 threads in the warp and 12 threads in the weft per cm. The pattern threads are made of a similar, but plied yarn, S-2z, and are 0.6-0.7 mm thick (table 6.2).



► Table 6.2: Technical details of the original textile chosen for the wool dress and the reconstructed textile.

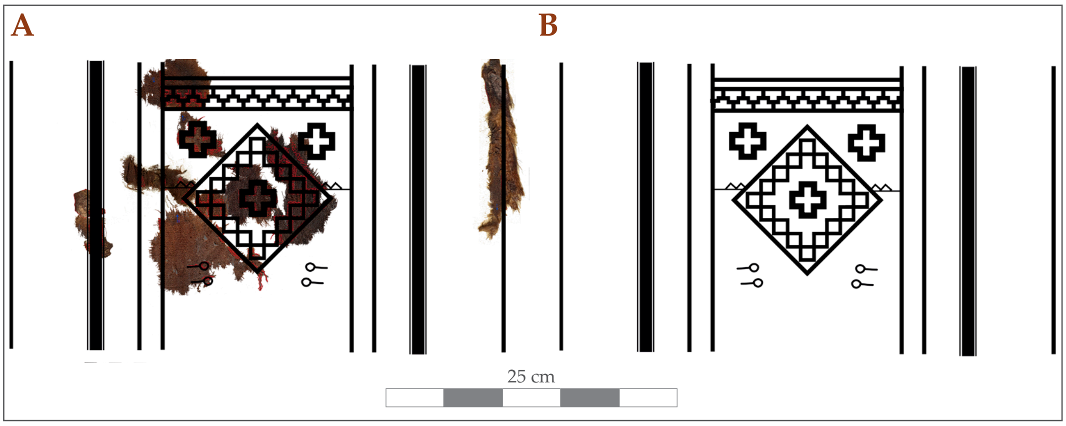
Textile	Colour	Twist direction	Twist degree	Yarn diameter in mm	Thread/cm	Fibre
C4280a Tabby with woven-in pattern wefts 6 fragments in all c. 20 x 30 cm	Reddish brown/ kermes	z/z Pattern thread: S-2z	35-45°/ 45-50°	0.3-0.4/0.3-0.4 Pattern thread: 0.6-0.7	22-26/12-13	Wool 2a
Reconstruction Tabby	Madder + Cochineal Undyed	z/z	20°-30°/ 30°-40°	0.4-0.5/0.4	20/11	Shetland wool

It is well-known that in the Late Iron Age and at least into the mid-10th century AD, women's clothing often comprised dress-fasteners such as bronze fibulae and, in the Viking Age particularly, oval brooches (Hägg 1974; Hedeager Krag 1994; Jørgensen & Jørgensen 1997). Therefore, most reconstructions of Viking Age female outfits have been constructed according to this premise. However, in graves from the later part of the Viking Age in Denmark, including the grave from Hvilehøj, dress-fasteners are not present. This has been interpreted as a sign of a new female dress type appearing, which no longer needed dress-fasteners to be functional. In this way, a new fashion, probably inspired by contemporary European female clothing design, seems to have influenced and changed the traditional and old-fashioned women's clothing of the Viking Age, at least when it comes to the upper classes and the other social classes that could afford or had access to metal jewellery. Unfortunately, there are no well-preserved finds of women's dresses from the Viking Age that can provide an exact idea of how these new dresses were constructed. It seems to be a general trait across time, that women's clothing was ankle length, and that dress commonly consisted of several layers, preferably with a long-sleeved, inner linen dress of a simple cut. An inner dress in different materials were used, just as in the case of the kirtle counterpart. The best preserved and most convincing, although still fragmentary, examples of such a late Viking Age dress type come from Hedeby, although it is important to note that these finds are fragmentsand not in their primary context (Hägg 1984; 1991; Elsner 1992). Nevertheless, it is evident that in the late part of the Viking Age, male and female clothing traditions were already coming closer to a common base, as exemplified by the Old Norse garments found in Greenland (Østergård 2004, 252). As such, an Old Norse dress (D10581), was used to calculate the fabric size and yarn needed in order to weave the Hvilehøj tabby fabric for a dress. On this basis, it was calculated that a 8.5 long and 0.45 m wide fabric would be needed to make the dress (table 6.3).

Tabby	Threads / cm	Width in cm	Length in cm	Shrinkage of 14% in cm	Warp waste in cm	Yarn length in cm	Number of threads	Yarn length in meter	Total yarn length in meter
Warp/z-twist	21	45	850	119	70	1039	1,092	11,346	17,092
Weft/z-twist	13	45	850	7	-	52	11,050	5,746	

◄ Table. 6.3: Calculation of the yarn needed for the dress fabric.

For the design of the in-woven pattern in the Hvilehøj tabby, Charlotte Rimstad used high resolution images in Photoshop to detect and match the different patterns. In general, the overall design is constructed of "Greek" crosses and various pyramid and square shapes framed by horizontal and vertical bands. One of the bands is constructed of small T-shaped figures, placed and connected alternately upwards and downwards. Due to the in-woven pattern technique, the final design ended up being very tight and symmetrical, in comparison to the Bjerringhøj more free-style embroideries (fig. 6.3).



◄ Fig. 6.3.A: Illustration of the reconstructed pattern from the Hvilehøj tabby, seen together with the original fragments.
B: Final reconstructed pattern.

Illustration: Charlotte Rimstad

As this pattern is woven into the fabric using an additional plied weft, the fabric could not be bought and had to be woven by hand. On the other hand, in order to save time, the use of different types of machine-spun yarns were discussed, for example a 16/1 worsted yarn produced by Jamieson and Smith in Shetland (Shetland Supreme Lace weight, https://www.shetlandwoolbrokers.co.uk). This yarn was developed in cooperation with Shetland Museum as part of the Fine Lace Project. It was quickly decided that it would not work for the warp in the ground fabric, as it would need extra twist to gain the required strength. Nevertheless, this yarn was used for a first test sample and subsequently for the weft in the reconstructed fabric.

Once again, Signe Vind spun the warp yarn on the spinning wheel using ready-made tops of a combed Shetland wool which was purchased from Adelaidewalker.co.uk. The fibre analysis showed that the fibre quality in the warp and weft yarns differs significantly and is characterized by a warp yarn with a large content of coarse fibres and a weft yarn with a large content of fine fibres (Skals 2023). Unfortunately, the Shetland wool could not provide these differences in fibre quality and the warp yarn is thus made in a fibre quality finer than the original, whereas the weft yarn has a satisfactory softness.

It took Signe Vind 106 hours to spin 13,000 metres of warp yarn from 1050 g of the combed Shetland wool top, and an extra nine hours for winding the yarn into hanks that could be put directly into the dye bath. Shetland Supreme Lace weight yarn (see above) was used for the weft, given extra twist by Mia Lohse. It took her c. 27 hours to add extra twist to c. 450 g of weft yarn.

The dye analysis of the original textile fragments proved the ground weave to be dyed with kermes (14152/30-32, 42-44) (Hedeager Krag 2018; Vanden Berghe et al. 2023). A preliminary calculation of the amount of kermes dyestuff needed to dye the yarn for this project showed that it would probably cost more than 100.000 DKK. This dye stuff is as exotic and expensive today as it may have been in the Viking Age, and it was therefore decided to

► Fig. 6.4: Yarn for the Hvilehøj dress, dyed with madder and cochineal to resemble the colour of kermes.

Photo: Anne Batzer

make a test dye bath with real kermes and afterwards try to match the given colour with cheaper dye stuffs. Five grams of true kermes lice were acquired from Kremer Pigmente in Germany and used to dye a wool sample. The colour turned out to be a beautiful bright red and this nuance was then recreated using cochineal and madder. On the other hand, no dye was detected in the plied pattern thread, and this therefore remained white/undyed. This meant that the yarn for the ground weave had to be dyed before the weaving started. The yarn was dyed by Anne Batzer and subsequently washed in hanks. They had to be wound into centre pull skeins before the warping could begin. Due to the many processes of dyeing and washing, the yarn had become uneven and had developed fluffy parts which caused it to stick. Not only did this make the winding a very time-consuming task, but it also caused a lot of the yarns to break. In order to make the most of the hand spun and dyed yarn, it was decided to tie the ends together and later simply let the knots be in the warp. It took 3-4 days to separate and wind the yarn into skeins, using a swift and a skein winder (fig. 6.4).

The first section of the fabric, where the woven-in pattern was placed, was worked by Ida Demant on a modern countermarch loom. The weaving started in the first part of April and lasted until the end of May 2020, but was then paused. Before the proper weaving started and in order to get acquainted with the pattern weaving method, a weaving sample was set up on a rising-shed table loom using the Shetland Supreme Lace weight yarn in a 70/10 reed with 3 threads per dent, that is 21 warp threads/cm. With this setup, it was possible to beat in 11 weft threads/cm, but as the warp was very fragile, many threads were easily broken.

For this weave, a shrinkage of up to 14% was estimated resulting in a fabric size of c. 10 x 0.52 metres. Due to the hard pre-dying and washing processes, where the yarn had lost some of its smoothness, it was decided to change the setup and use a 45/10 reed with 4 threads per dent, that is 18 warp threads/cm, hoping it would give a gentler handling of the warp threads. Further, the warp was threaded on 6 shafts in order to allow more space for the heddles, and it was decided not to use the reed and beater for opening the shed, as is often done in modern weaving. Instead, a flat stick, resembling a sword beater, was used to separate sticking warp threads and to do some of the weft beating. It resulted in a slow weaving process, but to some extent prevented the warp threads from breaking. Based on the experience from weaving the kirtle, the warp was smeared with a solution of bone glue from the start, and this continued throughout the whole weaving process.

◄ Fig. 6.5: The weaving of fabric with in-woven pattern for the Hvilehøj dress.

Photo: Ida Demant

In order to place the in-woven cross pattern correctly, without wasting too much fabric in the cutting process, the front piece with the pattern was woven as the first part on the loom (fig. 6.5). The geometrical patterns were created by inserting an undyed two-ply, S-2z weft yarn for each tabby weft in the ground weave. The pattern wefts do not follow the tabby, but must have been picked individually, therefore each pattern element also had to be worked out individually. This was done by first studying the fragments on the high-resolution photos, and then sketching the pattern on squared paper and sometimes making a sewing test on a similar type of fabric. In general, it can be concluded, that the patterns were woven using two different methods. In the horizontal lines in the weave, the pattern weft runs over four and under two warp threads, turns back and then passes under the two in the middle of four threads. In this way, the pattern weft forms a relatively dense surface. In the vertical lines, the pattern weft passes under two and over two a number of times and returns in a similar way. In both the horizontal and vertical sections there are thus two pattern wefts for each ground-weave weft. Only in the centred diamond pattern section is the pattern weft running with each tabby weft. Looking at the back of the fragments, it was further clear that this side was not intended to be visible. Long threads pass from where one part of a pattern element ends to where a new one begins. Instead of being cut off and darned in afterwards, the pattern thread was left hanging on the inside and picked up where it was needed to start in the next pattern weft pass. The biggest challenge was creating the transition between the horizontal and the vertical lines in the three crosses, as they changed gradually in a diagonal line from one method to the other. Further, the pattern report had to be adjusted to the altered dimensions in the reconstruction. As the number of warp threads per cm was decreased from 22-26 to 18 threads/cm, the number of repeats had to decrease as well to fit the final measurements of the overall pattern. Altogether the weaving process was very slow. One pattern weft row could easily take 20 minutes to create and after every second weft it was necessary to take a break to rest both eyes and neck. This meant that Ida Demant could weave 1.5 to 2 cm of the pattern per day.

When the pattern section was finished, the rest of the fabric was completed by Marie Wallenberg in September 2020. During this stage, Marie Wallenberg could initially weave c. 7 cm in an hour or c. 25-30 cm a day. In order to increase the weaving speed, Marie Wallenberg adjusted the loom by moving both the beater and the shafts forward. Further, instead of keeping the warp tense during weaving and slack when not in use, it was kept with a relatively low tension all the time, both while weaving and resting. Cleaning the sticky shed was done only by hand without the use of tools. The beater was used twice per weft, once gently to push it into place and once with a harder beat to maintain the density of the weft. In this way Marie Wallenberg managed to weave 50 to 75 cm per day.

A general problem in this weave was the tendency for the warp threads to break. During pre-dyeing and washing, the yarn had developed a hairy surface, which made it weaker and more receptive to wear when it passed through the heddles and the reed, and eventually made the opening of the sheds less smooth. This damage was definitely reduced by the adjustment of the warp tension and the tool settings, but as weaving progressed, the knots in the warp, which derived from the winding of the dyed yarn, created more problems than expected. Some of them would hold and be woven into the fabric. However, many would either slide apart or cause the warp thread to break when it passed through the heddles or the reed, or if the ends were not shortened, long ends would disturb neighbouring warp threads when the shed was changed. This caused the tension to become uneven as the weaving progressed. In the end there was a difference of up to 15 cm in the loom ends (some of which measured 55 cm). Finally, a lot of time was spent removing the knots from the warp in the finished fabric.

During weaving, the red dye transferred to the weavers' clothing, and we worried that it would run into the white pattern during washing. Therefore, the patterned part was wrapped in plastic and rolled onto a stick to help keep it out of the water while the rest of the fabric was washed. The fabric was then left to soak in c. 30° C water for an hour to dissolve the bone glue. Then it was washed in another bath with a mild wool detergent and rinsed until there was no more surplus colour. The surplus colour looked mostly like little bits of crushed cochineal shells. The patterned part of the weave was washed afterwards. All in all, 10 metres of fabric were created for the dress. After the fabric had rested for a week and all the ends were darned, it had shrunk to 9.69 m. After washing, the weave further shrunk to 9.30 m, while the width was unaltered and still measured 52 cm (table 6.4). After drying it was given a gentle pressing with a steam iron.

► Table 6.4: Measurements of the reconstructed dress fabric.

Reconstructed fabric	Length in cm	Width in cm
Warp	1070	52
On the loom	980	52
Cut off the loom	980	52
After resting a week	969	51-52
After wash	930	51-52
Shrinkage in total	5,5 %	0 %

Among the tabby fragments from Hvilehøj there are no seams or hems that indicate if and how this textile was used for a garment. As there are no dress fasteners in the grave either, it was decided to make a model based on the dress D10581 from Herjolfnæs in Greenland dated to 14th to 15th century AD (Østergård 2004, 163 and 253). Basically, this pattern has a body which consists of six pieces: two rectangles serving as front and back, two pieces cut to make the sides below the sleeves, as well as two pieces for the sleeves themselves (fig. 6.6). Extra width was also added by cutting a slit in the front and back and inserting two gores, each made up of two triangular pieces. The sleeves are slightly rhombic, only shaped a little at the shoulders, and a triangle is added in to give a bit of extra space between the tight-fitting sleeve and the back of the dress. Although it is impossible to know if and how different this dress type is from the ones worn by the elite in the 10th to 12th century AD in Denmark, similar shaped items are known from male contexts. It is thus not unlikely that such items were used by women too. For the reconstruction of this dress, it was decided to leave out the extra gores in the front and back, as they would disturb the nice pattern on the chest. Further, the length of the sleeves was extended, as the Herjolfnæs dress has short sleeves.

A

B

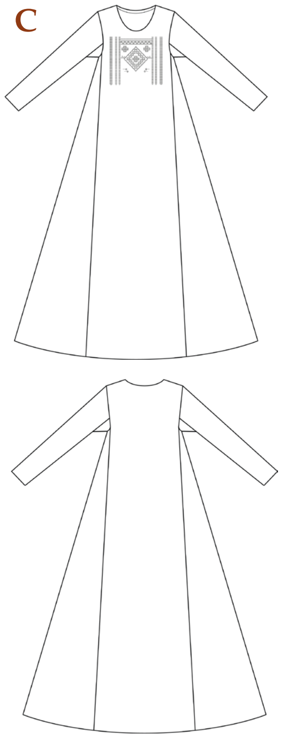
◄ Fig. 6.6.A: The finished dress for the female outfit, front.

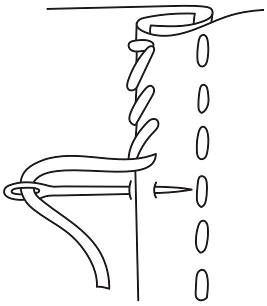
Photo: Roberto Fortuna

B: Seen from the back.
C: Schematic illustration of the undergarment (Top: front side. Bottom: back).

Illustration: Line Maria Mørch

C





▼ Fig. 6.7: Schematic illustration of how to make a flat-felled seam.

Illustration: Line Maria Mørch

Patterns of the Old Norse dresses are fortunately easily accessible (Fransen et al. 2010) and Ida Demant used one of these to construct the pattern sheet. It even turned out that the desired model size matched the smallest size of the premade patterns. After the mock-up was adjusted to the model, the final pattern parts were then laid out on the finished fabric, so as little material as possible was wasted. The pieces for the dress were cut out with the kind assistance of Lone Brøns-Pedersen. From the beginning, it was estimated that 8.5 metres of fabric would be needed for the dress. However, as the weave had not shrunk as much in the width as allowed for, it was possible to make even better use of the fabric. In particular, it was now possible to cut the side gores alongside each other. In the end, 6.5 m of fabric was used.

The final hand sewing and finishing of the garment was carried out by Birgitte Kjelstrup. As there are no seams preserved in the textile fragments from Hvilehøj to shed light on the construction, the Old Norse descriptions of seams is one possible source of inspiration (Østergård 2004). However, in order to make a solid seam, it was decided to use a flat-felled seam (fig. 6.7). This type of seam is recorded in the textile material from Hedeby and the settlement of Elisenhoff (Hägg 1984, 149-152; Hundt 1981, 195). It is a stable and solid type of seam, useful for handwoven fabrics with a tendency to fray.

The dress was finished in early October 2020, nearly one year after the work had begun. Six different craftspeople had been involved in the process, two spinners, a dyer, two weavers, a seamstress, and several extra hands, who altogether used many hours to create this beautiful dress. The most intriguing aspect in the process is that where we today have computer, paper and colour pencils at our disposal in the design process, the Viking Age weaver had all this in his/her mind or would have created the pattern as the weaving progressed. It is definitely not a straightforward and easy task and would have required experience and skill in order to achieve such a perfect and homogeneous appearance.

Beads

In the Hvilehøj burial, 14 beads plus several broken fragments were found on the chest of the woman (fig. 6.8). The ensemble comprises two mountain crystal beads, one glass bead with gold foil inlay, two glass beads covered with gold foil, two glass mosaic beads, two green glass beads, two white glass beads, one blue glass bead, one orange glass bead and one amber bead. A drawing from the excavation meticulously shows how some of the beads encircled an Otto I (AD 936-973) silver coin, pierced through the centre. The coin was thus also part of the jewellery ensemble (see chapter 10).

The beads and the coin were reconstructed by Kathrine Sode Vest, with help from Ulla Lund Hansen. As the beads were only found on the chest part of the woman, they were most likely attached to her dress. For the reconstruction the bead string ends were sewn onto the dress (fig. 6.9).

► Fig. 6.8.A: The complete preserved beads from Hvilehøj. B: The silver coin.

Photo: Roberto Fortuna

◄ Fig. 6.9: The reconstructed bead ensemble in the female outfit.

Photo: Roberto Fortuna

Fur cape

The Hvilehøj material consists of many small fragments of textiles, fur, and down that have decomposed into complex, flat layers (fig. 6.10). The microstratigraphy is thus important in order to understand how the different layers interrelate. In several of the layers, fur was found to be decorated with tablet-woven bands, narrow silk bands of a 3/1 twill as well as strips of silk samite and silk tabby (table 6.7). Altogether, c. 22 individual fragments with decoration indicate the presence of a decorated fur garment. It was on this basis decided to make an outer garment using these pieces. In 2019, the protein analysis of several different fragments of fur resulted in a preliminary identification of beaver and an unspecified carnivore fur. Based on the result it was decided to make a cape of pine marten with beaver fur edges. This decision was made in order to give the female fur garment a different look to the male beaver-fur caftan. However, the final results of the protein analysis later showed that the true materials are

◄ Fig. 6.10: Fragment with fur and textile from Hvilehøj, C4280c.

Photo: Roberto Fortuna

► Table 6.7: Technical details of the original fur and textiles chosen for the fur cape and the reconstructed fur and textiles.

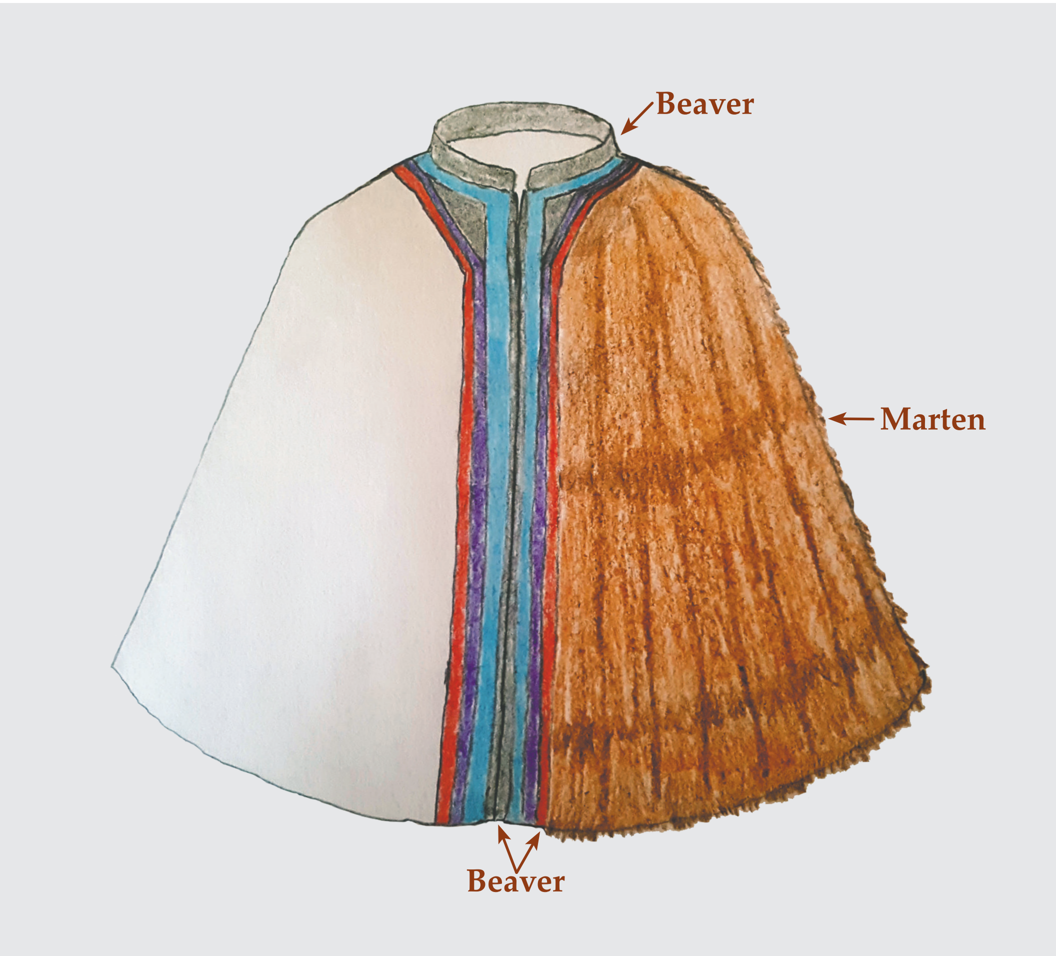
Textile C4280b, C4280c, C4280c extra C4291b 22 fragments	**Colour/dye**	**Yarn diameter in mm and twist direction**	**Threads/cm**	**Fibre**
Tablet weave 37 tablets C. 760 x 17 mm in all	Brown Indigotin	Warp: 0.2 mm, S2unspun Weft: 0.2 mm, unspun silk Soumak: 0,3, S2unspun Brocade weft: 0.2-0.3 mm/(metal lahn): 0.2 mm, S wound	37 tablets in all 20 tablets/cm Edge: 2x 6 (3 silk, 3 veg.) Pattern: 25 (all veg.) Wefts: 28/cm (1 main weft + 1 or 2 brocade wefts)	Silk, gold/silver lahn with silk core
3/1 twill C. 200 x 8 mm in all	Brown Madder, indigo	0.22/0.25 S-2 unspun/Unspun	32/30	Silk, gold/silver lahn with silk core
Samite (weft-faced compound twill) C. 100 x 10 mm in all	Brown Madder	0.16-0.2/0.16-0.2 z/unspun 20°/-	2/1 twill and 16-20 double main warps/ 18 double passes	Silk
Tabby 20 x 20 mm in all	Brown	0.2/0.15 S-2/S-2		Silk
2/1 twill rolls 12 fragments **(padding)** Longest: 110 x 8 mm	Brown	0.8-01.0/1.0-1.5 z/z 32°/34°		Wool
Fur	Brown			Beaver and squirrel
Reconstruction	**Colour**	**Yarn diameter in mm**	**Thread/cm**	**Fibre**
Tablet weave 37 tablets 1.7 x 300 cm (silk and silver) 1.7 x 20 cm (flax, silk and silver)	Edge: Dark indigo blue Pattern: Lighter indigo blue	Blue silk warp: 0.3 mm, 2 ply Z2unspun White silk warp: 0.3 3ply Z3unspun Light blue soumak: 0,3mm, 3 ply, Z3unpsun Brocade weft: 0.2 mm/(metal lahn) 0.3 mm	37 tablets Edge: 2x 6 (6 silk) Pattern: 25 (all flax) Wefts: 28/cm (1 main weft + 1 or 2 brocade wefts)	Silk thread Linen thread Brocade thread Silver and gold thread from Klöppel-werksatt, Germany
3/1 twill 0.8 mm wide	Purple	Purple warp + weft: 0.4 mm, S-2unspun Brocade weft: 0.3 mm/(metal lahn) 0.3 mm	26/22	Silk Silk, gold/silver lahn with silk core
Samite	Red	0.2/0.6 Unspun/S-2unspun	Warp: 45 ends per cm, 15 binding warps, 30 inner warps (1:2) Weft: 13-15 passes per cm (2 wefts)	Silk (gummed for warp, degummed for weft)
Tabby	Red	0.2/0.2 Unspun	30/30	Silk
Reconstruction	**Colour**	**Tannage**	**Thread/cm**	**Material**
Fur	Dark brown	Fat/oil		Marten and beaver

squirrel and beaver (Brandt et al. 2022). Even if we had known this from the outset, we would not have been able to make a full garment in squirrel fur, primarily because the European squirrel cannot be acquired commercially, but also because we would need to work with about three times as many skins. If we were to make a second construction of the fur garment, the main material would probably be beaver, as an indicator of the luxury connotation of the fur.

All in all, fur from 38 pine martens were used and placed in three rows in the cape design. The furs were fat tanned, based on a visual determination by Theresa Emmerich Kamper, who also did the tanning and sewing helped by Julia Hopkin and Malene Lauritsen (fig. 6.11). The sewing thread was flax and sinew (see also chapter 8). The pattern was designed as semi-circular, based on capes depicted on the gold-foil figures from the Late Iron Age (Mannering 2017a) as well as older archaeological textiles, such as the Burgundian Queen Bathilde's cloak, dated to the 7th century AD (Laporte & Boyer 1991). The pattern was constructed by Lone Brøns-Pedersen and first sewn in a mock-up and sized to fit the model (fig. 6.12, fig. 8.9a). As no obvious closing devices were found in the grave, simple leather strings were attached to the collar and are now used to tie the neck opening together.

◄ Fig. 6.11: The tanned pine marten fur before cutting into shape.

Photo: Theresa Emmerich Kamper



◄ Fig. 6.12: The construction pattern for the cape.

Illustration: Theresa Emmerich Kamper

In order to discover how the many pieces of tablet-woven bands, and strips of bands and textiles were used as decoration on the fur garment, images of the different fragments were printed on paper 1:1 and cut out, in order to fit them onto the mock-up of the cape (fig. 6.13). In this way, we tried to place the fragments in a realistic manner, considering both the sequence of bands, their relative location and the direction of the fur. On fragment C4280c, four wool textile rolls are placed in a triangular shape (see fig. 6.10). Another set of loose wool textile rolls also belong to the find (C4291b). These were probably used as a kind of padding, as known from Bjerringhøj. The wool roll triangles were placed on the upper front part of the cape, following the edge of the beaver fur. As the wool textile rolls in the Bjerringhøj grave are covered in silk textiles, it was decided to cover the Hvilehøj wool textile rolls in silk, too. On some of the fragments related to C4280b small pieces of a tabby silk are visible and the dye analysis proved them to be dyed with madder (14152/34) (Vanden Berghe et al. 2023). A piece of the silk tabby, handwoven on a treadle loom by Åse Eriksen, was dyed with madder by Anne Batzer and used for this purpose. In 1950, Margrethe Hald indicated that the abovementioned wool textile rolls could have been dyed with woad, but unfortunately our dye analysis did not provide evidence of blue dye.

► Fig. 6.13: The fragments with fur and bands printed on paper 1:1 and placed on a mock-up of the cape.

Photo: Charlotte Rimstad

Some parts of the textile fragments preserved from Hvilehøj contain remains of a very intricate tablet-woven band in silk yarn and brocading in silver and gold threads with a silk core. In all, c. 76 cm of this band is preserved (fig. 6.14, fig. 6.15). The pattern consists of geometrical diamond shapes in silver and silk threads with a reoccurring gold swastika in the middle (Hedeager Krag & Ræder Knudsen 1999). For this reconstruction, Lise Ræder Knudsen reanalysed the band and adjusted the pattern according to her findings. The band was woven with 37 tablets by Kateřina Křížová in Czech Republic. The dye analysis (14152/40, 33a-33b) showed the presence of indigo, and the band was woven using machine spun, pre-dyed blue silk threads. In total, 3 m of this band was produced. This took the weaver four months to make (fig. 6.16).

◄ Fig. 6.14: Hvilehøj C4280b fragment 6 with remnants of the tablet-woven band.

Photo: Roberto Fortuna

◄ Fig. 6.15: Hvilehøj, C4280b fragment 4. A strip of samite textile is visible to the left, next to a 3/1 twill band in the middle and the tablet-woven band to the right.

Photo: Roberto Fortuna

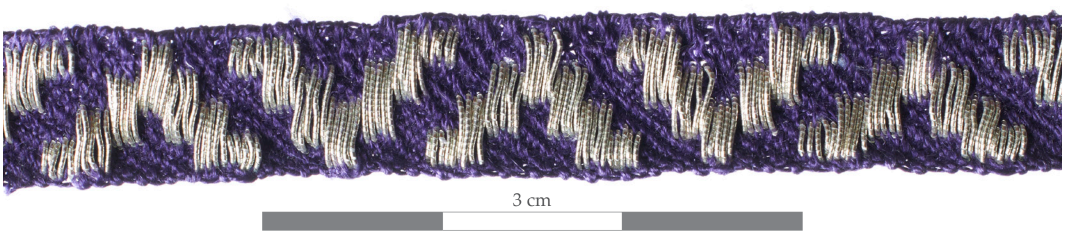
A 3/1 twill textile, possibly woven as a band made of silk and silver threads was also recorded on some of the fur fragments and here the dye analysis (14152/35a-35b) resulted in a combination of madder and indigo. On this basis, it was decided to reconstruct the band in a purple nuance in a pre-dyed silk thread. The band is preserved in a width of 0,8 cm and is decorated with a step pyramid pattern made in the silver threads that fills out the whole visible surface. The band was reconstructed by Marie Wallenberg (fig. 6.17) (tab 6.7). The 0,9 cm wide samite strip, which is also recorded in connection with the fur and tablet-woven bands, was not re-produced 1:1. Instead the silk samite made by Åse Eriksen for the male outfit was used and dyed with madder by Anne Batzer in accordance with the dye analysis (14152/41). To keep the different narrow bands and strips of textile in place on the cape, they were first stitched on a piece of the silk tabby made for the male outfit, which had also been dyed with madder. Marie Wallenberg attached these decorated pieces of silk tabby to the fur cape.

► Fig. 6.16: The reconstruction of the tablet-woven band from Hvilehøj.

Photo: Kateřina Křížová

► Fig. 6.17: The reconstructed 3/1 twill band.

Photo: Mads Lou Bendtsen



In general, the marten fur cape has a very soft touch and beautiful look (fig. 6.18). The fur is surprisingly light, weighing only 690 g. If it had been made in squirrel fur it would probably have been even lighter. It was decided not to line the fur cape and due to the fat tanning method, the flesh side has a nice white colour. The cape can also be worn with the inside out.

► Fig. 6.18.A: The finished cape, seen from the front.
B: Seen from the back.
C: Seen from the inside.

Photo: Roberto Fortuna

Fur shoes

Today, the Hvilehøj shoes consist of several small pieces which were analysed by Vivi Lena Andersen, in order to determine construction and sewing methods. During this examination, it became clear that the preserved fragments come from a right and a left shoe (C4281) (table 6.8, fig. 6.19). The right shoe is the best preserved and the toe part clearly shows that they belong to a group of specific cutting patterns classified as W-shaped (Volken 2014). Each shoe consists of two parts that are sewn together with a middle seam underneath the foot (fig. 6.20). As only the front part of the shoes is preserved, it is impossible to determine if the seam went all the way underneath the foot or just ran along the front part. Likewise, the tying/closing mechanism of the shoes is not preserved. This research has thus demonstrated that the pair of shoes in the Hvilehøj burial have quite a special design. Further, the protein analysis proved them to be made of goat skin (Brandt & Mannering 2020). Based on the visual analysis by Theresa Emmerich Kamper, it was determined that the shoes were constructed with the hair side out and that the hairs were most likely not removed.

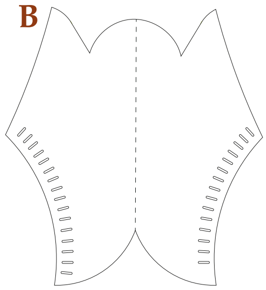
The goat fur was vegetable tanned by Theresa Emmerich Kamper, and the shoes were sewn by Espen Kutschera, using flax for the sewing thread (see also chapter 9). Because of the vegetable tanning, the shoes gained a reddish colour (fig. 6.20). Compared to other Viking Age shoes, this is a very simple pattern which has parallels in the many one-piece shoes found in the Danish bog burials, dated to the Bronze and Early Iron Ages (Hald 1972; Mannering 2017b).

► Fig. 6.19: The Hvilehøj goat skin shoes, C4281.

Photo: Roberto Fortuna

Fur/leather	Original	Reconstruction
C4281 A pair of fragmented shoes C. 10 x 15 cm in all	Goat skin, no hair preserved	Vegetable tanned goat skin with hair on

◄ Table 6.8: Technical details of the original fur shoes and the reconstruction.



◄ Fig. 6.20.A: The reconstructed shoes for the female outfit.
B: The pattern for the goat skin shoes.

Photo: Espen Kutschera

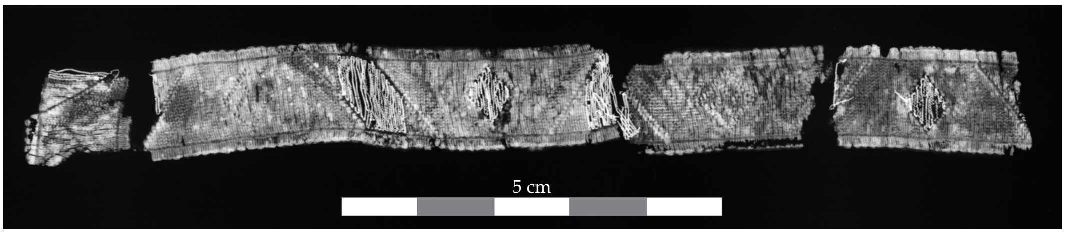
7. The reconstruction of the tablet-woven bands

Lise Ræder Knudsen, Marie Wallenberg and Kateřina Křížová

A very important part of the textile finds from the Hvilehøj and Bjerringhøj graves are the tablet-woven bands. Tablet weaving is a technique that can be used to produce separate bands and borders, integrated into woven textiles. Many small fragments of the same tablet-woven band made of silk, gold, silver and presumably flax threads are preserved from Hvilehøj. From Bjerringhøj, at least four different silver and gold brocaded silk tablet-woven bands are preserved, as well as one band made of wool. For the making of the male and female outfits in the *Fashioning the Viking Age project,* five of these bands were analysed and reconstructed. All of the reconstructed bands were produced as separate bands and, according to their context, the brocaded bands were used as decorations, sewn onto the different reconstructed clothing items. The wool band was reconstructed, but not included in the male outfit.

Method

The original bands were analysed visually under the microscope and sections of them were X-rayed at the Conservation Department at the National Museum of Denmark (fig. 7.1). The X-ray made it possible to see the very thin and fragile silver and gold threads, even when they were covered with corrosion and soil. Samples were taken for dye analysis where possible and analysed using High Performance Liquid Chromatography and photo diode array detection system (HPLC-DAD) (Vanden Berghe et al. 2023). Previous analysis of the Bjerringhøj bands using spectrophotometer and Thin Layer Chromatography (TLC) (Walton 1991) were included in the reconstruction process, especially when sampling was not considered possible, primarily due to the completeness of some of the bands.



► Fig. 7.1: X-ray image of a tablet-woven band, C136b, from Bjerringhøj.

Photo: Signe Nygaard

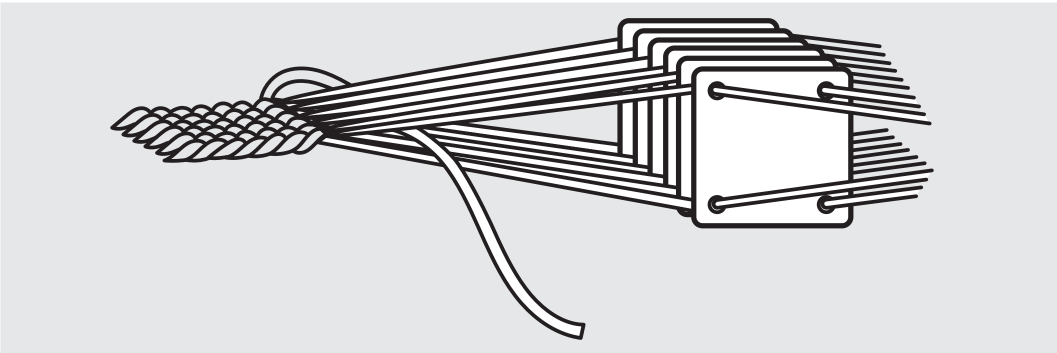
The visual analyses, and for some of the bands also the X-ray images, have given an overview of the proportions of the bands. However, some data are still uncertain, as all of the brocaded silk bands proved to have silk exclusively in the visible part of the bands, whereas warp threads were missing underneath the silver or gold threads. These degraded warp threads might have been made of flax, but today it is only possible to estimate the number of threads through comparison and knowledge of the standard weaving methods of these bands and the empty spaces between the preserved silk and silver/gold threads. The patterns of the bands were documented, and the possible colours discussed during the process of analysis.

The brocade threads consisted of narrow flat silver or gold metal lamella wound around an untwisted silk thread core (fig. 7.2). Most silver and gold threads seemed to be of a very uniform construction with a s-twist around the core and a diameter of c. 0.2-0.3 mm. The soumak silk thread was likewise made of an untwisted filament yarn.

◄ Fig. 7.2: A gold thread from the tablet-woven band in Hvilehøj, C4280b, with the silk core still preserved.

Photo: Charlotte Rimstad

Several scholars have published articles about the tablet-weaving technique (fig. 7.3). For the reconstructions, the works of Margrethe Hald (Hald 1932; 1980), Else Østergård (Østergård 1991), Egon Hansen (Hansen 1990; 1991) and Lise Ræder Knudsen were consulted (Ræder Knudsen 1991; 2005; 2015; Hedeager Krag & Ræder Knudsen 1999).



◄ Fig. 7.3: The principle of tablet-weaving. After the weft is inserted the tablets are turned together or individually to create a pattern.

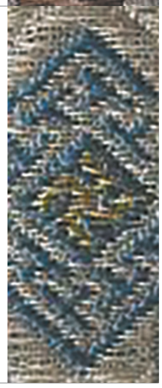
Illustration: Line Maria Mørch

In the preparation for a reconstruction, a constant dialogue is essential between the data extracted from the archaeological remains, the actual handcraft, and the aim of the reconstruction. For this project, it was decided to produce a certain length of the bands from Hvilehøj and Bjerringhøj, which would adorn the reconstructed outfits. The working methods should be as close as possible to the original, but shortcuts in the production process could be made, as long as the overall visual appearance remained the same. Further, a sample of each band was made as accurately as possible, for a sample book. Some of the five bands have been reconstructed before, while others were reconstructed for the first time. In the following, each of the five bands and their reconstruction process is described.

Hvilehøj (C4280b, C4280c)

All tablet-woven band pieces preserved in the Hvilehøj grave belong to the same brocaded band. Altogether, c. 20 fragments 1.7 cm wide, of which the largest piece is approximately 12 cm long (table 7.1), are preserved. The warp originally comprised of 37 tablets. Silk threads are preserved in six tablets while the warp threads from the remaining 31 tablets are missing. Most commonly, weft threads are missing and only the silver and gold pattern weft threads are preserved. The edges of the band consisted of two outer tablets threaded with silk warps, three tablets with missing threads (probably flax) and one inner tablet threaded with silk warps. This tablet-woven band has its own brocading variation using a weft-patterning technique where the silver and gold threads cover the entire surface, edges, and the pattern section. The weft count of the band is 28 wefts per cm: one main weft and one or two brocade wefts (silver thread and, in short sections, also gold thread) in each shed. Furthermore, a soumak silk thread was wrapped around the warp threads in the middle of the band, producing the pattern and, in these areas, covering the silver threads.

► Table 7.1: Technical details of the tablet-woven band from Hvilehøj (C4280b, C4280c) and its reconstruction.

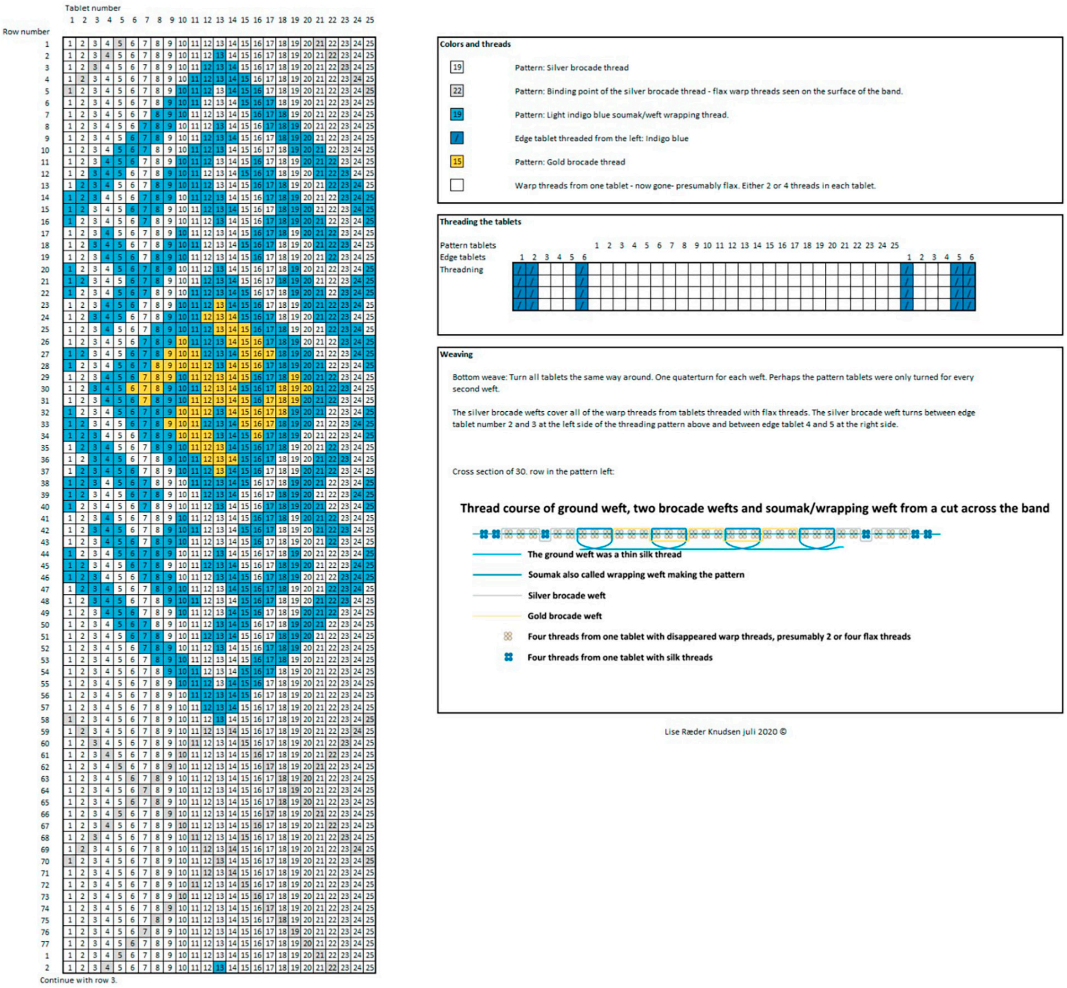
	Tablets /wefts	Material	Yarn diam. & twist direction	Colour/dye	Weaving	Image
Original Hvilehøj C4280b, C4280c C. 1.7 x 76 cm in all 20 fragments Used on: Skin garment	37 tablets in all 20 tablets/cm Edge: 2x 6 (3 silk, 3 veg.) Pattern: 25 (all veg.) Wefts: 28/cm (1 main weft + 1 or 2 brocade wefts)	Silk and silk core with gold/ silver lahn	Warp: 0.2 mm, S2unspun Weft: 0.2 mm, unspun silk Soumak: 0,3, S2unspun Brocade weft: 0.2-0.3 mm Metal lahn width: 0.2 mm, S wound	Brown/ Indigotin	-	
Reconstruction 37 tablets 1.7 x 300 cm (silk and silver) 1.7 x 20 cm (flax, silk and silver)	37 tablets Edge: 2x 6 (6 silk) Pattern: 25 (all flax) Wefts: 28/cm (1 main weft + 1 or 2 brocade wefts)	Silk thread Silk thread Brocade thread Silver and gold thread from Klöppelwerk-satt, Germany	Blue silk warp: 0.3 mm, 2 ply Z-2unspun White silk warp: 0.3 3ply Z-3unspun Light blue sou-mak: 0,3mm, 3 ply, Z-3unpsun Brocade weft: 0.2 mm Metal lahn width: 0.3 mm	Edge: Dark indigo blue Pattern: Lighter indigo blue	Quarter turns forward, pick up of one thread from side tablets, metal brocade and silk sou-mak	

The pattern section consists of 25 tablets where all the threads are missing today. The most distinct pattern part is the gold swastika framed by a diagonal geometric hexagon pattern (fig. 7.4). Most of the band fragments seem to contain this design, although at least one fragment shows another pattern which is not fully preserved. The inner left-turned swastika pattern measures 0.7 x 0.5 cm and is most often created in gold thread. The X-ray images have nevertheless revealed that some of the swastika patterns could, in fact, also have been made in silver threads. Due to the good preservation of the gold threads, these parts of the pattern are easily recognizable and are rarely covered by the silver corrosion that in most cases blurs the design. The overall hexagon pattern sections are repeated along the length of the band with a distance of c. 0.6-0.7 cm. between each section.

► Fig. 7.4: The best preserved pattern from the band from Hvilehøj (C4280b, C4280c).

Photo: Lise Ræder Knudsen

Already, in 1993 it was discovered that only six of the presumably 37 tablets were threaded using silk. Further, it was established that the band was made to look as if it was made entirely of silk, gold, and silver, although only 16% of the tablets (warps in six tablets) were threaded with silk and 84% of the warp (warps in 31 tablets) had a now missing, possible vegetable, thread (Ræder Knudsen 1996, 60, 109; Hedeager Krag & Ræder Knudsen 1999, 162-163). This is a very unusual and time-consuming technique. On the surface it gives the impression of a band made entirely of silk, silver and gold, although this is not the case (Ræder Knudsen 2005, 38). The pattern of the band is seen in fig. 7.5.



◄ Fig. 7.5: Pattern and weaving instruction of the tablet-woven band from Hvilehøj C4280.

Pattern and illustration: Lise Ræder Knudsen

Today, under the microscope, there is a visible colour difference between the outer edge of the band and the inner edge of the pattern. The impression is that some of the silk warp threads may have had a reddish hue, but analysis of the dyestuff only showed an indigoid dye source in the central part of the silk warp threads, while no other dye sources were detected in the edges.

The reconstructed band

Weaving a reconstruction of the Hvilehøj band turned out to be a complicated and time-consuming task. Copies of brocaded tablet-woven bands are sometimes produced for garment reconstructions and museum exhibitions. It takes a skilled weaver to produce good copies, but the Hvilehøj band is particularly complicated to recreate, and to our knowledge, a true reconstruction of this band has not previously been made. As mentioned, the Hvilehøj band is woven using far less silk than in a traditional brocaded band but results in a similar appearance using a very time-consuming working method. Although it was discovered that not all the swastika patterns were made in gold threads, and the pattern may have varied along the length, it was decided to use a fully preserved hexagon pattern with gold swastika along the entire band.

Three metres of the Hvilehøj band were woven by Kateřina Křížová from the Czech Republic (fig. 7.6). The band was woven in pure silk, even though the main part of the original decayed warp was most likely made of a vegetable fibre. The reason for this decision was that it was easier to produce the band using the same fibres in all the tablets. Silk and flax have different flexibilities and a combination of these materials would make it necessary to adjust the tension of the warp while weaving. Furthermore, the two different fibres would also wear out differently, and as the difference in materials is only visible on the reverse, it was decided to create the band this way. A 20 cm long sample made in silk and flax was produced for display purposes. The silk thread used in the reconstruction was a little thicker than a modern 100/3 sewing silk. To highlight the pattern, it was decided to use a dark, indigo-blue coloured silk in the six tablets edging the pattern and a lighter, indigo-blue silk in the soumak thread wrapped around the missing warp thread producing the pattern (fig. 7.7). These were dyed by the weaver using indigo. The diameter of the silver and gold brocade threads was 0.2 mm, and they were purchased at Klöppelwerkstatt in Germany. The weaving speed was 45 minutes per cm for the silver sections and 90 minutes per cm in the area where the gold thread was also used. The weaving speed was around one hour per cm for the entire band.

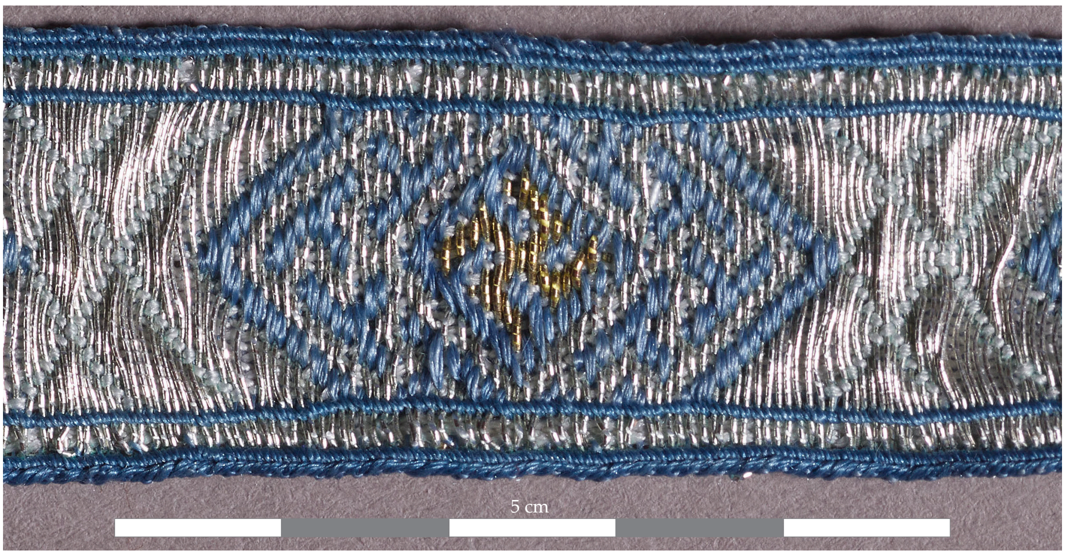
The reconstruction process gives a good indication of the working hours needed to produce a band using this unusual method. It underlines the fact that during the Viking Age silk was a rare and very expensive material, and that spending many extra working hours in the weaving process was less important than saving a few metres of silk thread.

► Fig. 7.6: The ongoing pattern on the reconstruction of the tablet-woven band from Hvilehøj (C4280b, C4280c) woven by Kateřina Křížová.

Photo: Kateřina Křížová

► Fig. 7.7: Detail of the finished reconstructed tablet-woven band from Hvilehøj.

Photo: Roberto Fortuna



Bjerringhøj C138

The two fully preserved wrist cuffs are decorated with tablet-woven bands, each 1.4 cm wide and 25.3 cm in circumference (see fig. 5.43). A beautiful drawing of one of the wrist cuffs was published in 1869 (Worsaae 1869, 208-210, 218, pl.5), although the technique used to produce the bands was unknown at that time. Hald was the first to analyse the tablet-woven bands from Bjerringhøj (Hald 1980, 107-110, 225-239), and in the late 1970s Hansen made the first reconstructions. Primarily, he used Hald's analysis, but found that some details had to be corrected. Hald thought that the bands had been made using two threads in the tablets in the pattern section, while the edge tablets had four threads in each tablet, but this idea did not match up with Hansen's reconstruction. His conclusion was that half of the silk threads in the pattern section of the band and all the threads under the silver part in the edges were originally made of a vegetable fibre like flax (Hansen 1990, 55-57; 1991, 146). Herfrid Tausen also used this method in 1991 when weaving the copies of the tablet-woven bands for the reconstruction of the Viking Magnate outfit (Hansen 1991; Munksgaard 1991; Bender Jørgensen 1992).

The warp of the tablet-woven bands was originally threaded using 33-35 tablets (table 7.2). Silk thread was preserved in the edge tablets, but the tablets for the stave borders were entirely threaded with a non-preserved material, while the remaining 23 tablets were threaded with half silk and half a missing thread of probably vegetable material. Most silk weft threads, the silk soumak threads and the silver and gold-pattern weft threads were preserved. The silver lamella, however, are mostly gone, leaving the silk core exposed. The weft count is c. 30 wefts per cm.

	Tablets /wefts	Material	Yarn diam. & twist direction	Colour/dye	Weaving	Image
Original Bjerringhøj C138 25.3 x 1.4 cm 25.3 x 1.4 cm Used on: Wrist cuffs	33-35 tablets 25.5 tablets/cm Edges: 7 and 6 (3/2 silk, 4 veg.) Pattern: 23 (of 2 silk and 2 veg.) 30 wefts/cm	Silk and silk core with gold/ silver lahn	Silk warp: 0.2-0.3 mm, S-2unspun Soumak silk thread: 0.3-0.4, Z-2unspun Brocade weft: 0.2-0.3 mm Metal lahn width: 0.1-0.2 mm, S wound	Light grey and golden No dye analysis	-	
Reconstruction 1.4 x 130 cm. 23 cm used for each wrist cuff.	33 tablets Edges: 2 x 5 tablets. 2 tablets for the stave border in each side (4 threads, Z orientated) Pattern: 23 tablets (2 threads, alter-nating Z and S orientated) 27 wefts/cm	Warp: Silk Nm 60/2 (+ extra twist) Linen Nel 100/2 (stave border) Weft: Silk Nm 60/2 (split to 1-ply) Brocade: Silver and gold no. 4 from Klöppel-werkstatt Floss silk from Pipers Silks, UK.	Pink silk warp: 0.3 2 ply, S-2z White linen: 0.3 2 ply, S-2z Weft: 0.2 mm, lightly Z spun Brocade weft: 0.3 mm Metal lahn width: 0.3 mm	Pink silk (based on lichen dye analysis from the loose band C136c) Dark red silk for soumak	Quarter turns forward, pick up of one thread, metal brocade and silk soumak	

◄ Table 7.2: Technical details of the tablet-woven band from the Bjerringhøj wrist cuffs (C138) and their reconstruction.

This tablet-woven band has its own brocading variation, which is similar, but not identical, to the band from Hvilehøj and two of the other brocaded bands from Bjerringhøj (C137 and C136b) using a soumak silk thread wrapped around the warp threads in order to accentuate parts of the pattern (fig. 7.8). The silk, gold and silver brocade threads can only be studied on the front as the reverse is hidden in the construction of the wrist cuffs.

The two bands are not entirely identical and have variations in both the repeating pattern and between the two bands, regarding when gold or silver thread is used and how much the soumak detail is employed. In general, the edges of the band consists of two outer tablets threaded with silk, two or three tablets with missing threads (probably vegetable fibre)

► Fig. 7.8: Detail of the brocaded tablet-woven band for the Bjerringhøj wrist cuffs, C138.

Photo: Roberto Fortuna

and one inner tablet threaded with silk. The pattern section consists of 23 tablets which were threaded with half silk and half a non-preserved, probably vegetable, material. The silver and gold brocade covers the entire surface, the edges and the pattern section and are tied down by one warp thread at a time and in places accentuated by the silk soumak threads.

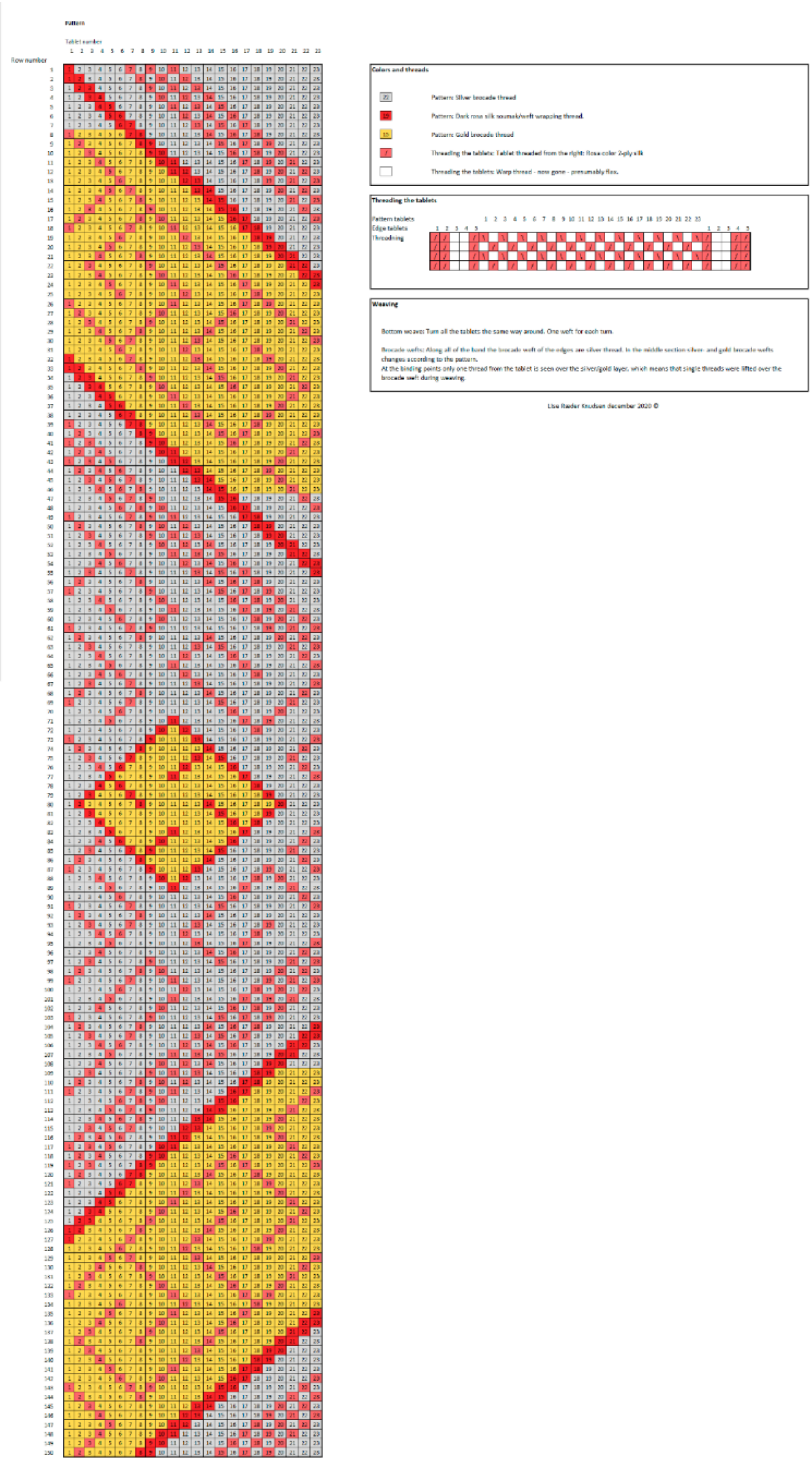
The pattern consists of right-turning and left-turning swastikas, c. 0.7 cm in the length. It is placed inside a cut-off triangular field and surrounded by geometrical patterns. Each field is flanked by borders which are surrounded by three lines of varying sizes. A full cut-off triangular field measures c. 3 cm at the base and c. 1.5 cm at the top. The swastikas are most often in gold, but sometimes in silver thread. Today, the silk warp threads appear dark brown with a reddish hue, while the soumak threads accentuating some of the patterns, are lighter brown. The surface of the gold threads is mostly preserved while the surface of the silver threads is almost completely destroyed and only the yellow-brown silk core of the brocade threads is seen.

The wrist cuffs are so well preserved that taking samples for dye analysis was impossible for this project and this was likewise not done in the 1990s (Østergård 1991, 131). The colour decision for the reconstructions is thus based on samples from an almost identical band from Bjerringhøj (C136b, fig. 7.9), which is not attached to any textile. This specificband was not used for the male outfit and thus not reconstructed. Dye analyses of the band, however, showed that some of the threads were dyed with lichen purple (Walton 1991, 139-140). Lichen purple is related to litmus, and it was noted that the threads turned red when placed under acidic conditions as litmus would (Walton 1991, 139). In alkaline surroundings, the colour would be more blueish. According to these considerations, it was decided to make the reconstruction of the tablet-woven band for the wrist cuffs in two different rose-pink colours.

► Fig. 7.9: The loose brocaded tablet-woven band from Bjerringhøj, C136b.

Photo: Roberto Fortuna

Wallenberg and Ræder Knudsen carefully studied the new detailed photos of the wrist cuffs and discovered details that have not been noticed before. It was earlier believed that the gold and silver brocade threads replaced each other along the pattern, but the larger gold parts of the pattern are actually edged by a silver part along the stave borders. This means that the weaver worked with three different brocading wefts and sometimes also a soumak weft for every row, and this in a band just 1.4 cm wide. This is really challenging, even for a skilled tablet weaver. The pattern of the band is seen in fig. 7.10.



◀ Fig. 7.10: Weaving instruction and part of the pattern from the tablet-woven band on the Bjerringhøj wrist cuffs (C138).

Pattern and illustration: Lise Ræder Knudsen

The reconstructed band

For the reconstructed band, the initial intention was to use a handmade gold and silver thread with a silk core purchased from Japan. Unfortunately, the metal part of these gold and silver threads was too wide. Being a little over 1 mm in width, the strips were wound less than 10 turns per cm around the silk core, compared to the original threads which had around 40-50 turns per cm. This created a different visual impression and the threads also had trouble turning at the edges. Instead of folding they began to unwind, creating a speckled appearance. To get the dimensions of the gold and silver strips right, a thread using gold-and silver-plated strips wound around a cotton core was used. This thread had the metal strip wound c. 30 turns per cm around the core.

The chosen colour for the warp was a rose-pink lichen colour, as described above. Here the plan was to use an industrially dyed yarn rather than real lichens, as they would not be light fast enough to withstand a long exposure to daylight.

In tablet weaving, the twist of the threads is continuously being changed when weaving. Twist is either added or removed depending on how the tablets are threaded and how they are turned. It is therefore difficult to give an exact measurement for the twist for the warp yarn in a tablet-woven band. However, it is possible to say that the original warp threads had a higher twist than the ones used for the reconstruction. The Nm 60/2 silk warp was therefore given extra twist using a spinning wheel. This gave the warp threads a better likeness to the original and also reduced the diameter of the thread a little.

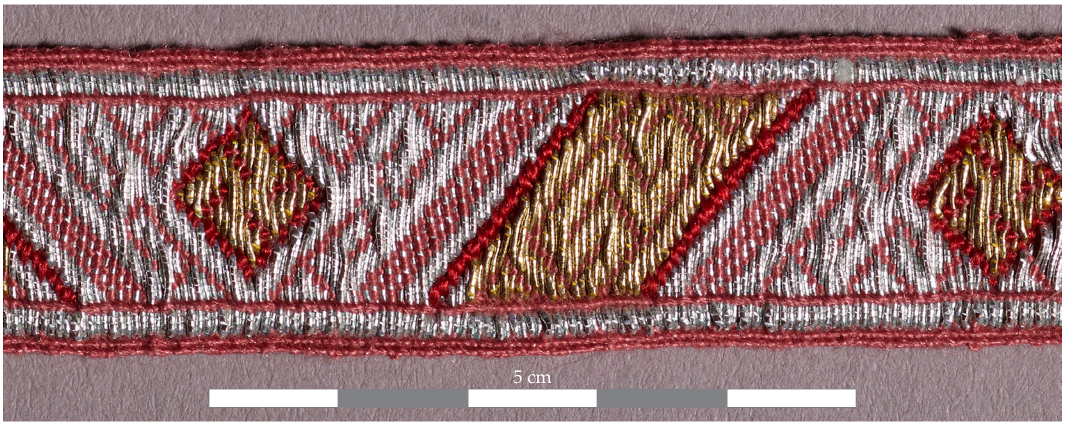
The warp threads for the stave border are completely missing. The estimated number of tablets ranges between two to four tablets. Both two and three tablets were tested and two turned out to be more proportionate for the threads used, so for this reconstruction the stave border was made up of two tablets on either side. For the silk brocading, a silk filament yarn was used with several threads together to get a suitable thickness. With the brocading threads having a slightly bigger diameter than the original, the weft count is c. 27 wefts per cm, compared to the original c. 30 wefts, which makes the pattern on the reconstruction slightly elongated.

After weaving samples and working through previously proposed methods for weaving the bands, Wallenberg preferred Hald's threading of the tablets using only two threads per tablet. It was decided to weave the band for the wrist cuffs and also the band for the two pendants (C137) according to this method (Hald 1980, 231-233). The bands were therefore woven using only two silk threads in the pattern tablets and four threads per tablet for the edges of the bands, and quarter turns forward for all tablets (fig. 7.11). The weaving speed for the band was 0.5 cm per hour.

During the initial sample weaving, it became apparent that the patterns on the bands sewn onto the wrist cuffs differed more than previously thought. On one of them, the pattern is more repetitive and similar, while on the other, the general pattern is repeated, but the gold, silver and silk soumak patterns are slightly different. Apart from the differences in the patterns of the bands, they also have a number of weaving mistakes. For example, a diagonal line is missing one of the warp picks or the line is broken and moves up one weft and is continuous from there. Other variations might be intentional and not true mistakes. A diagonal line usually consists of nine warp picks, but one of the pattern sections has eleven. For the reconstruction of the two wrist cuffs, minor mistakes have not been copied into the reconstructed bands. All other variations as well as changes between silver and gold thread were copied as faithfully as possible (fig. 7.12), following the pattern on the original bands row by row, using high-resolution photos. This way, new mistakes that inevitably occurred during weaving nearly 4000 weft rows, reflect these minor mistakes. The mistakes made during weaving matched the original mistakes both in type and frequently in the same parts of the patterns. This indicates that the weaving method follows the original one.

◄ Fig. 7.11: Weaving the reconstruction of the wrist cuffs (C138).

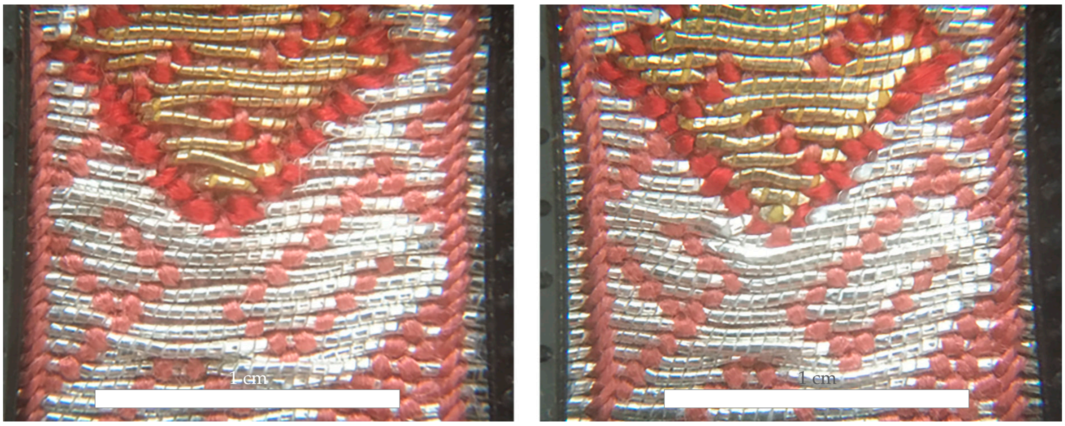
Photo: Marie Walllenberg



◄ Fig. 7.12: Detail of the reconstructed tablet-woven band from the wrist cuffs (C138).

Photo: Roberto Fortuna

Even with most of the silver now missing in the original bands, leaving the silk core exposed, the surface of the bands from both wrist cuffs and the loose fragment gives a visual impression that is calm, smooth and organized. During the initial weaving of the reconstruction, however, the surface appeared to be muddled and not as neat and tidy as the original bands. Under the microscope and on the X-ray images the metal threads often seem flattened, and an earlier made cross section of a gold thread from C136b also appeared flattened (Østergård 1991, 137). It is quite difficult to make a tablet-woven brocaded band, where the brocade threads totally cover the surface between the pickups. In order to create the same look, Wallenberg tried flattening and pressing samples of the bands using three different methods: hammering, a rolling pin and pestle made of wood. The wooden pestle gave the best results, and, the reconstructed bands were flattened this way (fig. 7.13). The flattening of the surface gave a better visual likeness to the originals, removing the somewhat muddled appearance and making the pattern more visible. The flattening also made the bands softer and more pliable.



► Fig. 7.13: Detail of reconstruction of C138. Left: Not pressed. Right: Pressed with a wooden pestle.

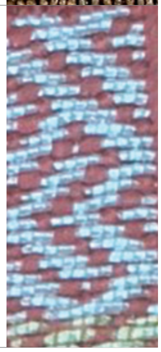
Photo: Marie Wallenberg

It can thus be concluded that the patterns of the tablet-woven bands from the wrist cuffs are not identical. Moreover, the bands have silver brocade along the edges and the silver and gold threads of the pattern do not replace each other in the stave border as previously believed. The brocade bands were surely treated after weaving by flattening the surface and thus making the brocade wefts cover the surface completely.

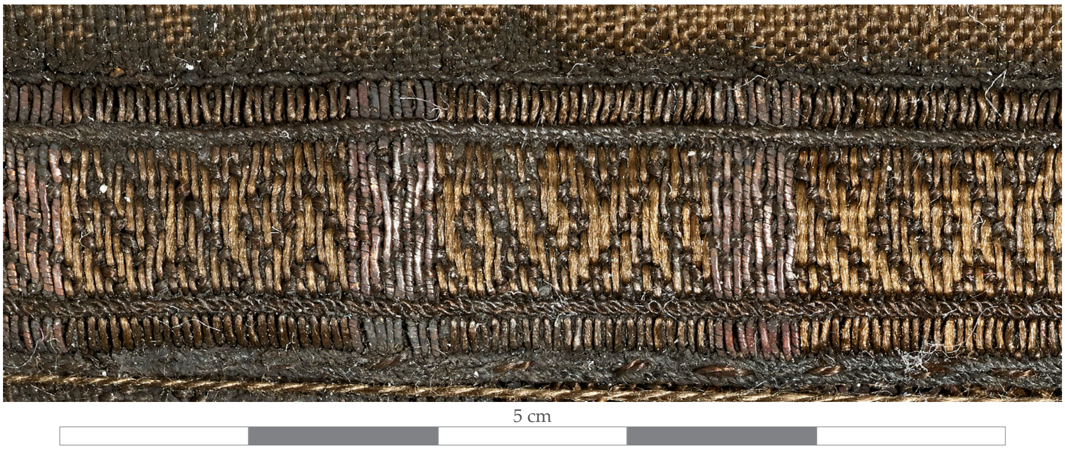
Bjerringhøj C137

The tablet-woven bands of the two pendants are each about 15 cm long and are sewn onto both sides and, in this way surrounding the pendants (see fig. 5.34). The width of the bands is 1.0 cm (table 7.3). As the bands are sewn onto the pendants it is impossible to see the reverse side, but the close-up pictures of the front indicate that there are empty spaces behind the brocade threads in the edges. This means that they were probably woven using the same weaving method as the wrist cuffs.

The warp consists of 19 tablets. The edges consist of two outer and one inner tablet threaded with silk and two tablets in the middle, probably made of a disintegrated vegetable fibre which was fully covered by the brocade threads. The silk warp threads, and the silver and gold brocade threads are well preserved, apart from the missing silver strips (fig. 7.14). This tablet-woven band has its own brocade variation consisting of areas of gold thread (6-9 rows) and areas of silver thread (26-29 rows) which create a striped pattern that does not follow the pattern of the brocading. In this band, there are no extra soumak wefts, and the gold and silver brocade threads are not used at the same time. Therefore, this band was easier and less time-consuming to produce than the other brocaded bands from Bjerringhøj and Hvilehøj.

	Tablets /wefts	Material	Yarn diam. & twist direction	Colour/dye	Weaving	Image
Original Bjerringhøj C137 1.0 x 15 cm 1.0 x 14.8 cm Used on: pendants	19 tablets in all 19 tablets/cm Edge: 2x5 tablets Pattern: 9 tablets Wefts: 30/cm	Silk Silk with gold or silver lahn	Warp: 0.3-0.4 mm, S-2unspun Weft: 0.25 mm, unspun Brocade thread: 0.2 mm Metal lahn width: 0.1-0.2 mm, S wound	Greyish and golden No dye analysis	Quarter turns forward, metal brocade	
Reconstruction 1.0-1.1 x 100 cm	19 tablets Edge: 2x5 tab-lets, 2 tablets for the stave border in each side (4 threads in tablets, Z orientated) Pattern: 9 tab-lets (2 threads in tablets, al-ter-nating S and Z orientated)	Warp: Silk Nm 60/2 from The hand-weavers Studio, London. Linen, Nel 100/2 (stave border) Weft: Silk, Nm 60/2, split to 1-ply. Brocade weft: Klöppelwerkstatt no. 4, gold and silver	Pink silk warp: 0.3 2ply, S-2z Linen warp: 0.3 2ply, S-2z Pink weft: 0.3 mm, lightly Z spun Brocade weft: 0.3 mm Metal lahn width: 0.3 mm	Pink (same as wrist cuffs C138)	Quarter turns forward, metal brocade	

◄ Table 7.3: Technical details of the tablet-woven band from the Bjerringhøj pendants (C137) and their reconstruction.



◄ Fig. 7.14: The original tablet-woven band on the pendants, C137.

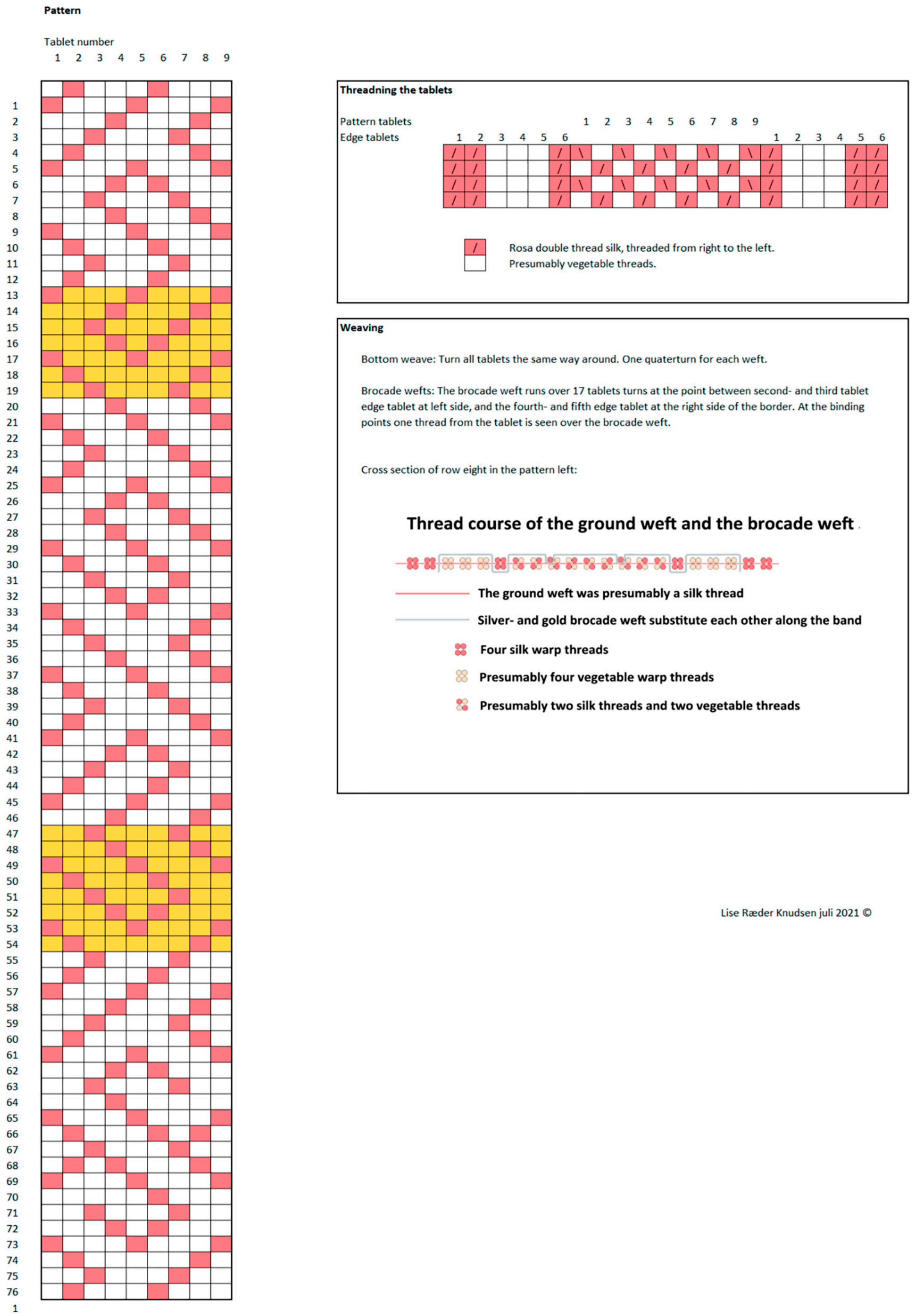
Photo: Roberto Fortuna

Hald had already described the pendants and the tablet-woven bands adorning them in 1950. She noticed that the bands were "…very similar to the border of the wrist cuffs, but not in the same pattern" (Hald 1980, 108), and that the technique for making the tab-let-woven bands was the same (Hald 1980, 231). Østergård also made some technical ana-lyses of the pendants (Østergård 1991, 132-133), and Hansen made reconstructions of the tablet-woven bands and a drawing of the pattern (Hansen 1990, 57,104).

The visual colours were not studied under a microscope, and on the high-resolution photos provided it was not possible to see any significant differences between the colours of the warp threads. Just as in the case of the wrist cuffs, these bands are so well preserved that it is impossible to sample for dye analyses. Therefore, there is no scientific analysis available to determine the original colour. Nevertheless, the warp and brocade threads seem to be very similar to the threads of the tablet-woven bands on the wrist cuffs. The pattern is also formed by single threads from one hole in the tablet that are picked up. The tablet-woven bands of the pendants reflect the same weaving tradition as the tablet-woven bands of the wrist cuffs. Furthermore, dyestuff analysis of the tabby silk of the pendants and of the loose tablet-woven band (C136b) are both lichen purple (Walton 1991). It was therefore decided to choose a lichen purple colour in a pink shade for the reconstruction, as chosen for the wrist cuffs. The pattern of the band is seen in fig. 7.15.

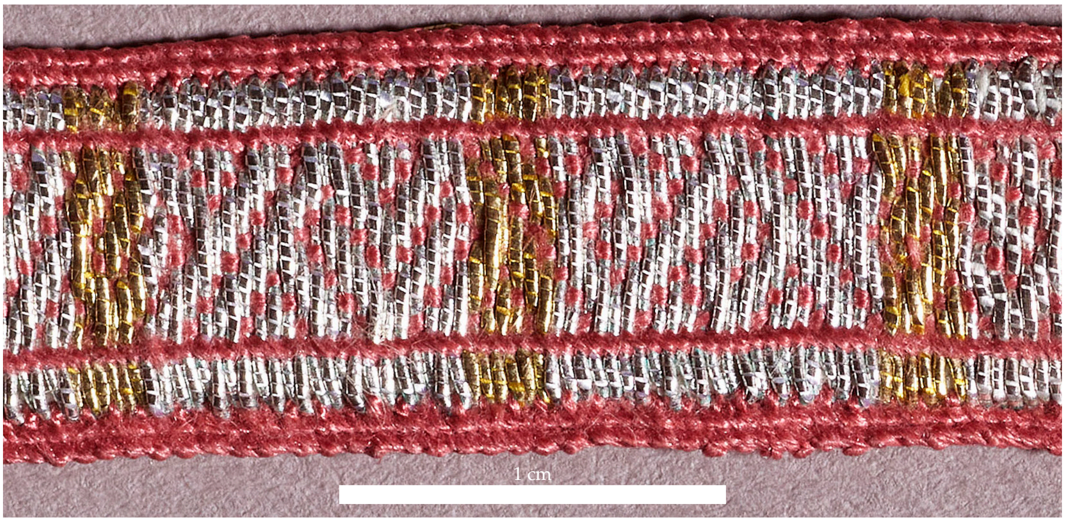
► Fig. 7.15: Weaving instruction and part of the pattern from the tablet-woven band on the pendants (C137).

Pattern and illustration: Lise Ræder Knudsen



The reconstructed band

Wallenberg wove one metre of this band according to Hald's method, using two threads of silk per tablet for the pattern section and four threads per tablet for the edges (Hald 1980, 231-233) (fig. 7.16). The weaving speed was 1-1.5 cm per hour, depending on the time of the day.



◄ Fig. 7.16: Detail of the reconstruction of C137, repeated to a continuous pattern.

Photo: Roberto Fortuna

The brocading thread provided for the reconstruction had a slightly larger diameter than the original, so the pattern became slightly elongated. In the original bands, the sections with gold brocade are over six to nine wefts, and are not found at specific points in the pattern but appear after 26-29 wefts of silver. In making the repeating pattern for the 1-metre-long band, it was decided to compensate for the small elongation of the pattern by keeping to six to seven wefts of gold and only 25-26 wefts of silver, but with small variations to reflect the diversity of the original bands.

The same types of threads were used for reconstructing these bands as for the reconstructions of the wrist cuffs. Likewise, the silk warp was given extra twist using a spinning wheel. The reconstructed band was flattened in the same way as the wrist cuffs with a wooden pestle.

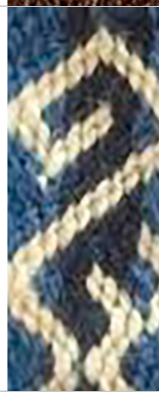
Bjerringhøj C136a

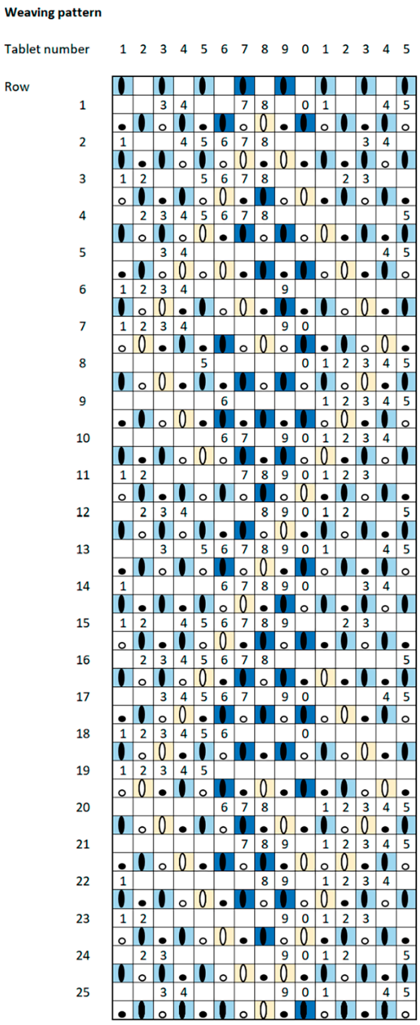
From Bjerringhøj, three fragments are preserved of a tablet-woven wool band measuring respectively 9.8 cm, 20.3 cm and 2.9 cm in length, and with a width of 1.4-1.5 cm. The fragments are most likely part of the same band (table 7.4). The pattern section in this band consists of 15 tablets and there is one edge tablet at each side. The edge tablets were threaded with wool yarn while the tablets in the pattern section are threaded with half wool and half a completely disintegrated material, probably a vegetable fibre. The band is woven in 3/1 double-faced broken twill with individual turns. The individual pieces contain different designs which consist of a meander sign, sometimes duplicated and combined with various cross patterns (fig. 7.17).

▼ Fig. 7.17: The original tablet-woven wool band, C136a.

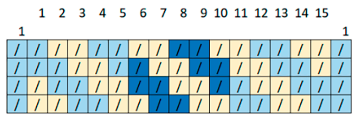
Photo: Roberto Fortuna

► Table 7.4: Technical details of the tablet-woven wool band from Bjerringhøj (C136a) and its reconstruction.

	Tablets /wefts	Material	Yarn diam. & twist direction	Colour/dye	Weaving	Image
Original Bjerringhøj C136a 1.5 x 33 cm 3/1 double-faced broken twill Used on: Unknown	17 tablets 12 tablets/cm Edge: 2x1 (wool) Pattern: 15 (2 wool, 2 veg. fibres in each tablet) Wefts: 10/cm	Wool Missing (vegetable) threads	Warp: 0.7, S2z Weft 0.6, S2z	Dark brown Indigo in central part. No dyes detected at edges	-	
Reconstruction 1.5 x 350 cm 3/1 doublfaced broken twill	17 tablets 12 tablets/cm Edge: 2x1 (wool) Pattern: 15 (2 wool, 2 veg. fibres in each tablet) Wefts: 10/cm	Warp: Wool Nm 20/2, dyed light blue with indigo, by Historical Textiles, Sweden. Dark blue dyed by Tove Lodal, Denmark Linen 16/2 Bockens lingarn Weft: Same as light blue warp	Light blue warp: 0.7 mm, S2z Dark blue warp: 0.7 mm, S2z Linen warp: 0.7 mm, S2z Weft: 0.7 mm, S2z	Dark blue wool in centre, light blue wool at edges. Pattern: White linen	Quarter turns forward and backwards in fixed order (see pattern, fig. 7.18)	



Threadning the tablets



Light indigo double thread, wool theaded from right to left

Dark indigo double thread, wool theaded from right to left

Presumably single flax thread theaded from right to left

Weaving

The woollen band 136a from Mammen was pattern woven and some tablets must be turned forwards, others backwards. The rows of the weaving pattern are devided into two different types: One with colors showing how the treads are placed in the tablets, and one with numbers showing the direction in which the tablets must be turned. In row number 1 some of the numbers of the tablets are mentioned and some are not. Where the numbers are mentioned the tablets must be turned away from the weaver, where the number is missing the tablet must be turned against the weaver.
The edge tablets are not mentioned in the weaving pattern as the are turned the same way all the time.

Means blue threads in the two upper holes of the tablet

Means one blue thread in the upper hole near the weaver

Means light threads in the two upper holes in the tablet

Means one light thread in the upper hole near the weaver

1	2					7	8	9	0	1	2	3		

Means turn tablet number 1 and 2 forward, 3- 4- 5 and 6 backward, 7- 8- 9- 10- 11- 12 and 13 must be turned forward and 14 and 15 backward.

► Fig. 7.18: Weaving instruction and part of the pattern from the tablet-woven band from Bjerringhøj, (C136a).

Pattern and illustration: Lise Ræder Knudsen

Under the microscope, there is a clear difference between the colour of the threads in the five tablets in the middle of the pattern section and the five tablets at each side of the pattern section. This indicates that the threads had different colours. The dye analyses from the 1990s gave no results (Walton 1991, 140), while the new analyses detected an indigoid dye source plus tannin in the central pattern section. The other samples from the pattern part, as well as the single edge tablet, showed no trace of dyestuff (Vanden Berghe et al. 2023). Thus, it was decided to dye the central part of the reconstructed wool band indigo blue and, as the pattern is difficult to see without a colour difference, and assuming that the vegetable fibres were white, it was decided to make the reconstruction indigo blue in the middle and light indigo blue in the edges.

Hald's analysis of the band concluded that it was woven with a complicated technique, where the pattern was achieved by individual turning of each tablet and she interpreted that this band was made using only two threads in four-hole tablets in the pattern section (Hald 1980, 229). Hansen instead interpreted the weaving method of the wool band with four threads per tablet, but that two of these threads were made of a vegetable fibre which had deteriorated due to the particular preservation conditions in the burial mound (Hansen 1988, 264; 1990, 49). Hansen made his weaving pattern in 3/1 double-faced broken twill, based on black and white photos of the original band (Hansen 1990, 67).

In the late 1980s, Ræder Knudsen studied the wool band under the microscope and found tiny fragments of the missing threads, presumably made of vegetable fibres, thus proving Hansen's theory to be right. A weaving pattern was constructed during this analysis (Ræder Knudsen 1991, 149-150), which was also used for the current reconstruction (fig. 7.18).

The reconstructed band

Wallenberg wove 3.5 m of the wool band following the pattern from 1991 constructed by Ræder Knudsen (Ræder Knudsen 1991, 149-150) (fig. 7.19). Weaving this wool and linen band in 3/1 double-faced broken twill was done with a speed of around 7 cm per hour. The reconstructed pattern is close to the original and so are the size and weaving method, although minor differences exist.

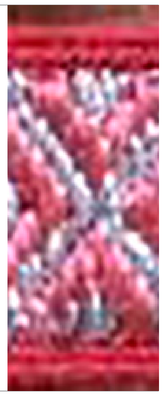
◄ Fig. 7.19: Reconstruction of the wool band from Bjerringhøj (C136a) woven by Marie Wallenberg.

Photo: Roberto Fortuna

Bjerringhøj C145

Four fragments with lengths of 5.0 cm, 6.0 cm, 6.5 cm and 7.5 cm are preserved together with a human tibia bone. The width of the band is 7.5 – 8.0 mm (table 7.5). This band has never been analysed before, as it was stored for more than 50 years with the textile finds from Slotsbjergby (Rimstad et al. 2021). The band is made of 19 tablets. The edges of the band are fully preserved and consist of two tablets threaded with four silk threads (fig. 7.20). Originally, the middle part with the pattern was presumably constructed of 15 tablets of four threads each. All warp threads in the pattern section have deteriorated and are missing today, possibly because they were of a vegetable material. Where the band is broken, it is possible to see the hollow interior and that the missing warp threads must have been quite thick. The edges of the band are woven in ordinary straightforward tablet-weaving and seem red under the microscope. The brocade pattern is made of silver threads and now almost black silk threads. As the brocade pattern is reversed, the pattern of the black silk threads is on the front when the silver threads are on the underside and vice versa. The pattern of the band is seen in fig. 7.21.

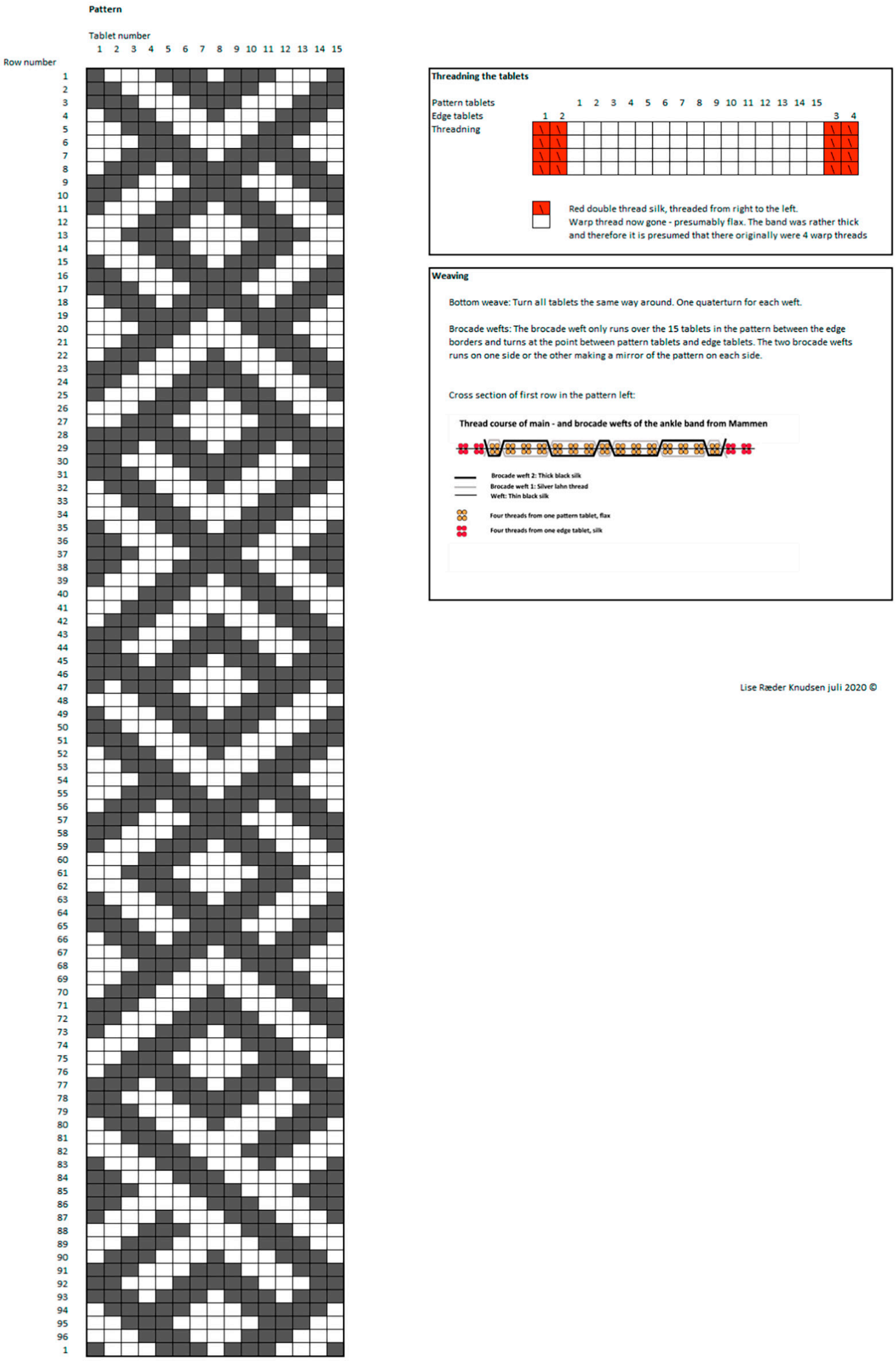
► Table 7.5: Technical details of the tablet-woven band from Bjerringhøj (C145) and its reconstruction.

Original	Tablets /wefts	Material	Yarn diam. & twist direction	Colour/dye	Weaving	Image
0.8 x 17 cm 0.8 x 8 cm 0.8 x 5 cm 0.8 x 2 cm Used on: Ankle cuffs	19 tablets 15 tablets/cm Edge: 2x2 tablets Pattern: 15 tablets Wefts: 28/cm	Silk Silk with silver lamella Missing (vegetal) threads	Warp edge: 0.2-0.3 mm, 2 ply Silk weft: 0.3-0.4 unspun Brocade weft: 0.3 mm Metal lamella width: 0.3 mm	Dark brown No dyes detected	-	
Reconstruction						
80 x 0.8 cm	19 tablets 15 tablets/cm Edge: 2x2 tablets (4 threads in each tablet, Z orientated) Pattern: 15 tablets (2 threads in each tablet, alternating Z and S orientated) Wefts: 28/cm	Warp: Silk Nm 60/2 (edges) Linen Nel 110/2 (pattern) Weft: Silk Nm 210/2, Pipers silks Brocade weft: silver thread no. 4 from Klöppelwerkstadt and floss silk from Pipers silks	Red edges: 0.3 mm, 2 ply S-2z White linen warp: 0.3 mm 2 ply S-2z Pink silk weft: 0.4 mm, 3 ply S-3unspun Brocade weft: 0.3 mm Metal lamella width: 0.3 mm	Red and rose silk Silver	All tablets one quarter turn forward	

► Fig. 7.20: The original tablet-woven band, C145.

Photo: Roberto Fortuna

Dye analysis of the reddish silk edge threads and the blackish silk threads in the pattern section showed no detection of dyes. In order to match the colour scheme of the wrist cuffs and pendants, a red silk for the edges and a rose-pink colour for the brocading silk was chosen.

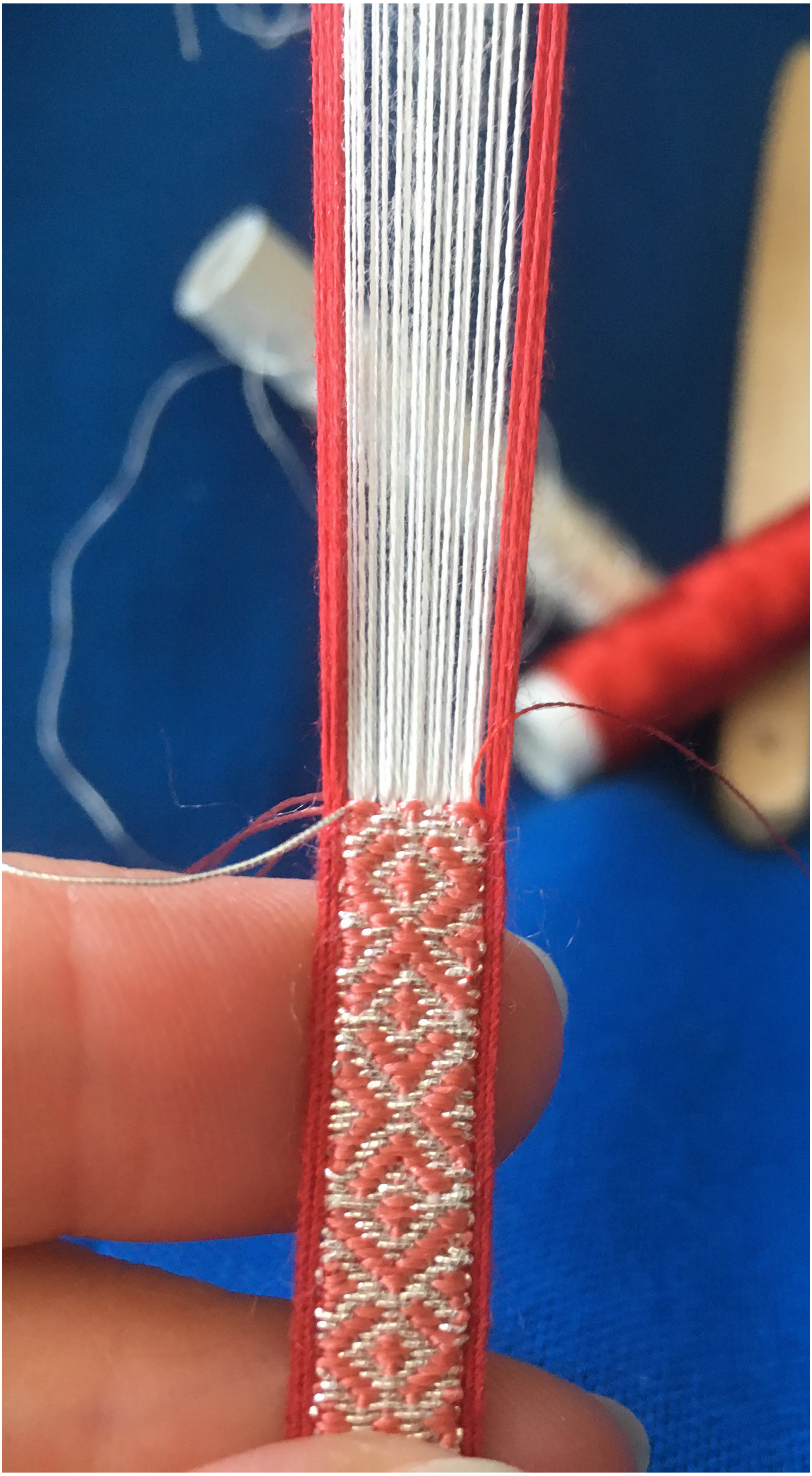


◄ Fig. 7.21: Weaving instruction and part of the pattern from the tablet-woven band from Bjerringhøj (C145).

Pattern and illustration: Lise Ræder Knudsen

► Fig. 7.22: Weaving in progress.

Photo: Marie Wallenberg

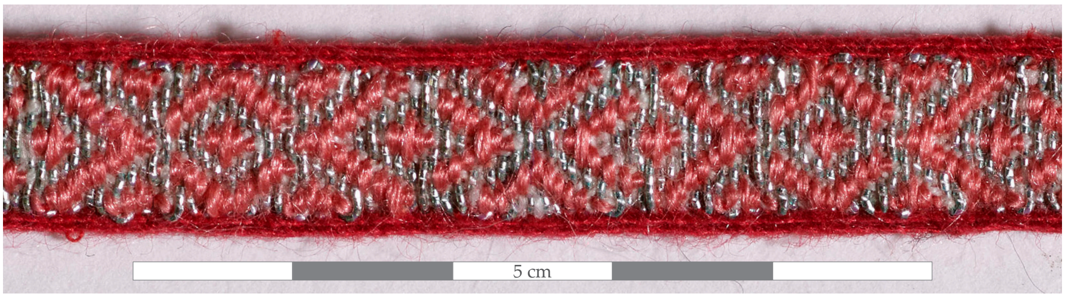


The reconstructed band

Wallenberg produced 0.8 m of this silver-brocaded tablet-woven band. It was a very time-consuming process to pick up the threads for the two brocade wefts, so it was only possible to weave a few millimetres an hour (fig. 7.22). Therefore, Wallenberg decided to make three sets of heddles for the three most common thread combinations. In this way 75 of the 96 pattern rows could be picked up at a much quicker pace and made it possible to increase the weaving speed from less than 5 mm an hour to nearly 1 cm an hour.

Since the original warp threads for the pattern tablets have completely disappeared, the diameter of the warp threads is unknown. For the reconstruction, several linen threads of different thicknesses were tested. In the end, a 110/2 linen thread was used. With four threads per tablet in the pattern section, the weft density still did not reach the desired 26-28 wefts per cm. The threading was therefore changed to two threads per tablet for the pattern section, increasing the number of wefts to closer to the original (fig. 7.23).

The weaving method of this band is unique in a Danish context, and a tablet-weaving brocade method, where the pattern of the front and back are reversed has never been recorded before.



◄ Fig. 7.23: Reconstruction of the C145. Woven by Marie Wallenberg.

Photo: Roberto Fortuna

Conclusion

While reconstructing the tablet-woven bands, many new insights were gained. The scientific analyses of the preserved dye stuff gave a better understanding of the original colours. The X-ray pictures made it possible to see structures of the weaving which had hitherto been hidden inside layers of metal corrosion and dirt, and the meticulous analyses of thread courses of the finds under the microscope have provided a basic knowledge of the original outlook of the tablet-woven bands. The possibility of making test weavings and reconstructions during this project has yielded yet another dimension to the knowledge of these rare finds. As such we have now also gained new insights into the working methods and production of tablet-woven bands from the Viking Age.

The following tablet-woven bands were produced for the project:

3 m of silver and gold brocaded band from Hvilehøj (C4280b, C4280c) woven by Katerina Krizova. The weaving speed was c. 1.3 cm per hour for the silver sections and 0.6 cm per hour in the parts where the gold thread was also used. The weaving speed was around 1 cm per hour for the entire band.

1.3 m silver and gold brocaded band from Bjerringhøj (C138) woven by Marie Wallenberg. The weaving speed of the band was 0.5 cm per hour.

1 m silver and gold brocaded band from Bjerringhøj (C137) woven by Marie Wallenberg. The weaving speed of the band was 1-1.5 cm per hour, depending on the time of the day.

3.5 m patterned wool band from Bjerringhøj (C136a) woven by Marie Wallenberg. The weaving speed of the band was 7 cm per hour.

0.8 m silver brocaded band from Bjerringhøj (C145) woven by Marie Wallenberg. The weaving speed of the band was little less than 1 cm per hour.

The fastest band to produce was the one made of wool (C136a), although in this band the tablets had to be individually turned in order to produce the pattern. The wool threads are thicker than silk and metal threads, and the band only has one weft thread, thus making it easier to get a good working pace while weaving. In contrast to this, the tablets are turned the same way in the brocaded bands, and even though they are considerably narrower than the wool band, they are more time-consuming because of the many different wefts that have to be controlled to create the pattern. The narrow band from Bjerringhøj (C145) is, in theory, the most time-consuming to produce, as all the warp threads had to be individually picked up. It is uncertain if the Viking Age weavers used heddles for the tablet-warp as in the current reconstruction work.

In general, the use of a soumak thread, as seen in the case of the Hvilehøj band (C4280b, C4280c) and the Bjerringhøj wrist-cuff bands (C138), adds extra time to the production. The soumak thread is not difficult to add per se but gives the already complicated weaving yet another dimension.

This is also emphasised in the use of materials for the bands. The analyses of the original bands revealed that all of these have missing warp threads, presumably made of flax or another vegetable material which was not preserved. Vegetable fibres often comprised a substantial part of the warp threads as seen in the Hvilehøj band (C4280b, C4280c) and the band from Bjerringhøj (C145) or half of the warp threads in combination with silk threads. Even in the wool band (C136a) vegetable threads must have been used in the pattern part instead of, for instance, white wool threads. This indicates that the vegetable fibres played a vital part in is production. Nevertheless, the different flexibility of the different materials, wool and vegetable fibre, would have made it necessary to adjust the tension of the warp while weaving, causing extra working hours. Further, vegetable fibres would have been more readily available to use than the rare and exclusive silk. Saving a few metres of silk thread was obviously considered important, even if it demanded using many extra working hours.

Getting hold of the right materials for the reconstructed bands caused some problems in the start-up process. Making a reconstruction as close as possible to the original band depends on many different issues. The thickness of the warp threads, their twist angle, and the fibre length as well as the thickness and fibre type of the gold and silver thread, their metal composition, to mention just some issues. Even small variations in the threads may have great influence on the final product. One of the problems was getting hold of silk and metal threads with the right thickness and material composition. It was difficult to find the right brocade threads. As described above, the threads initially bought for the project, had a too wide metal lamella of 1 mm, wound less than ten turns per cm around the silk core compared to the original threads which had around 40-50 turns per cm. The visual impression was therefore different, and the threads were extremely difficult to turn around at the outer edges. Therefore, it was decided instead to use a cotton thread with metal lamella wound c. 30 turns per cm around the core. For the Bjerringhøj bands, metal thread with a diameter of 0.2 mm was impossible to get hold of, so they were woven with metal thread of 0.3 mm instead. For the Hvilehøj band, we succeeded in finding the right thread of 0.2 mm. It might not be visible with the naked eye, but looking closer into the bands, the thread thickness actually makes a difference and the patterns easily become slightly more elongated because of the thicker thread diameter.

Another new insight was gained particularly for the bands of the wrist cuffs (C138). Only by studying the tablet-woven band meticulously while weaving, did Wallenberg discover that the patterns were not identical and that weaving mistakes were present. Moreover, the bands have silver brocade along the edges, so the silver and gold threads did not replace each other in the stave border as previously believed. Further, the reconstruction work has shown that the metal-brocaded bands were surely flattened on the surface after weaving. Adding this to the finishing process of the bands, made them look much more like the originals, giving the appearance of one large surface of gold and silver.

The similar production method of the bands reconstructed here has led to the question of where these tablet-woven bands were, in fact, produced. Some scholars have assumed that these fine bands made of foreign materials were imported (Geijer 1994, 86). Others have argued that they could be homemade using imported materials (Grace 1956, 451-452; Hansen 1990, 62-63), while Hald argued that more information was needed before the origin of the bands could be established (Hald 1980, 233-237). The current research on the technical differences of tablet-woven brocaded bands of the 10th century in Northern Europe has led to new conclusions. The original appearances of the bands seem to be similar in their design, but there are many technical differences in the tablet-weaving methods. Therefore, it seems unlikely, that they were woven in central workshops. It is our current conclusion that many of these bands were probably woven in the northern area using imported materials (Ræder Knudsen 2005, 40-41), and that they derive from the same band-weaving tradition. The narrow band found at the feet of the Bjerringhøj man (C145) is the only band woven using a brocade method where the pattern of the front and back are reversed. This detail has not been recorded in a Danish context before, but this does not necessarily imply that it was made in a different area.

After working with these precious tablet-woven bands from the Viking Age, it can be concluded that they are indeed delicate and exquisite pieces of art. Their size alone may impress many Viking Age enthusiasts as they are much narrower and have a more complicated construction than one might think. They are truly a manifestation of the dedicated and experienced craftspeople of the Viking Age.

8. The reconstruction of the fur garments

Theresa Emmerich Kamper & Julia Hopkin

The organic components of the Hvilehøj and Bjerringhøj burials include numerous protein-based materials, notably keratin (hair, including wool and fur), fibroin (silk), and collagen (skin). As well as the textile fragments, both burials include multiple fragments of animal skin and hair, in varying states of preservation. The tannage technologies used for the reconstructions were technologically accurate based on the scientific analyses of the skin and fur objects in the graves (see chapter 3). Based on several morphological and behavioural characteristics, the preserved skin items (Bjerringhøj C142 and Hvilehøj C4281) have been identified as vegetable tanned. However, the dermal component of the fur pieces in both the Bjerringhøj (C143) and Hvilehøj (C4280b, C4280c) burials has nearly completely degraded. They are not in a state of preservation where either macroscopic or low magnification microscopic analysis is possible. However, this lack of preservation is diagnostic in its own right. Compared to the Hvilehøj shoes for instance, this indicates that the various skin and fur pieces were originally treated differently from each other, most likely by using different tannage technologies. It is probable that an oil/fat tannage was used to process the fur items, though alum tawing is also a possibility as it was a known technology during this time period. These technologies do not have the same resistance to bacterial attack as seen in vegetable tannage when interred in wet preservation environments.

The species used were likewise based on the results of the scientific analyses. While some species identifications were later challenged by analysis that was completed later in the project (see chapters 5 and 6), the species used for the reconstruction are still similar to those identified in the most recent analysis, and give a good sense of the possible appearance of these materials within the limitations of modern fur availability. For this project 42 pine marten (*Martes americanus*), 24 North American beaver (*Castor canadensis*), two calf skins (*Bos taurus*) and one hair-on domestic short haired goat skin (*Capra aegagrus hircus*) were tanned for the construction of the fur garments and shoes.
While the tannage technologies and species were well evidenced, the design of the fur and skin garments required another level of creative interpretation due to the highly fragmentary nature of the materials.

Materials

The furs were purchased in a dried, raw state with very minimal processing by the fur handlers, aside from basic de-fleshing and drying. They were sourced from healthy animal populations in Canada and were harvested in a sustainable and humane way in accordance with the Canadian regulations for trapping and hunting fur bearers. The calf and goat skins were acquired from a local hide handling house in the UK which collects this commodity from the surrounding abattoirs.

No thread was identified which could be directly linked to the furs in the two graves. Keratin (hair) and fibroin (silk) both survived in the burials, but as no sewing threads survive it is unlikely to have been made from either of these two materials, leaving two other options: sinew (tendon) or linen (*Flax spp.*). Both materials would have degraded in the same way as the dermal portion of the furs did. On this basis it was decided to use single-twisted linen thread based on its availability in the time period and its properties. With the very soft nature of the furs, it allowed for a better drape than would be achieved using sinew.

◄◄ Fig. 8.1: De-fleshing Pine marten on a beam.

Photo: Theresa Emmerich Kamper

◄ Fig. 8.2: De-fleshing and thinning beaver.

Photo: Theresa Emmerich Kamper

Method

Two tannage technologies were therefore used in the reconstruction of the garments. The furs to be used in the male and female outfits were processed using a fat/oil tanning method. The shoes from Hvilehøj (C4281), the boots and the strap (C142) from Bjerringhøj were tanned using a vegetable tanning method. Very little evidence exists for Viking Age tanning equipment. Therefore, the tools and techniques used here are ones that could have been used, but are not all necessarily based on direct evidence from this period.

The initial stage of skin processing, cleaning the flesh and membrane from the skin, is the same for all tannage types. After this step, the pre-processes then differ between skins intended to be hair-on and those from which the hair/fur will be removed. The pre-process stages can also vary within tannage technologies, such as, whether one chooses to remove the grain layer or not for fat tannages.

De-fleshing is the removal of all the subcutaneous tissue that remains adhered to the main dermal portion of the skin after taking the skin off the body. The same method was used to de-flesh the calf, goat and pine marten skins. This was accomplished by laying the skins over a wooden tanner's beam and then scraping over the flesh side using a metal scraping tool (fig. 8.1). This method was chosen due to evidence of beaming tools which were found archaeologically at Coppergate in York dating to the late 11th - 12th century (Mould et al. 2003, 3236). Though somewhat later in time and not geographically adjacent to the Hvilehøj and Bjerringhøj burials, there are few, if any, other tanning tools found in Viking contexts, making the finds from York the closest available evidence. In addition, the small size of some of the species made wet scraping over a beam more logical, as well as more time efficient, than methods such as lacing the skins into frames. Framing skins constitutes the other most common method for de-fleshing skins.

A different technique was used for the beaver skins. Traditionally, beaver skins are laced into a frame and allowed to dry, after which they can be de-fleshed using a sharp tool. Depending on the intended future use for the skin, this scraping process can be continued until as much of the dermal thickness as necessary has been removed. The beaver skins for this project arrived in a dried state, and the time available it was not feasible to rehydrate and lace 24 skins into frames. Instead, the skins were tacked out using finish nails on plywood sheets and were carefully de-fleshed and thinned using an angle grinder with a sanding wheel attachment. Thinning allows the beaver dermis to become much softer and therefore, have a more comfortable drape (fig. 8.2).

De-hairing

After washing the freshly de-fleshed skins with soft soap in warm, clean tap water, the goat skin and pine marten furs which were to be tanned with the fur on, were placed in a freezer to await the next stage of their respective tanning processes.

The calf skins were placed into an alkaline solution of potassium hydroxide (KOH) to slip or loosen the hair. Potassium hydroxide is the alkaline component in wood ash, a material well documented ethnographically as a de-hairing and degreasing agent. This is the most likely source of alkaline solutions used for similar purposes prior to the production and use of slaked lime (Cameron 1998; Richards 1997). In this case the chemical in its pure form was employed as opposed to wood ash due to time constraints. The pH of this solution registered 12-13 for the entire 14 days the calf skin spent in it.

The skins were left in the solution until the hair could be pulled out with little effort. When the hair loosened sufficiently, each skin was placed back over the tanning beam and the hair carefully pushed off using a slate tool with a rounded edge. Great care must be taken not to damage the grain surface during this stage. In addition to removing the hair, the alkaline solution is the most efficient and thorough way of removing the ground substance from between the dermal fibres, though this can also be broken down and removed mechanically by multiple cycles of soaking and scraping, or by sweating (a process of controlled bacterial decay) and then scraping the skin. The ground substance is made up of soluble interfibrillary proteins and mucous, most of which must be removed in all skin processing technologies, with the exception of rawhide. In living skin, this chemically complex substance determines the amount of water held within the dermal network. It appears to do this by controlling the passage of aqueous fluids containing charged ions through the skin (Reed 1972, 31). The removal of a portion of the ground substance creates space within the dermal network, which allows aqueous solutions such as tanning solutions to penetrate more effectively (Reed 1972; Cameron 1998; Covington 2011). Secondarily, the alkaline solution helps to degrease the hide by creating a saponification reaction which degrades any triglyceride grease present within the fibre structure (Covington 2011, 139).

After de-hairing, the calf skins were neutralised as the pH level must be returned to neutral to facilitate the uptake of tanning agents during the following steps. Neutralising can be achieved, albeit slowly, by soaking the alkaline skins in successive tubs of fresh water until the rubbery, swollen feeling of the skin is lost. It can also be achieved by placing a skin in a pond or running stream and allowing the alkalinity to leach out. No river or pond was available for this project and as a time saving measure, a mild neutralizing solution was used to lower the pH level of the samples. This solution consisted of 240 ml of vinegar to 8 litres of water with an approximate pH of 4. The skins were allowed to soak in this solution until they were no longer swollen, and the rubbery feeling disappeared. When neutral, the skin will feel slippery, not rubbery, and will hold a stretch when pulled in one direction. The skins were then left to soak overnight in clean, plain, tap water to ensure they were not overly acidic before continuing with the vegetable tanning process.

Fat and smoke tanning of the beaver and marten fur

Fat and smoke tanning technologies are very ancient with preserved skin fragments as old as 8,000 BC having been identified as using this tannage technology (Emmerich Kamper 2020). The overwhelming use of this type of combination tanning over a wide geographic area, including all of North America, many parts of Scandinavia and Siberia has been documented ethnographically (Mason 1891; Oakes & Riewe 1995; Issenman 2011; Klokkernes 2007; Binford 1967; Beyries 2002; 2008). Fat tanning and smoking are so interconnected that they are often talked about as a single technology. They are, however, two separate technologies with differing properties and chemical components.

During fat tannage, lipids are introduced to spaces in the dermal network left after removing most of the ground substance. These lipids, depending on the saturation level of the lipid added and the warmth produced during the softening process, oxidise to various degrees. This oxidation produces aldehydic compounds which create a polymer matrix, mirroring that of the collagen matrix, thereby supporting the collagen fibre structure, and preventing its collapse and the re-sticking of the fibres which would accompany this collapse (Covington 2011, 317). Only lipids with medium to high levels of unsaturation are capable of oxidising at temperatures below the general shrinkage temperatures of the raw collagen from which the skin is composed. In the commercial production of chamois, cod oil is used, and the heat is blown in – in the form of hot humid air - to create a temperature of 40-50 °C which initiates auto-oxidation (Covington 2011, 316).

In the case of traditional fat tannages, the use of warm dressing solutions and the friction created during the aggressive softening process produce a similar, though not as consistent effect. Both egg yolks and brain tissue contain a large percentage of unsaturated fats (Bitman 1976). In addition to having an advantageous composition of fatty acids, both egg yolks and brain tissue are high in phospholipids, which act as a powerful emulsifier for other fatty acids contained in the brains or yolks, as well as fat from any other source added to the mixture (Haines 1991a, 24). This emulsification action helps to suspend the fat particles in an aqueous solution, which acts as the delivery system for transporting the lipids through the full dermal thickness. For the pine marten and beaver skins, soy lecithin, a modern substitute for brain or egg yolks, was used. Lecithin is one of the major phospholipids present in brain tissue, and this, plus a small amount of vegetable oil mixed with warm water to create an emulsion, was used as a dressing solution (fat tanning solution) for the furs. Camelina sativa oil was chosen for this solution as it is known to have been cultivated in Northern Europe and can be used as an oil producing seed (Larsson 2013).

Smoke, as a stand-alone tannage type, relies on the aldehydic compound, acrolein, which is a by-product of burning wood (Covington 2011, 333). This compound reacts with the charged primary amino groups of the collagen alongside phenols, a second compound found in wood smoke which appears to react with other sites via hydrogen bonding (Haines 1991a, 25). These reactions remove some of the hydrophilic properties of the collagen, helping to prevent the re-sticking of the dermal fibres on drying. When used in combination with fat tannage, the heat from warm smoke further oxidizes the lipids creating more aldehydic compounds and oil polymers, further cementing the tanning action (Haines 1991b; Reed 1972).

After de-fleshing the pine marten and beaver pelts, the next step involved the addition of a dressing solution of lecithin and oil in the form of an aqueous solution (fig. 8.3). The solution was heated to a temperature which was uncomfortably warm to hold your hands in for longer than approximately 15 seconds.

◄ Fig. 8.3.: Beaver pelts being placed in the dressing solution.

Photo: Theresa Emmerich Kamper

While the solution was heating, the pelts were rolled into dry towels and trodden on to remove excess moisture from the fur and fibres. When the solution was the correct temperature, the furs were placed in it and stirred, rubbed and worked around to encourage the absorption of the lipids by the dermal fibres. Each fur was wrung out by hand then hung to partially dry.

The pine martens have very thin skins and so only required one round in the dressing solution to achieve adequate penetration of the solution. The beaver pelts were thicker and are more challenging skins to tan. For the beaver, each fur was stretched by hand until the separation of the fibres changed the colour of the dermis from blue/grey or cream to white then placed back in the solution (fig. 8.4, fig. 8.5). This process was repeated three times for each sample before final softening was begun. After the last round in the dressing solution, a very thin layer of Camelina oil was wiped onto the flesh side of the furs with a cloth rag. The skins were then folded in half, flesh side to flesh side, and allowed to sit overnight in a cool place. The following morning, the furs began the final softening process.

One additional experiment in procedure was attempted on a small first batch of beaver skins. After de-fleshing and thinning, this batch was pre-smoked while damp. This involved hanging the skins in a smokehouse for four hours before they were placed into the dressing solution. This is a technique used occasionally for difficult skins such as moose

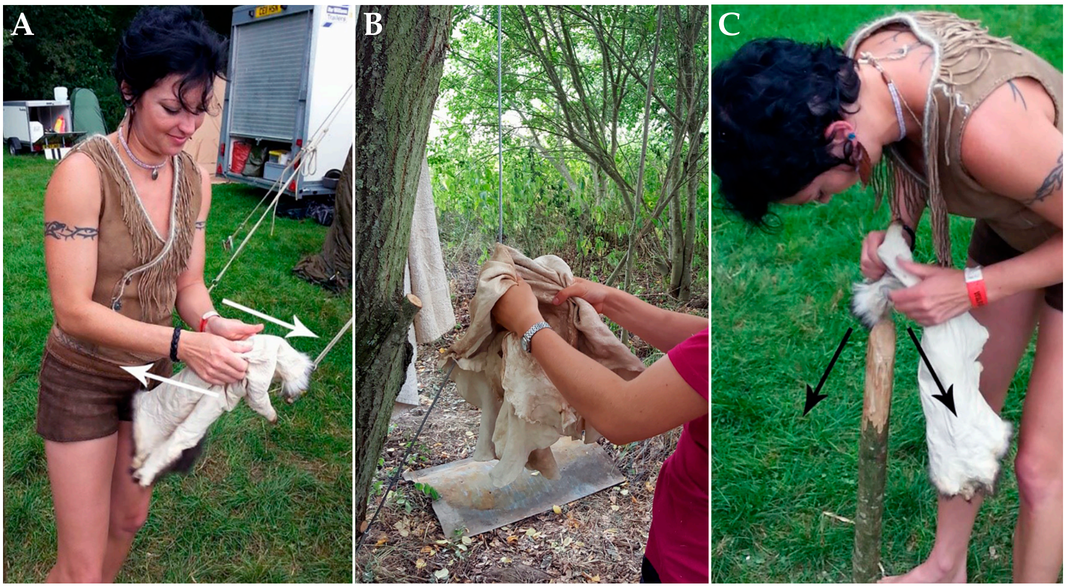
► Fig. 8.4: Marten pelts beginning to change from blue/grey or cream to white.

Photo: Theresa Emmerich Kamper

► Fig. 8.5: Beaver pelts hanging to dry.

Photo: Theresa Emmerich Kamper

(*Alces alces*). The addition of smoke at any point in the process can reduce the work involved in the softening stage. While this did make this batch somewhat easier to soften, for this situation, the reduction in labour during the softening step was not offset by the amount of time needed to set up and pre-smoke the skins.
The final softening of the pine marten was done in batches of 10-15 furs at a time, while the beaver were done in batches of five. The others were frozen until ready for softening. Softening was achieved by constant manipulation of the fibre structure in all directions until the dermis lost all moisture. This was accomplished by pulling the samples in all directions and rubbing them using a back-and-forth motion between the hands, as well as pulling them through a cable and over a staking post (fig. 8.6).



◄ Fig. 8.6: Methods for softening skin.
A: Hand softening.
B: Softening using a cable.
C: Using a staking post.

Photo: Theresa Emmerich Kamper

Fat tanned furs, though now very soft, are more versatile after they are smoked. White (unsmoked) fat tan will return to a stiffer state if the skin is wetted and allowed to dry without being worked soft again. However, a secondary softening is never as laborious a process as it is initially, as the fat tanning process is non-reversible. If exposed to wood smoke, however, the fat tan changes dramatically and will stand up to wetting and even washing without becoming stiff, as long as no harsh detergents are used. Smoking can be done in a number of ways, including using a smokehouse, hanging it in the rafters of a shelter or sewing it into a bag which is placed over a stove pipe or hole in the ground to funnel the smoke into the skin bag (fig. 8.7).

For this project due to the small size of the skins, the garments were sewn first and then smoked as finished items. The caftan was turned inside out and then the neck, front opening and wrists of the caftan were clipped closed to prevent the smoke from depositing tar on the fur. The cape was laid flat then a sheet was carefully pinned over the fur side. Both garments were then hung in the rafters of a reconstructed Stone Age house with an open fire for four days. Each day the garments were adjusted slightly to be smoked as evenly as possible. This method allows the skins to be smoked with very little worry about the temperature being too high as the garments were hung far above the fire. If the temperature gets too high, it will irreversibly damage fat tanned skins.

Vegetable tannage of the goat and calf skins
Tannins comprise a large group of plant polyphenols and are secondary metabolites of higher plants, which can react with collagen (Khanbabaee & van Ree 2001). The reaction of these polyphenols with protein is the cause of the dry mouth sensation experienced when biting into a green apple and is referred to as 'astringency' (Covington 2011, 281). This reaction with protein is the basic reaction behind tanning using polyphenols or tannins. Tannins can be divided into two groups, the condensed (catechol) and hydrolysable (pyrogallol) tannins (Reed 1972).

► Fig. 8.7: Smoking a fox over a bucket of hot coals.

Photo: Theresa Emmerich Kamper

Following the pre-processes, the hair-on goat and hair-off calf skins were tanned using tannin rich tree bark. At this stage both hair-on and hair-off skins were suspended in a tannin solution made by extracting tannins from oak bark (*Quercus sp.*). The oak bark was crushed and thoroughly dried. Each batch of bark was boiled in fresh water three times. These multiple boiling cycles produced solutions with decreasing concentrations of tannins. These different solution strengths allow for the introduction of tannins into the skin in a controlled manner. The skins are added initially to a weak tannin solution, and the concentration of the solution is gradually increased. This avoids case hardening the skin. Case hardening occurs when the outer layers of the skin become densely packed with tannins before the centre of the skin is fully tanned (Reed 1966, 239; Covington 2011, 295). It was too early in the year for bark gathering when these skins were being tanned and only a limited supply of bark from the previous season was available. To make up the deficit some powdered commercial wattle bark (trade name Mimosa-Acacia mollissima) and powdered commercial sumac leaves (*Rhus coriaria*) were used to ensure a strong enough full-strength solution.

The order of operations for the goat and calf skins was as follows. The water from the third boiling was poured into a large plastic container, and then an equal amount of fresh water added to it before submerging the skins. This solution was increased in strength every 24 hours, first adding the remaining weak strength third boil solution, then the medium strength second, then full strength first over the course of four days. The solution and skins were stirred every hour during the day for the first two days, then stirred well each time a new solution was added. After the solution was brought up to full strength, it was stirred morning and evening. Tannin absorption was monitored twice a week, starting one week after the skins went into the full-strength solution. This was done by cutting a thin slice from a corner of the thickest part of each skin. When the colouration had permeated the entire thickness, and no light-coloured stripe remained, the skins were removed from the solution, rinsed in clean water to remove any bark sediment, and preserved frozen until the weather allowed for them to be dressed and softened.

After being thawed out the skins were rolled up in dry towels and trodden on to remove excess moisture until they were merely damp. A solution of Camelina oil and a very small amount of bar soap (lye and lard soap) was used to lubricate the fibres of the skin, which adds strength and elasticity to the dermal structure. This process is often referred to as stuffing or fat liquoring in commercial tanning literature and any number of oil and fat combinations have been used in this process (Reed 1966; 1972; Covington 2011). The skins were placed into this solution at a temperature which was just a bit too hot to comfortably hold your hands in. The skins were worked and stirred in this solution until it cooled down (about 20 mins). As vegetable tannage can withstand higher temperatures than fat tannage without damage to the collagen fibres, hotter solutions can be used to help facilitate good oil impregnation through the full dermal thickness. Then the skins were taken out and hung to partially dry. When the skins were at the dryness stage where they change colour when the fibres are stretched, they were then pulled over a staking post until the entire skin had been worked (fig. 8.8). They were then put back into the reheated solution. Each skin went through this process twice. Unlike fat tanning, where the dressing solution is producing the actual chemistry via oxidation of the lipids, in vegetable tanning the dressing solution is simply lubricating the fibres of the dermis. Because of this important difference a much wider range of oils and fats can be used for dressing vegetable tanned leather depending on what kind of handle, look and feel is desired for the final product.

After the second round, the skins were allowed to drip dry to the point where they were still damp but not wet. Camelina oil was poured onto a rag and rubbed into only the flesh side of the hair-on goat skin and both the flesh and grain sides of the hair-off calf skins. The skins were then softened by working them between the hands, over a staking post and by pulling them through a cable. The cable had to be used gently and only on the flesh side as the rubbing would mar the grain, and any overenthusiastic pulling could cause tears or cracks to appear in it. The grain layer is less elastic than the fibre network (mid-dermal) layer and will fail during stretching if care is not taken to judge the force necessary to manipulate the fibres without damaging the grain. When the skins were at a three-quarters dry stage, another coat of oil was applied to the flesh side of the goat skin, and only to the grain

► Fig. 8.8: Using a staking post to soften vegetable tanned calf skin.

Photo: Theresa Emmerich Kamper

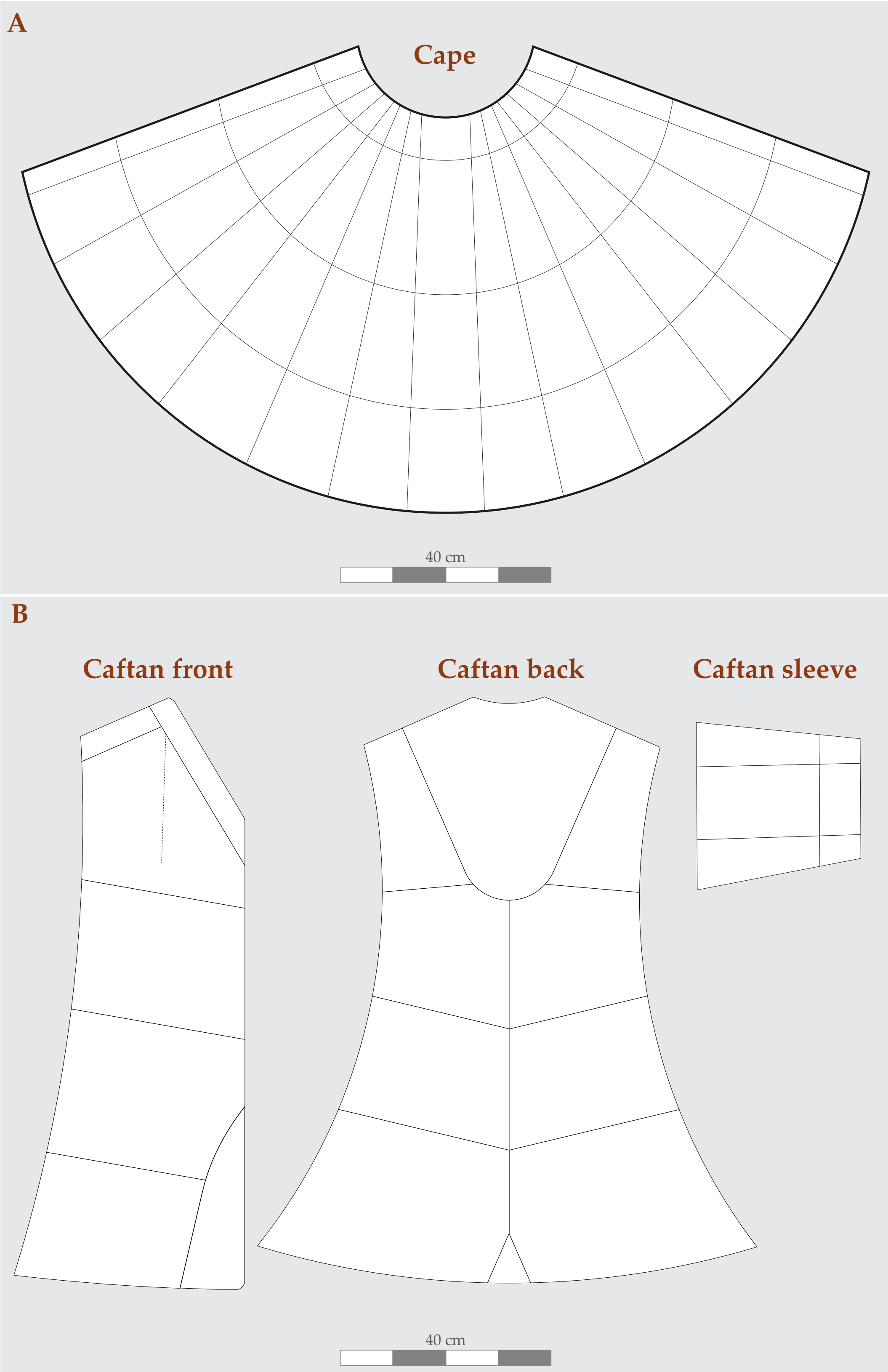
side of the hair-off (depilated) calf skins. If applied to the flesh side of the hair-off skins at this stage, the oil can leave dark blotches on both surfaces, which, while not detrimental to the softening process, are unattractive. Because the skins were tanned early in the year, the skins were put in the tumble dryer on the low heat setting for 15 minutes at a time to speed the drying process. Working the fibre structure of the skins was continued until they were fully dry and soft. The finished goat and calf skin were sent to Espen Kutchera to be made into shoes (see chapter 9).

Patterning cutting and sewing

The patterns were constructed by Ida Demant and Lone Brøns-Pedersen, but eventually adjusted slightly in order to make them more suitable for fur garments (fig. 8.9). Fur is much bulkier than fabric and as such does not lend itself to being scrunched up under a belt, so the caftan was repatterned to be more form-fitting in line with this behavioural trait. A less significant revision of the cape removed some of the fullness as the natural pattern of the fur itself is lost if there are too many folds in the finished product.

Each fur needed to be custom cut to fit into the pattern and this was done using a razor knife. When cutting fur, a pair of scissors is not appropriate as it can cut the fur as well as the skin, making obvious short areas along the seams, whereas a knife cuts only through the skin/dermal portion of the skin. A small Viking Age style knife was also used for cutting just to get a feel for how this compared to the modern razor tools (fig. 8.10). It required a bit more pressure to use, as the blade is thicker, and needed to be resharpened with regularity to maintain an efficient cutting edge. However, overall using a knife would not have originally added much additional time to the construction process.

For the furs the skin was held up in mid-air to cut the dermis, as pinning it between a knife and the board runs the risk of cutting through some parts of the fur underneath, giving the same choppy result as using a pair of scissors. The straps for the male fur garment were cut using the same knife, but employing a slightly different method. The leather was laid on a board and the cuts were made by pressing the knife into the leather and drawing it down the line whilst pressing down with force into the underlying board.



◄ Fig. 8.9.A: Pattern of the cape.
B: Pattern of the caftan.

Illustration: Mads Lou Bendtsen

Most of the sewing was done using modern steel needles with a sharp point but without sharp edges (i.e. not leather/cutting needles). Cutting needles with a triangular point and sharp edges which are manufactured for stitching leather are problematic when sewing fat tanned skins. The cut edges of each hole will stretch significantly over time as the dermal fibres are damaged by this type of needle. This is exacerbated if the garment gets wet or is worn when the skin is damp. The cutting needles are designed for vegetable tanned skin and modern tannages such as chromium and aluminium tannages which do not possess the same propensity for stretching as is seen in fat tans. As these garments are designed

► Fig. 8.10: Cutting tools and bronze needle used in the reconstruction process.

Photo: Theresa Emmerich Kamper

as museum pieces which are very unlikely to get wet at any point, cutting needles were used occasionally for the beaver furs in areas which were too thick or stiff to efficiently use standard pointed needles.

A bronze needle, like needles found in archaeological deposits from Birka and Gotland in Sweden was also used to gauge the difference, if any, in the time needed to sew a 10 cm section of seam (Andersson 2003, 77-78; Klessig 2015, 95-96). While iron needles have been found from the 10th century, no iron needles were available for a comparison (Welander et al. 1988). The bronze needle (fig. 8.10) was slower to sew with as its point was simply not as sharp or smooth as the modern steel needles. A 10 cm seam in a soft portion of the beaver furs took approximately seven minutes to sew using a modern steel needle. The same seam with the bronze needle took 12 minutes, nearly double the amount of time. For thicker sections of skin, holes needed to be pierced first using an awl in order to sew with the bronze needle. Due to time constraints, modern needles were a necessary compromise.

The furs were stitched almost exclusively using a whip stitch (overcast stitch) as this is the stitch seen most frequently in both archaeological and ethnographic items from soft furs such as marten, rabbit, Felids and Canids (fig. 8.11). This stitch is ideal for areas which will not be placed under any undue stress. High stress areas such as fastening points are often sewn using flat stitches such as running stitch or saddle stitch. These stitches inhibit the

► Fig. 8.11: Sewing using a whip stitch (overcast stitch).

Photo: Theresa Emmerich Kamper

ability of the fastening to stretch out the seam as it is reinforced by the stitching material, whereas whip stitch will allow a seam to stretch making it less fit for purpose in high-stress areas of a garment.

Each beaver skin needed to form a flat piece before it could be sewn into the garment. This was simply accomplished by cutting the pattern pieces out of the skin in such a way that it avoided the leg openings and the wavy area present near the neck (fig. 8.12). The cutting of the pine marten was a much more involved process that required four darts per skin, one in each axial zone (arm pit) to produce a flat piece of a reasonable size. Once all the darts were finished the pieces of marten were trimmed and fitted together. Instead of attempting to copy the modern style of fur use, where the fur strips look seamless from top to bottom, the different colours of fur from the back to belly and differences in density from the neck to hind quarters, were used to create a consistent pattern from the top of the cape to the bottom, and from the front to back. Additionally, just below the collar in the centre of the back section, two of the throat sections were sewn together forming two distinctive V-shaped patches of colour. Pine martens have an orange patch of fur on their throats which varies by size and shade between individuals. It is an instantly identifiable feature for this species and was included to remind those viewing the garments that these furs once belonged to an animal that many of them are familiar with from their local woodlands (fig. 8.13).

◄ Fig. 8.12: Cutting pieces from beaver skins.

Photo: Theresa Emmerich Kamper

The sections of beaver fur seldom required darts, only careful cutting. The skins for the caftan had the belly fur cut away from the main section of back fur, as the two areas are distinctly different colours and textures. The main body of the caftan was sewn by carefully matching the sections of back fur to one another for both colour and fur density (texture) to create a consistent look across the large expanses such as the back, front and arms of the garment. One individual was a gold colour, very different from the rest of the dark brown or reddish-brown skins. This was used as a feature by placing this section of skin in the centre part of the upper back of the caftan. The belly fur from the golden pelt was used to edge the visible front edges of the caftan (fig. 8.14). The very soft, short, thick beaver belly fur is a lighter grey than the rest of the back fur. This was used to construct the collar and to edge the front of the pine marten cape, and to edge the cuffs and non-visible front edges of the caftan.

Two adjustable tailors' dummies were set to the measurements of the models for whom the original patterns were sized and were used for all subsequent fitting of the garments after the initial patterns were made (fig. 8.15).

► Fig. 8.13: Cutting and sewing the marten cape.

Photo: Theresa Emmerich Kamper

Discussion

Like so many items we look at archaeologically, these garments represent a chain of events and interconnections between many individuals from potentially disparate cultures with great distances between them. It is important to remember that each of these furs started out as a living animal, which had to be hunted or trapped, possibly from a great distance away.

Beavers were not present in the immediate local area at this time, suggesting that the furs making up the Bjerringhøj garment and part of the Hvilehøj garment were imported, either from other areas of Scandinavia, or further afield, rather than being locally produced (Brandt et al. 2022). Red squirrel (*Sciurus vulgaris*) is common across Europe, and it is possible that the squirrel fur identified in the Hvilehøj assemblage came from local populations. However, fur from other squirrel species may have been available through trade. While the original colour of the fur in the burial is difficult to discern, it is notable that several textual sources from this period specifically refer to the use and trade of grey squirrel fur (Owen-Crocker 2004, 244; Lunde & Stone 2012, 69, 120, 169, 177). Red squirrels exist in several colour variants, including grey, but these texts could also suggest that furs from Siberian flying squirrels (*Pteromys volans*) were in circulation as well, probably traded from east of the Baltic. In addition, the Hvilehøj burial is broadly contemporary with the earliest evidence for European explorations in North America, so there is a slim possibility that pelts from eastern grey squirrels (*Sciurus carolinensis*) could have been available, but it is unlikely that these were circulating in Europe in any significant numbers, if at all, at this time.

◄ Fig. 8.14: Piecing together the beaver caftan.

Photo: Theresa Emmerich Kamper

► Fig. 8.15: The caftan and cape on tailor's dummies.

Photo: Theresa Emmerich Kamper

While squirrel furs could have been sourced from local populations, the smaller size of squirrel compared to marten would have meant that many more animals would have been needed to produce a garment comparable to the reconstructed cape, and this may make local origins less likely. A modern trapping line set for marten in a good year, in an area of high productivity, can yield as many as 200 martens a season, though this is rare and between 30 and 100 is more average (Opdahl 2014). While we do not know the size of historic trap lines, we can assume the length of the season has likely stayed fairly stable for much of the historical period, as the time during which pelts are at their best (prime), has to do with actual climactic seasons which have changed little in this time period. Gathering the sheer number of furs required would have needed considerable effort and expertise, which may point to origins with nearby groups, such as the Sámi, who hunted or trapped pelts in large numbers before trading them with neighbouring groups. There is plenty of

documentary and archaeological evidence for furs including beaver, squirrel and marten being highly desirable commodities that were extensively traded around the Early Medieval world. It seems likely that the producers of garments involving large number of furs may have employed those thriving exchange networks rather than necessarily hunting all the furs themselves. Othere's 9th century account describes Sámi hunters providing both unprocessed furs and ready-made fur jackets (Fell & Lund 1984, 20), making it a possibility that the garments were imported to this area in their entirety.
While beaver may be a larger animal than marten or squirrel, and therefore require fewer individuals to complete a garment, their larger size and more specialized winter diet of cambium (inner bark) means larger territories are needed to support beaver through the winter months. In many areas, this means there will be a lower population density than the smaller squirrel or marten with its more opportunistic carnivorous and occasionally omnivorous diet. Simply obtaining the number of beaver, squirrel or marten furs required for a garment of this size is likely to represent a significant financial investment for the original owner, even before the many stages needed to process them into wearable garments are taken into consideration.

In addition to the necessary importation of the pelts and the potentially lower numbers available, beaver pelts are significantly more difficult to process than those of marten. Beaver is notoriously difficult to skin, compared to most mustelids, and they have a substantial subcutaneous fat layer, the majority of which much be cleaned before they can undergo further processing. This de-fleshing process is time consuming and more physically demanding than for the smaller carnivores. The dermal thickness of beaver pelts needs to be reduced, multiple dressing cycles used and the addition of a heavier oil in the last stages of preparation are needed to make softening this species an efficient process. Due to these factors approximately six to ten marten pelts can be tanned in the time needed to tan one beaver pelt.

A second difference of note between the species was the speed at which the hair began to slip (fall out due to bacterial action). The pine martens were very sensitive and began to slip quickly, sometimes within eight hours of being rehydrated. This made it a race against the clock to get them from the rehydrated, but raw, state completely through to a finished and once again dry product. The process could, of course, be managed by freezing the skins to allow for delays in between the steps. The beaver, however, seemed nearly impervious to slippage. Some pelts were wet for nearly 72 hours and not a single skin had even a small area of the belly fur slip. This is a useful characteristic in light of how many dressing cycles this species requires, meaning that the skins have to be wet for a much longer time than the marten skins. Squirrel skin is thinner than marten furs, and they have a fairly tight dermal structure. Careful softening is needed to ensure they are soft enough for garments instead of becoming papery. However, the process of tanning them, and the softness of the fur is broadly similar to marten.

The differences between the species extended into the fitting and sewing portions of the project. However, the disparities in time were inverted, in that the pine marten cape, though a simpler garment, took longer to finish than the beaver caftan. This is due to a number of factors. The martens were simply smaller, so it required more seams overall to construct the garment. Due to their small size the pieces required more fitting to lie flat in the pattern. Each skin required four darts to flatten the undulations in the skin which originally allowed it to wrap around a three-dimensional animal. Doing this process by hand is incredibly time consuming, and this issue would have been magnified in a garment constructed using much smaller squirrel skins. The beaver skins were much larger than the marten and they are much squatter animals in life, which means that the skins lie nearly flat when they are tanned. This meant that fewer seams were needed overall when sewing the beaver skins. The skins from both species had occasional small holes introduced during skinning or de-fleshing which required mending or, in a few cases, small patches, all of which added to the effort and time required to prepare the skins.

A second consideration which influenced the total number of person hours per garment was the handling of the skins. The pine martens were harder to hold onto and more challenging to sew, as the skin was very soft and needed constant adjustment as the seam was being sewn. Constructing the garment out of squirrel fur would likely have had similar problems. Fabric pins can be used to hold soft skins together, but they are generally avoided when sewing skins as they leave permanent holes in the skin. The beaver skins were more solid and did not drape in such a soft way as the pine marten. This made lining up a seam and sewing down the length of it less time consuming as adjustments to the seam edges were needed much less frequently.

The last variable which influenced the total labour invested in each garment was the difficulty in pushing a needle through the skin thickness. This level of perceived difficulty is somewhat subjective due to the difference in hand strength between the three tailors working on the garments. However, the thicker parts of the beaver skins, such as the neck skin, were challenging to sew quickly, even for those with significant finger strength, and consequently those areas were slower to sew.

Table 8.1 compiles the approximate number of hours needed to complete the garments from tanning the skins through to fitting, sewing and finishing. The tanning portion of the work was completed by Theresa Emmerich Kamper, who has over 30 years of experience in traditional tanning. The construction of the garments was done by craftspeople who are experienced tailors and who are familiar with working with fur as a material. However, before claiming that the above table is a completely accurate representation of the time these garments would have taken to construct originally, a number of compromises need to be stated. The first is thread: the thread used for the garments was commercially produced 2-ply linen thread, which we reduced to single ply by untwisting the threads. Originally, producing this essential part of the construction process would have required the flax to be grown, harvested, retted, cleaned, and spun. This is a highly time-consuming series of processes which may have involved different groups of people to those who carried out the tanning. Other compromises which have been mentioned already, but could do with restating here, include the use of modern steel needles, lecithin as a brain substitute and commercial bark powder to strengthen the goat and calf skin tanning solutions. The use of steel needles, based on the basic time trials undertaken with the bronze needle, would have speeded the sewing process up considerably. The lecithin in place of brain tissue does not change the time needed for the tanning process. It instead makes the preservation of the tanning solutions for such large batches of skins, over a long period of time, less problematic. However, the addition of commercial bark powder which in many cases, is sorted by the molecular weight of the tannins, allows for faster penetration of the tannins through the dermal thickness of the skins. This meant that the goat and calf skins needed less time in the tanning solution to tan through the full dermal thickness, than would have been needed in a non-commercial, full bark solution. This last compromise was unavoidable due to the time of year and lack of additional bark available.

Despite some compromises to the period appropriate nature of the choices listed above, one thing can be said without a doubt. These reconstructions, and the original garments they emulate, represent an extraordinary amount of time, labour and skill (fig. 8.16). From the initial trapping of the animals and preservation of the pelts, through the processes of tanning, designing, cutting, sewing, fitting and then sewing some more. These garments, which we as archaeologists often designate simply as 'high status', are now, and were likely in the past, a labour of love connecting a long line of hunters, trappers, farmers, traders, craftspeople, and eventually, the people who wore them to the grave.

► Table 8.1: The approximate number of hours needed to complete the garments. Tanning done by a single person. Sewing was split between three people. The calf and goat skins lay in a tanning liquor for approximately one month, only needing to be stirred once a day. The total time is shown as well as the actual hours of labour before and after the soaking period.

	Beaver caftan 24 skins	**Pine marten cape 42 skins**	**Boot skins 2x calf skins**	**Shoe skin 1x hair-on goat**
Tanning	110 hours	75.5 hours	16 hours labour 35 days full process	12 hours labour 30.5 days full process
Patterning	3 hours	2 hours	NA	NA
Cutting, fitting, and sewing	16 days 128 hours ~5.5 days x 3 people per day	26 days 208 hours ~8.5 days x 3 people per day	NA	NA
Total	241 hours	285.5 hours	16 hours	12 hours

◄ Fig. 8.16: The finished fur garments.

Photo: Roberto Fortuna

9. The reconstruction of the footwear

Espen Kutschera

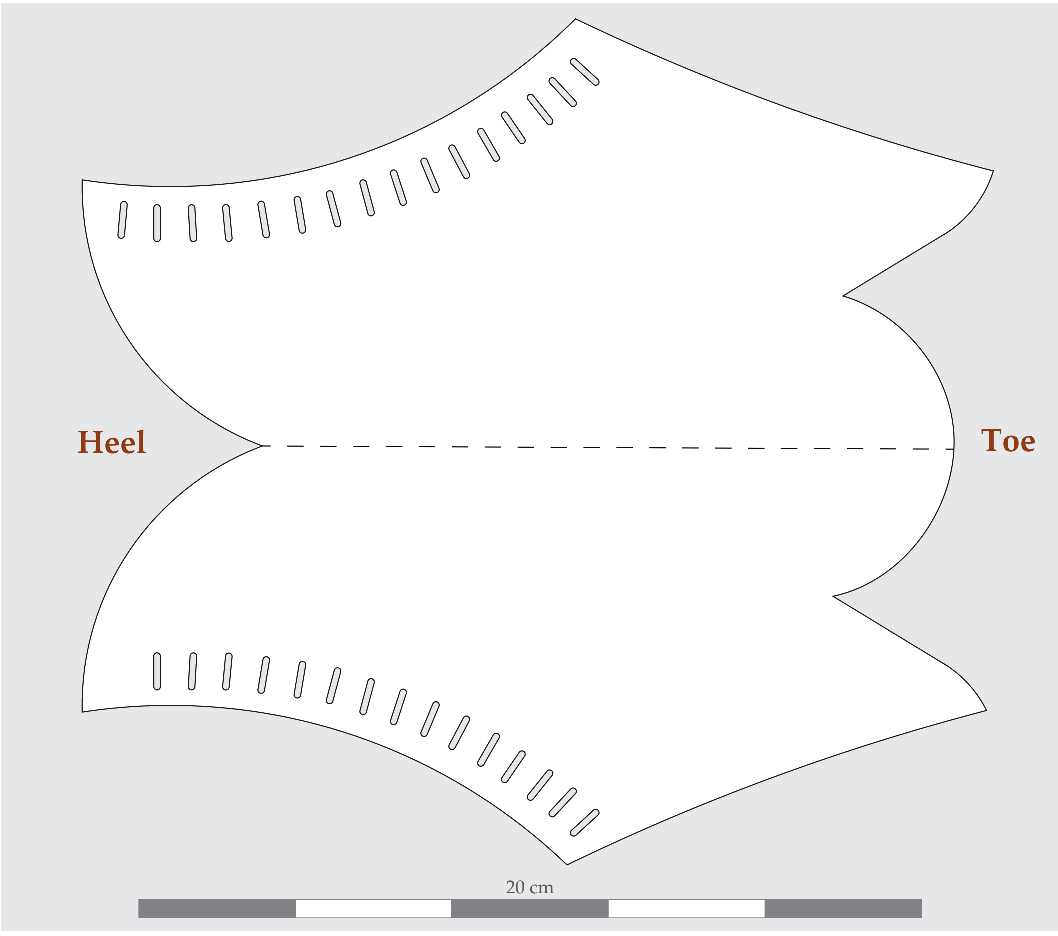
The shoes for the female outfit

The Hvilehøj shoes are among the very few preserved Scandinavian Viking Age shoes from burial contexts. As the shoes are fragmentary, their shape and cutting pattern is not possible to reconstruct completely. However, the remains are well-enough preserved to identify them as belonging to a group of one-piece shoes, although the Hvilehøj shoes seem to be made out of two pieces. The missing parts and hence the shape and cutting pattern of the Hvilehøj shoes can, to a certain degree, be inferred from other more well-preserved finds, although the parallels offer several variations. An interesting feature is the preserved hairs. Hide shoes were often made of fur-on rawhide. However, the Hvilehøj shoes were most likely vegetable tanned, and hair-on vegetable tanned shoes seem to have no known prehistoric parallels.

Espen Kutschera did not study the remains of the Hvilehøj shoes in person, but was provided with photos, drawings, descriptions and analyses of the fragments. Because the shoes are very fragmentary, the reconstruction is partly guesswork based, however, on knowledge of similar shoes from the European archaeological record. Although there are no exact parallels to the cutting pattern of the Hvilehøj shoes in two halves, the shoes were probably shaped in the same way as a group of more or less contemporary one-piece hide shoes.

► Fig. 9.1: The reconstructed pattern of the Hvilehøj shoes with a V-shaped heel incision.

Illustration: Espen Kutschera



The toe-parts clearly show that the Hvilehøj shoes belong to a group of specific cutting patterns classified as W-shaped (Volken 2014). Of course, the rest of the shape, especially the cutting of the heel-part, the fastening type and the height of the shoes are uncertain, and the many parallels offer several possibilities. Most contemporary parallels are drawstring shoes, as is also the case with most soled Viking Age shoes, hence the slots and leather thong. In the end, it was decided to make a simple, low cut drawstring shoe with a V-shaped heel incision, very close to the W-model termed Oslo (Volken 2014, 131, fig. 172) (fig. 9.1). There are however no W-cut hide shoes found in Oslo in Norway, but the type is found in Tiel in the Netherlands (Volken 2014, 266). This is also close to the form suggested by Vivi Lena Andresen and Theresa Emmerich Kamper. Another heel shape or higher instep, even other types of closures or no closure at all, are also possible ways of reconstructions. There are, for instance, a lot of examples from Hedeby in North Germany that vary from the Oslo shape (Groenman-van Waateringe 1984).

Materials and methods

The shoes were made from thick vegetable tanned hair-on goat leather provided by Theresa Emmerich Kamper (see chapter 8). The shoes were stitched with six cord-waxed, natural coloured linen threads. The thread was industrially made, as it was not possible to get hold of handspun linen thread with the strength and quality needed. For leather thongs, the vegetable tanned calf leather, also provided by Theresa Emmerich Kamper, was used.

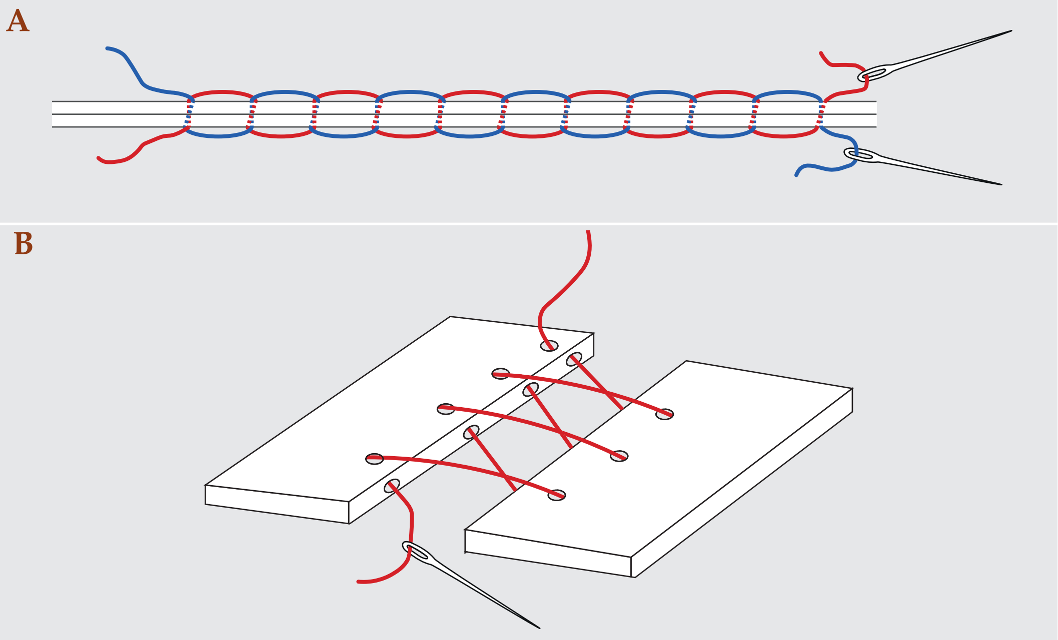
After going through the literature looking for cutting patterns with similar features, a few different possible models were found. Different patterns and a number of test shoes were made with several different approaches, before the final shoe model was chosen and the pattern made. Kutschera's wife and crafting partner had about the same shoe size as the female model, making it easier to experiment with the fitting of the shoes. As the leather arrived late in May 2020, a couple of test pairs were sent to Denmark already in January 2020, made in another high-quality thick vegetable tanned goat leather (believed to be almost the same thickness as the reconstruction leather) to test how it would fit the feet of the models, as well as one in low quality goat fur just to give an idea of how the furry shoes would look (fig. 9.2).

▲ Fig. 9.2: The test shoes in leather and fur.

Photo: Espen Kutschera

After a discussion with Theresa Emmerich Kamper, it was decided to cut the parts of the shoes so that the fur direction pointed down from the ankle opening in all directions. The shoes and thong were cut with scissors, although the originals probably were cut with some sort of knife. The slits were stabbed with a chisel.

The analysis reports states, that the Hvilehøj shoes are turn-shoes, for the most part stitched inside out and then turned. The seam on top of the toe seem to be saddle stitch, but the rest of the seams are whip tunnel stitches, both the long seam under the shoes as well as the closing of the toe in front (fig. 9.3, 9.4.). The whip stitches do not penetrate the grain side of the leather, only the flesh side, making the seam invisible on the outside, to protect it from wear and tear. The advantage of using whip stitches, compared to tunnel saddle stitches or running stitches, is that the seam becomes flatter, which makes it better to step on, given the fact that the shoes have a seam running lengthwise underneath the middle of the sole. An awl and saddler's needles were used for stitching and a shoemaker's hammer and a smooth pebble were used as anvil to flatten the seams. The finished shoes are seen on fig. 9.5.



► Fig. 9.3.A: Schematic illustration of the saddle stitch. B: Schematic illustration of the tunnel whip stitch.

Illustration: Charlotte Rimstad / Mads Lou Bendtsen

► Fig. 9.4: The tunnel whip stitch was used for the seam underneath the shoes.

Photo: Espen Kutschera

◄ Fig. 9.5: The finished reconstruction of the Hvilehøj shoes.

Photo: Espen Kutschera

Discussion

The shoes from Hvilehøj can be identified as a pair of hide shoes, that means primitive shoes without separate soles and uppers. This is a numerous and heterogeneous group of footwear, known from a vast geographical area and time depth, ranging from very primitive to quite sophisticated examples. The remains of the Hvilehøj shoes clearly belong to the latter.

Hide shoes are usually made from one piece of hide or leather, although some have additional parts. However, the shoes from Hvilehøj seem to be made of two equal pieces stitched together along the middle of the sole. No comparisons are known, whether prehistoric, historical or ethnographical, with this feature, which seems entirely against the nature of such shoes. The seam obviously makes the shoes less waterproof, less resistant to wear and less comfortable. Maybe the seam was a result of scarcity of material or a way of using leftovers from another fur-product.

Another option is that a specific combination of fur colour variations was desirable, or that the two-part division could have to do with the hair-direction. Specifically, the hair direction of the shoes was discussed with Theresa Emmerich Kamper and it was concluded that the hair should point downwards from the instep in all directions. This was a purely aesthetic conception on our behalf, but the maker of the original shoes might have had similar intentions. Downward pointing hair direction over the whole upper part of the shoes is impossible if the shoes were made in one piece. There could also be other considerations behind the original cutting pattern, for instance a specific desired hair direction underneath the soles, to prevent slipping on snow and ice, as known from more recent Norwegian fur shoes. In the end, the less furry parts of the goat hide were used for the reconstruction, to prevent the shoes from being too fluffy. Unfortunately, the original shoes are not in a condition to tell us anything about the direction or length of the hairs.

The shape of the shoe and hence the original cutting pattern is only partly documented, as the shoes are very fragmented. The toe-parts, which are best preserved, clearly show a W-shaped cutting pattern (Volken 2014). The missing heel part could be either W-shaped or V-shaped, or even shaped in a totally different way. Several approaches were tried, but it ended up with a single V-shaped notch for the heel, simply because it is the easiest solution with a hide shoe made up from two different, symmetrical parts.

The closing of the shoe is not preserved, but most hide shoes of similar types (W-cut), as well as most other low shoes in the Viking Age, have a drawstring fastening, with a leather thong fed through slits spaced evenly around the instep. The number of slits varies greatly, but because of the fur, a relatively low number of slits were chosen, though still enough to give an even form when the thong is tightened. As the instep is missing, the height of the shoes is not certain. It was decided to make low shoes with the fastening right under the instep, but they could also have been higher, for instance reaching over the ankle, as one can see on examples from Hedeby (Groenman-van Waateringe 1984).

Normally, hide shoes are considered home-made, as an alternative to shoes made by professional shoemakers, which have separate soles and uppers. However, in the Viking Age, there are a number of hide shoes of high quality, with intricate and precise cutting patterns that might suggest professional manufacture, for instance in Hedeby. The Hvilehøj shoes seem to be professionally made rather than homemade because of the cutting pattern, the stitching and the fur-on leather.

The fur-on solution might indicate that the shoes were for winter use, something that is well attested until modern times in the Nordic countries. There could however also be other reasons for the fur, for instance to signal social status. The saga of Erik the Red, also called the Vinland saga, gives a detailed description of the völva Thorbjørg's costume, which includes furry shoes: "She wore hairy calf-skin shoes on her feet, with long and strong-looking thongs to them" (Saga of Eric the Red, translated in 1880 by J. Sephton). The shoes in this saga are made of calf skin, and the use of Medieval sagas as source of Viking age material culture is debated, but still worth mentioning. This is not to suggest that the woman in the Hvilehøj burial was a völva, but as an example that such shoes might be social markers, and probably also costly belongings.

The shoes for the male outfit

As no footwear is preserved in the Bjerringhøj burial, the shoes for the reconstructed outfit had to be based on another find. Originally, the idea was to replicate a pair of low boots from Katmose in Denmark (Mannering 2015). It was, however, difficult to obtain detailed documentation to base the reconstruction on. Hence, it was decided to make the low boots from Hedeby instead. The calf leather for the shoes was provided by Theresa Emmerich Kamper.

Hedeby is our most important source of information on Scandinavian footwear in the Viking Age. The excavations have provided a lot of different types and models, divided into ten types, based on how the uppers are stitched together and how the shoes are closed (Groenman-van Waateringe 1984). This division does not take into account whether the shoes have soles or are made with sole and upper in the same piece. It was decided to use a shoe with separate sole and upper, namely Hedeby type 6, described as a semi-high or high shoe with a few slits close to the ankle (Groenman-van Waateringe 1984, 26-27, abb. 11:1, 12:6 and 13:3). As can be seen by the published illustrations there are many variations, and according to Volken (2014), this would be a variation of a type L cutting pattern.

Kutschera had a lot of experience with making the Hedeby type 6. They are semi-high, made from separate uppers and soles, the uppers stitched together on the medial side (inside) of the foot. Viking Age shoes often have less defined left and right soles than later medieval shoes. Although it is true that some of the soles are almost symmetrical along the foot, there are also several soles that are clearly shaped to fit right and left feet respectively. For this commission, definable right and left soles were made and it was also decided to produce a triangular, raised heel, which is characteristic, but not a rule for Viking Age footwear.

The final boots are not exact replicas of a specific Hedeby find, but within the range of the known variations. To make an exact replica, it would be necessary to study the actual shoe remains from Hedeby as well as detailed drawings and documentations of the shoes, which was beyond the scope of this project.

Materials and methods

The shoes' uppers are made of bark-tanned calf leather, provided by Theresa Emmerich Kamper. The leather thongs for fastening are also cut from the same leather. The sole leather was provided by Kutschera and consists of c. 4.5 mm thick vegetable tanned cattle leather from Tärnsjö Garveri in Sweden. Tärnsjö make high quality, traditionally prepared and eco-friendly leather. For stitching, industrially made waxed flax thread was used as well as a saddler's needle, although a hand-spun thread with bristles would have been preferred. The result would however look the same, as there are no seams and therefore no thread visible on the outside.

First, a pair of test shoes were made after the given measurements, ensuring that the shoes would fit the male model (fig. 9.6). After the first fitting on the model, it was decided to adjust the fit a little bit, to make them more spacious and a little more closed in front.

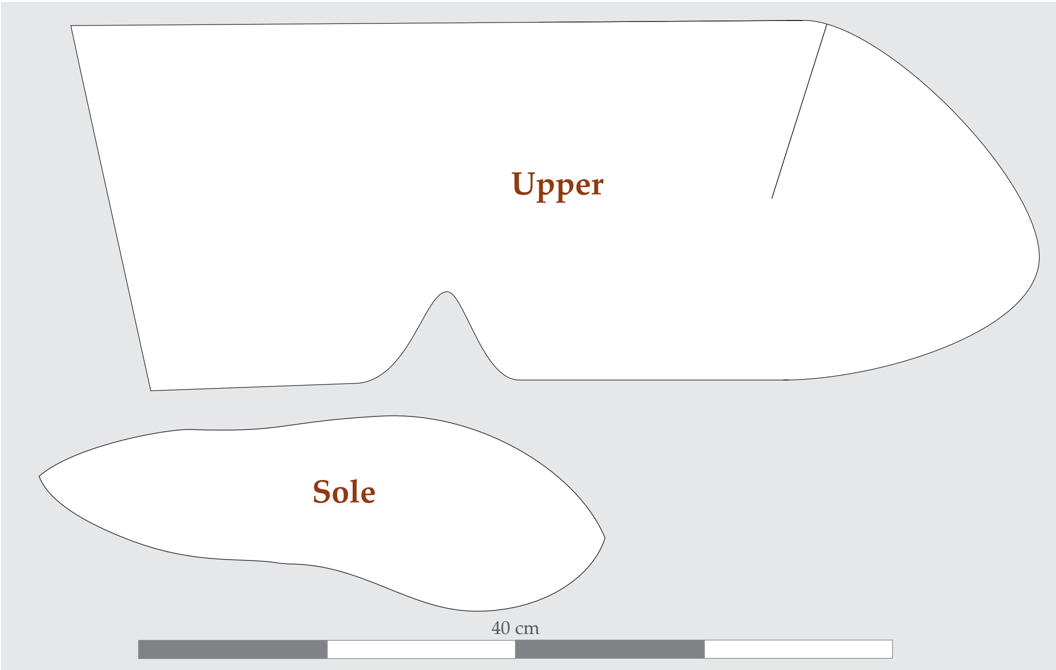
▼ Fig. 9.6: The test boots.

Photo: Espen Kutschera

The pattern for the uppers was laid out symmetrical on either side of the hide, to ensure that the shoes would be as identical as possible regarding thickness, stretch and so forth (fig. 9.7, 9.8). Also, parts of the leather, like the neck and spine, was avoided as well as areas with tear marks and weaknesses. Scissors were used to cut both uppers and soles, although a Viking Age shoemaker would have used a knife. The triangles for the heel-incision were cut afterwards. A Viking Age shoemaker probably would have made a shoe last for each customer, but no such thing was available, so the shoes were not stretched and stitched over a last. The shoes were stitched together with saddler's stitch, leaving no seams visible on the outside after turning them (fig. 9.9). This goes for both side seam and the seam connecting sole and upper. After turning the shoes, the seams were beaten with a shoemaker's hammer, which gives both better comfort and shape. Then the slits were made at the instep and the shoes were laced up. The finishes boots are seen in fig. 5.49.

► Fig. 9.7: The boot pattern.

Illustration: Mads Lou Bendtsen



► Fig. 9.8: Cutting out the leather.

Photo: Espen Kutschera

▼ Fig. 9.9: Sewing the shoes while turned.

Photo: Espen Kutschera

Discussion

As no footwear was preserved in the Bjerringhøj burial, a combination of guesswork and logic was necessary when trying to find proper patterns for the footwear for the male outfit. Given the high social status of the buried man, and the valuable and highly decorated grave goods he was equipped with, the shoes must obviously have been of high quality, possibly even extravagant. Still, since there are no clues to how the shoes looked, they should not be too eye-catching. Instead, they were made as functional, well-fitted, but simple boots. A side-seam was used in the uppers, as opposed to the less complicated front seam and slightly fitted soles rather than symmetrical.

The shoe finds from Hedeby are an obvious choice for inspiration. Hedeby was the largest and most important urban centre in Scandinavia throughout most of the Viking Age. Shoemakers were probably for the most part working and selling their products in towns and marketplaces, although we cannot rule out travelling shoemakers and shoemakers working for wealthy and powerful patrons. The shoe models are much the same in all of Scandinavia and further away in the Viking Age, although some smaller local variations and specialties can be observed.

It must be said that anyone who wore professionally made soled footwear with individual fit in the Viking Age would have been well-off. The Viking Age and medieval shoemaker was, contrary to the popular belief, a highly professional craftsman who probably knew well what to charge for his goods and services. In medieval towns shoemakers were often among the largest, wealthiest and most influential groups of craftsmen. Less is known of the Viking Age and Early Medieval shoemakers, but given the often high quality craftsmanship documented in the archaeological record, shoes were probably quite expensive.

It can be a challenge to work with an unknown leather quality, but the calf leather for the uppers was excellent for the purpose, and worked well together with the sole leather from Tärnsjö. Hence, making the shoes was routine work, and the size fit was established beforehand with a test shoe. The shoes ended up having a nice and rather authentic look, being modest but still high-quality Viking Age footwear.

10. The reconstruction of the beaded jewellery from Hvilehøj

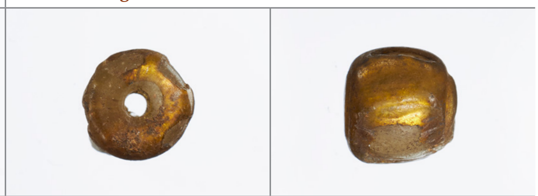
Torben Sode & Ulla Lund Hansen

From the Hvilehøj excavation, 14 whole beads and a number of bead fragments exist. The beads vary in material, shape and colour, but they all seem to have been part of a necklace or a beaded piece of jewellery found on the chest of the dead woman. In order to reconstruct the visual appearance of the beaded ornament, both the beads themselves as well as the written documentation from the excavation have been included. The preserved beads (C4278) and the silver coin (C4279) are shown in table 10.1 and 10.2.

► Table 10.1: An overview of the preserved complete beads (C4278) from the Hvilehøj grave.

Photo: Charlotte Rimstad & Mads Lou Bendtsen

2cm

1. Rock crystal bead	2. Rock crystal bead
	
A mostly spherical shaped rock crystal bead, in a greyish tone, with brown cracks and inclusions. Diameter: 10 mm Width: 8 mm Hole diameter: 2 mm	Round facetted, translucent rock crystal bead with hexagonal facets along the centre and pentagonal facets around the hole. Diameter: 9 mm Width: 8 mm Hole diameter: 1.5 mm
3. Glass bead with gold-foil	**4. Gold-foil glass bead**
	
Cylindrical, translucent glass bead in a greyish tone with three square pieces of gold foil fused into the bead. Diameter: 8.5 mm Length: 16 mm Hole diameter: 4 mm	Barrel shaped, gold-foil glass bead made of light brown translucent glass with remnants of gold-foil below the deteriorated surface. Diameter: 10 mm Length: 9 mm Hole diameter: 2 mm
5. Gold-foil glass bead	**6. Glass bead with stratified eyes**
	
Barrel shaped, gold-foil glass bead made of light brown translucent glass with remnants of gold-foil below the partly deteriorated surface. Diameter: 10.5 mm Length: 10 mm Hole diameter: 2 mm	Ring shaped, opaque reddish-brown glass bead with stratified eye decoration in red and yellow glass, framed by opaque white octagonal pattern. Diameter: 12 mm Length: 6 mm Hole diameter: 4 mm

7. Glass mosaic eye bead	8. Glass bead, monochrome
 	 
Barrel shaped, opaque reddish-brown glass bead with three mosaics in alternating yellow and dark brown radiating pattern and with red centre. Diameter: 10.5 mm Length: 6.5 mm Hole diameter: 4 mm	Ring shaped, translucent monochrome blueish green glass bead. Diameter: 11.5 mm Length: 5.5 mm Hole diameter: 3 mm

9. Glass bead, monochrome	10. Glass bead, monochrome
 	 
Barrel shaped, monochrome opaque greyish-blue glass bead with slightly impressed sides. Diameter: 11 mm Length: 7 mm Hole diameter: 4.5 mm	Barrel shaped, opaque white glass bead. Diameter: 11.5 mm, Length: 7 mm Hole diameter: 5 mm

11. Glass bead, monochrome	12. Glass bead, monochrome
 	 
Barrel shaped, opaque monochrome orange glass bead. Diameter: 10 mm Width: 8 mm Hole diameter: 3 mm	Barrel shaped, opaque green glass bead. Diameter: 10 mm Width: 6 mm Hole diameter: 4 mm

13. Glass bead, monochrome	14. Amber bead
 	 
Barrel shaped, opaque monochrome white glass bead. Diameter: 9 mm Length: 6.5 mm Hole diameter: 3 mm	Round, double conical, convex reddish brown amber bead. Diameter: 11.5 mm Length: 4 mm Hole diameter: 3 mm

◄ Table 10.1 continued: An overview of the preserved complete beads (C4278) from the Hvilehøj grave.

Photo: Charlotte Rimstad & Mads Lou Bendtsen

2cm

► Table 10.2: The silver coin (C4279) from the Hvilehøj grave.

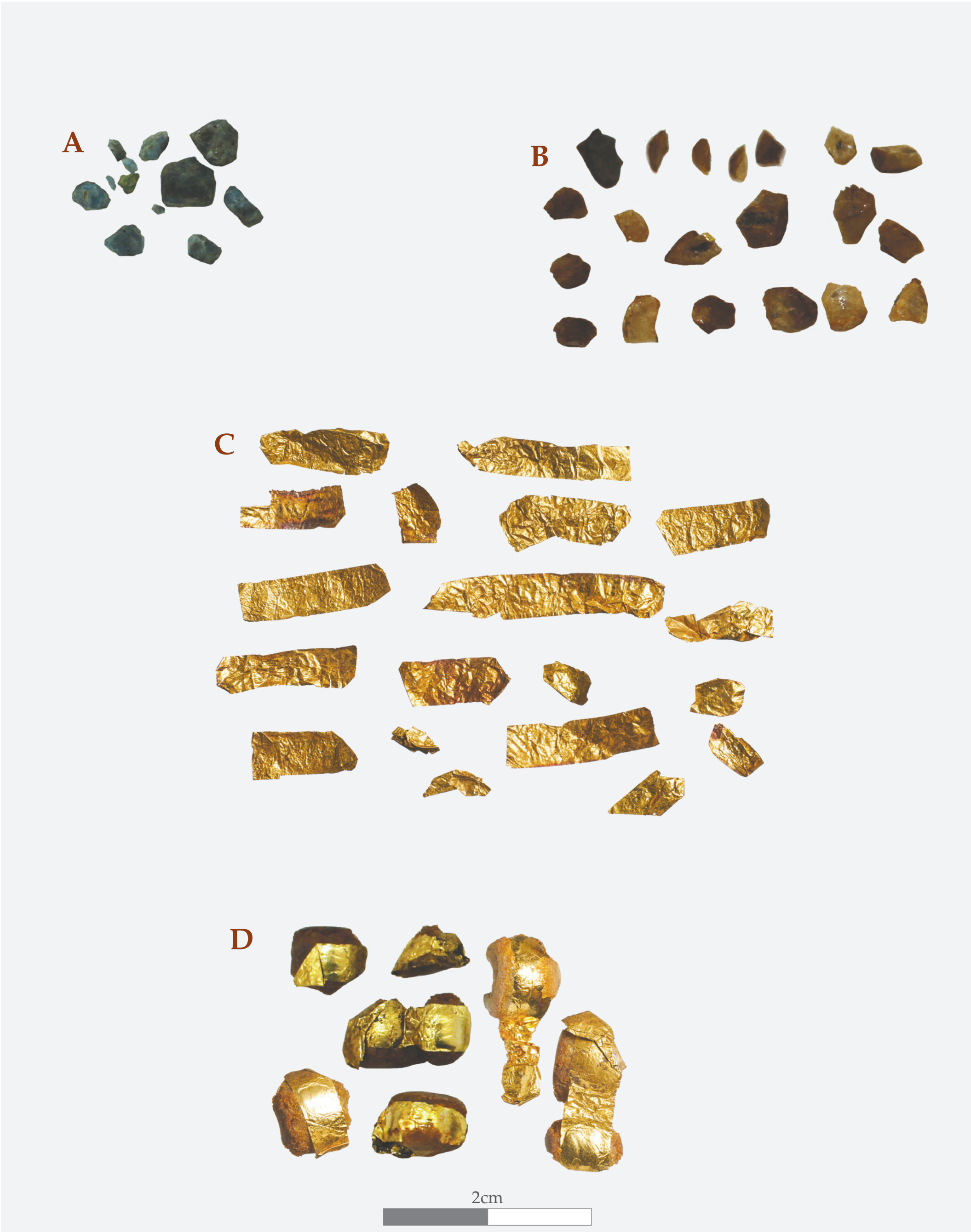
Photo: Roberto Fortuna

2cm

Silver coin	
	
Silver coin pierced through the middle. There are clear signs of wear from the attachment, probably from a silver wire. Diameter: 18 mm Thickness: 0.5 mm Hole length: 3 mm Hole width: 2 mm Weight: 0.679 g	

► Fig. 10.1: The fragmented beads and gold-foil from Hvilehøj.

Photo: Charlotte Rimstad



In addition, the following objects have been preserved from the grave, also registered under number C4278 (fig. 10.1).

- Some crushed opaque green glass beads (fig. 10.1a).

- Fragments of highly degraded glass beads of opaque, light, yellow-brown glass, derived from glass beads with fused, rectangular pieces of gold-foil. Also, two half glass beads with gold-foil, two fragments (quarter pieces) of a glass bead held together by an approximately 4 mm wide piece of gold-foil, as well as a smaller fragment of a glass bead with gold-foil (fig. 10.1b).

- Nineteen larger and smaller pieces of gold-foil, varying in length between 5 and 23 mm, and a width between 2.5 and 4.5 mm, with an average width of about 4 mm. These oblong pieces of gold-foil have originally been wrapped around the highly degraded gold-foil glass beads in a similar manner as can be seen on the half and quarter glass beads, on which gold-foil is still preserved (fig. 10.1c).

- Fragments of severely degraded glass beads, some of which have remnants of gold-foil on the surface (fig. 10.1d).

It seems highly probable that most pieces of broken glass and the gold-foil strips originate from glass beads, which are made with a piece of gold-foil fused under a thin layer of clear glass. These beads are known from the late Viking Age in the form of various types of wound glass beads with gold-foil. The beads usually date to the early 11th century, and are found in both barrel shaped, flat double-conical and cylindrical shaped varieties. The beads are known in relatively large numbers from the Russian and East Slavic areas, but are also found, albeit rarely, in Scandinavia. A bead is known from Hedeby (Armbruster 2002) and three beads derive from Dalarne in Sweden (Serning 1966). They are also known from several burial finds on Gotland, including Strånga, Grötlingbo and Hemse (Thunmark-Nylén 1998), just as there is a bead with gold-foil under a thin layer of clear glass from Bjerregård on Bornholm, and from York in England (personal observation).

Finally, the fragmented pieces of glass and gold-foil may originate from glass beads that have been wrapped with gold-foil, but which have not been covered by a thin layer of glass. Unlike the segmented, gold-foil glass beads and beads with gold-foil fused into the bead, such glass beads are very unusual and fragile. There are three glass beads with gold-foil fused directly onto the glass bead from the excavations in Hedeby (Steppuhn 1998) just as 14 pieces of gold-foil, corresponding to the gold-foil from Hvilehøj, have been found at the excavations in Hedeby (Armbruster 2002). In addition, a bead with gold-foil has been found in Ralswiek on Rügen, but generally these glass beads with gold-foil without covering glass are rare. The half bead, the two quarter beads and the smaller fragment of an originally barrel shaped bead with gold-foil, could derive from this type of glass bead. The same applies to the very fragmented and degraded glass beads and the 20 pieces of gold-foil. Regarding these beads, they are presumably gold-foil glass beads, where the original layer of thin clear glass has broken off. It is most likely that the outer glass was not properly fused onto the gold-foil. This, combined with the fact that glass and gold have different coefficients of expansion means that the outer glass layer has only been fused to the bead on the edges and was therefore very fragile.

Bernard Gratuze at the Center Ernest-Babelon, Institut de Recherche sur les Archéomatériaux, Le Center National de la Recherche Scientifique (CNRS) at the University of Orléans, France, has kindly analysed three pieces of the fragmented gold-foil glass beads. The analyses were carried out with laser ablation connected to an inductively coupled plasma mass spectrometer (LA-ICP-MS). This scientific analysis method can very precisely determine the composition of the glass, while the method is nearly non-destructive (Gratuze 2013). The analyses show a type of glass that is unusual in this period. The glass may have been made from crushed pieces of pure quartz, with a very pure potash added. In addition, the glass has a low content of phosphorus, magnesium, aluminium and chlorine. It is possibly an early European potash-lime glass. Analytically the glass roughly corresponds to glass from Corvey and Brunshausen-Gandersheim in Germany, which is dated to the 10th and 11th centuries (Wedepohl 1997). All in all, there seems to be evidence of at least 24 beads from the Hvilehøj grave as well as one pierced silver coin, which was clearly used as a pendant.

Written documentation

When the Hvilehøj mound was excavated in April 1880, the finds were reported by architect J.F.C. Uldall to curator and chamberlain, J.J.A. Worsaae, from the National Museum of Denmark. Worsaae then sent professor C. Engelhart and professor J.M. Petersen to Randers to conduct the excavation. Three reports and the excavation report provide information on the original appearance and position of the jewellery in the grave.

Extract of the report from architect F. Uldall, the 27th of April 1880, to curator J.J.A. Worsaae:

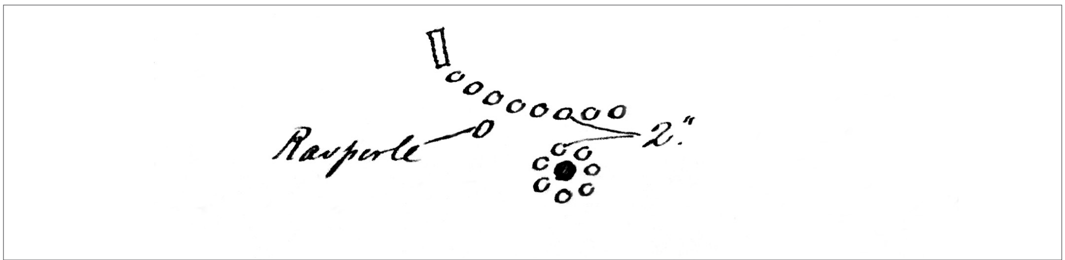
... When the fragments of the lid had been removed, and we had reached the blanket or mantle that covers the corpse, I considered our task to be over, and that our expertise did not go any further. I therefore proposed to our chairman, Chamberlain Rosenørn, to telegraph to you and ask for the museum's assistance, which he was happy to agree on - we could not, however (which must be forgivable when admitting the mistake) keep ourselves from looking a little behind the cover, and then we saw one or two rows of beads, the beads of which are of coloured glass, amber and gold (1), just as we could guess that the clothes themselves must be of precious materials.…

(1) In addition, a thin silver coin about the size of a 25 øre coin, on which a cross is said to be placed, the last of which I have not seen myself.

Later, architect Uldall writes, in June 1880, as an addition to Engelhardt's report regarding the excavation of Hvilehøj on 27th of April 1880:

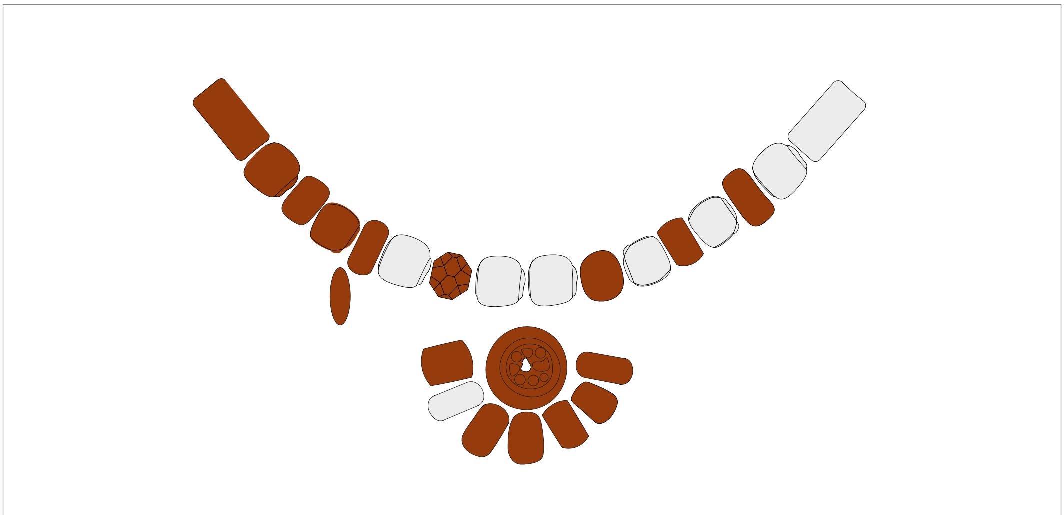
14. Since I do not know whether Prof. Magnus Petersen drew the exact location of the necklace, I must allow myself to share the impression we over here have of it. The beads lay in 2 rows, but the lower of these formed a small circle, in the centre of which the coin lay. The arrangement was thus approximately as follows: (sketch, see fig. 10.2). I remember that every second of the beads in the top row was with gold-foil, while none of the (probably around 6 to 7) beads, all of which had strong colours, and of which

► Fig. 10.2: Architect Uldall's sketch of the placement of some of the beads in the Hvilehøj grave.



► Fig. 10.3: A schematic overview of the preserved beads

Illustration: Mads Lou Bendtsen



2 green ones were broken, which made up the lower part of the jewellery, had gold-foil. It seems to me that the oblong cylindrical bead with gold-foil finished the necklace furthest to the south-west, although I dare not say for sure. The amber bead had the location indicated in the small sketch, and seemed to have rolled slightly out of its original position in the larger top row.

Extract from excavation report by Engelhardt 1880:

When the Board later came across wood, beads and clothes with gold threads during the excavation, Architect Uldall telegraphed on 25th of April 1880 to the museum in Copenhagen and on the 27th, the grave was examined by me together with members of the Board and Professor J.M. Petersen as illustrator.

The stretcher and what once lay on it in the grave, the body in its dress and jewellery, vessel and casket, it was dissolved by moisture and sunken into a flat, dense layer of 1½ to 2 inches thick. As this layer was also soaked through from the rain of the previous days, the work on the site itself had to be limited to collecting the beads and a few more conspicuous items that did not belong to the garments, and thus to record the "cultural layer" in larger pieces by inserting glass plates underneath that.

A clothed corpse was once laid on the stretcher with the head to the west, the feet to the east; this is confirmed by the remains of the garments, at the place where the beads lay, and by the fact that some bones of toes were still preserved in the remains of a leather shoe from the eastern end of the grave.

The beads lay at the top of the layer, about 2 feet from the head end, as if they had formed two rows a couple of inches apart. 16 small beads are preserved, namely a round, faceted one of colourless glass – a cylinder of whitish glass adorned with wide, flat bands of very thin gold-foil, over which a thin film of glass has been fused – four round beads of whitish glass with gold-foil inside – a similar one without gold-foil – six pieces of green, blue, white and yellow porcelain – two mosaic beads – one small flat amber bead. Some were crumbled away; where dissolved beads have been, we collected among others fragments of thin gold-foil. In the upper row, every second of the beads was covered with gold-foil; in the lower row they lay in a circle around the small silver coin mentioned below. The elongated cylindrical bead completed the row of beads at the top, furthest to the southwest.

Among the beads in the lower row, 2 feet and 2 inches from the west end (the head end) a small, very degraded silver coin from Otto the First (King 936-962; Emperor 962-973) was collected. Council of Justice Herbst has described it as follows: Adv. +ODDO REX around Rev. S(ancta) Colonia A(grippina). It is therefore minted in Cologne, is pierced in the middle and, based on its place in the grave, has been pulled on the string of beads and carried on the front of the chest.

Extract from the 1880 protocol of The National Museum of Denmark:

C4278 Some Beads:

a) *Two of rock crystal, one matt grounded, the other faceted*

b) *6 glass beads, clear as water, with underlying gold-foil; 5 are round, 1 is oblong*

c) *Two glass beads with a mosaic design*

d) *5 glass beads of different colours*

e) *1 small amber bead, as well as a number of fragments of similar beads and gold-foil, some of which have been a substrate under a thin glass cover*

C4279 A small silver coin pierced in the middle to be pulled on a string. The Council of Justice Herbst has determined the coin as follows: Adv. + ODDO + REX around Rev: COLONIA; Santa Colonia Agrippina; approximately like H. Dannenberg, Die deutschen Münzen des Sächsischen und Fränkischen Kaiserzeit Taf. 14 No. 329a. So, from Otto I, King 936-962.

Uldall describes the necklace that consisted of two rows of beads a few inches apart, where the lower part of the necklace consisted of a small circle of beads in the centre of which the silver coin lay. He also writes that every other one of the beads in the top row was gold-foiled, and that none of the beads in the lower part of the necklace "had gold". Moreover, he states that the small circle of glass beads (with 6 to 7 pieces) all had strong colours and that two green beads were broken, and that the oblong, cylindrical glass beads with fused gold-foil completed the necklace at the one end. Finally, he points out that the amber bead lay below the upper row of beads.

In the excavation report, Engelhardt writes that 16 small beads were preserved: a round, faceted colourless glass bead (must be identical with the rock crystal bead no. 2), and a similar bead without gold-foil (must be identical with the rock crystal bead no. 1). Engelhardt was not aware that bead no. 1 and no. 2 were of rock crystal and not of glass. He also mentioned the cylindrical shaped bead of whitish glass decorated with wide, flat bands of very thin gold-foil, which was covered by a thin layer of glass (identical to glass bead no. 3), four round beads of whitish glass with gold-foil inside (identical with beads no. 4 and 5) as well as six beads of green, blue, white and yellow porcelain (opaque glass), and also two mosaic glass beads and a small flat amber bead. Furthermore, Engelhardt writes that some of the beads were crumbled and that the dissolved beads were in the same place as the fragments of thin gold-foil.

The reconstruction of the beaded jewellery

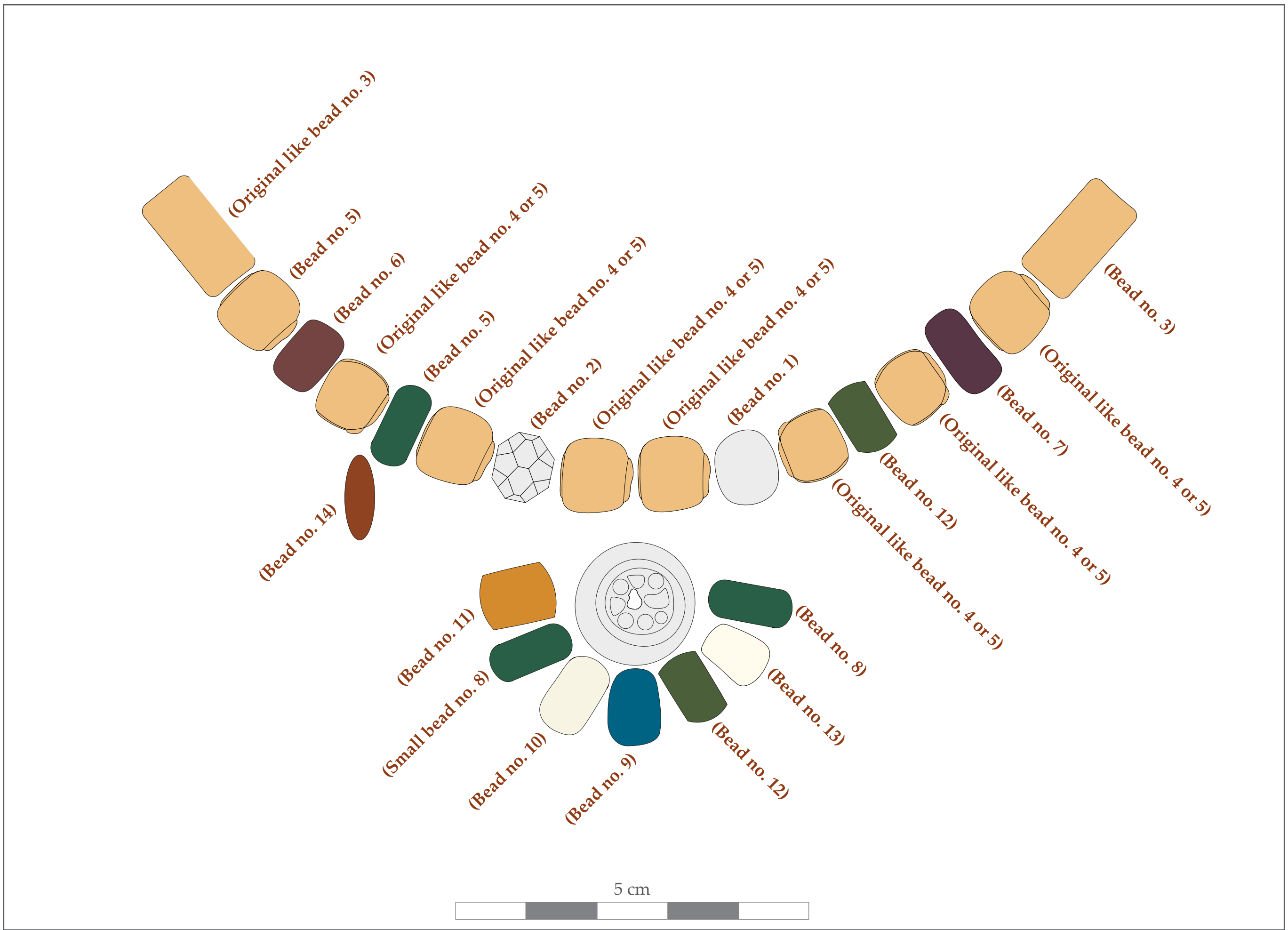
Based on the descriptions mentioned in the written documentation, it is likely that the beaded jewellery consisted of a row of beads with pendants, a rosette of glass beads, a pierced silver coin and an amber bead.

The beaded jewellery can thus be reconstructed in the following way from left to right (fig. 10.3, 10.4):

Cylindrical glass bead with pieces of fused gold-foil (bead no. 3)
Gold-foil covered glass bead (bead no. 4)
Mosaic glass bead (bead no. 6)
Gold-foil covered glass bead (bead no. 5)
Green glass bead (bead no. 8)
Gold-foil covered glass bead (originally like bead no. 4 or 5)
Facetted rock crystal (bead no. 2)
Gold-foil covered glass bead (originally like bead no. 4 or 5)
Gold-foil covered glass bead (originally like bead no. 4 or 5)
Rock crystal bead (bead no. 1)
Gold-foil covered glass bead (originally like bead no. 4 or 5)
Green glass bead (bead no. 12)
Gold-foil covered glass bead (originally like bead no. 4 or 5)
Mosaic glass bead (bead no. 7)
Gold-foil covered glass bead (originally like bead no. 4 or 5)
Cylindrical glass bead with pieces of fused gold-foil (originally like bead no. 3)

Pendant section of glass beads, from left to right:
Orange glass bead (bead no. 11)
Green glass bead (originally like bead no. 8)
White glass bead (bead no. 10)
Blue glass bead (bead no. 9)
Green glass bead (originally like bead no. 12)
White glass bead (bead no. 13).
Green glass bead (originally like bead no. 8)
Silver coin, pierced (C4279)
Amber bead, double conical, convex (bead no. 14)

In the upper row of beads, every second bead is a gold-foil glass bead, as was observed by Uldall. However, only two nearly intact barrel shaped gold-foil glass beads have been preserved. In the protocol from 1880, it appears that there were six clear glass beads with merged gold-foil - five round and one oblong. Engelhardt subsequently writes in the excavation report that there are four round glass beads with gold-foil. This means that



▲ Fig. 10.4: A schematic overview of the reconstructed bead jewellery.

Illustration: Mads Lou Bendtsen

at least three round glass beads with gold-foil must be missing today. Furthermore, he adds that the crumbled and dissolved glass beads were found together with the pieces of gold-foil. The missing beads may also be found amongst the fragmented glass beads with gold-foil, which today are located with the other broken glass beads and the preserved pieces of gold-foil. It is cautiously estimated that the fragments of degraded glass beads and gold-foil strips must come from at least seven glass beads with gold foil.

In the current reconstruction, the jewellery is finished at each end with a cylindrical glass bead with fused pieces of gold-foil. Only a single cylindrical glass bead of this type was preserved (and observed), but since a symmetrical construction of the beaded ornament was apparently aimed at, a corresponding bead from the opposite end of the string may have broken down. These fragments might be found amongst the broken glass and the pieces of gold-foil. The smaller, almost rectangular pieces of gold-foil apparently originate from such a cylindrical glass bead.

In the necklace, the two rock crystal beads, the two preserved green glass beads and the two mosaic beads have also been inserted. Between each of these beads, we have placed a round glass bead with gold-foil. Thus, the beaded jewellery contain 16 beads consisting of eight barrel shaped gold-foil glass beads, two cylindrical shaped glass beads with fused gold-foil, two green glass beads, two mosaic beads and two rock crystal beads.

In the grave, two inches from the upper row of beads, a rosette of monochrome glass beads was observed. We decided to reconstruct this rosette with seven plain glass beads and with the coin placed in the centre. The circular bead pendant is attached with a twisted silver wire to the upper bead string. Bead pendants with twisted silver wire are often seen on

► Fig. 10.5: The bead necklace reconstructed by Kathrine Sode Vest.

Photo: Roberto Fortuna

Viking Age bead necklaces. Uldall describes that the lower row of beads formed a small circle in the centre of which the coin lay, just as he writes that there were remains of two broken, green beads. Seven beads are drawn on Uldall's sketch. In our reconstruction, we have therefore chosen to use seven glass beads corresponding to the preserved beads together with three green beads, which are represented by the existing fragments of green beads.

It was described that the amber bead had possibly slipped out of its position in the upper bead row. Another possibility is that the amber bead was attached to the ornament as a pendant in a silver wire as well. If this was the case, and if the beaded jewellery is to appear symmetrical, another amber pendant might have existed on the opposite side of the central circular beaded pendant. Since, however, no more than the one amber bead has been observed or found, we have chosen in our reconstruction to mount only a single pendant with an amber bead in the ornament.

The silver coin was positioned in the grave so that it lay in the middle of the circle of monochrome coloured glass beads. There were no recorded finds of silver wires in the grave, but the characteristic wear of the hole in the coin indicate that it had been mounted on a metal wire, most likely a silver wire. These pendants with silver wire are known from quite a lot of contemporary beaded jewellery from the Viking Age. It is easy to imagine that remains of degraded, black-oxidized silver wire would have been difficult to detect in a dark, rain-soaked layer of soil. Due to the early date of the excavation (1880), the difficult excavation conditions and the poor state of preservation of the find, there are probably materials that were not observed during the excavation and therefore not preserved.

Bead necklaces with attached pendants, using twisted silver wire were presumably inspired by Byzantine jewellery fashion. The Byzantine beaded ornaments were often composed of beads, pearls and pendants with gemstones in gold mounts. Parallels to beaded ornament with pendants, like the reconstructed one from Hvilehøj, are in Scandinavia known amongst others from the Norwegian hoard found in Hon (Almgren 1967; Fuglesang & Wilson 2006), and from a series of high-status female graves in the cemetery of Birka in Sweden (Arbman 1940; 1943; Wärmländer & Wåhlander 2012).

Conclusion

The beaded ornament from Hvilehøj is composed of more beads than normally found in late Viking Age high-status female graves and compared to the other contemporary beaded ornaments this is an unusual piece of beaded jewellery.

The reconstruction is inspired by a jewellery fashion that favoured large necklaces such as the necklace in the Hon treasure and necklaces in a number of rich graves from the Birka cemetery (eg. Bj 557; Bj 632; Bj 642; Bj 649). But what makes this necklace special amongst the wagon graves is particularly the number of glass beads, rock crystal beads and gold-foil glass beads, as well as the construction with pendants.

For the small bead necklaces in late Viking Age graves, it seems that they are often composed of much older glass beads, even from the Roman period or the Germanic Iron Age, whereas others are contemporary. The complicated burials in wagon graves, grave chambers or the like apparently reflect the graves of early Christian women, where burial customs and burial equipment differ from the pagan times. The Hvilehøj woman's jewellery represents in this way the exclusive and latest fashion of the time, which was without the oval brooches used in connection with the traditional suspension dress. The chamber graves with wagons from Hørning and Jelling were both found under or adjacent to the remains of a later church, which also indicates the Christian affiliation.

In the late Viking Age, the richest women of the society set themselves apart by wearing the new high fashion continental-inspired dress, which was often worn with a small piece of beaded jewellery. The early Christian women's costume was inspired by the Frankish and Byzantine fashion, just as the beaded ornament. The oval brooches, the trefoil brooches and other fibulae did not belong on this new exclusive women's dress, on the contrary the small beaded ornament does.

11. The finished outfits

The textiles from Bjerringhøj and Hvilehøj are some of the most well-preserved from Danish Viking Age burials. Even so, there is still quite a gap between the archaeological finds and the finished reconstructed outfits. The results of all the various analyses presented here have been a great help and guide for the different production processes and the final design – but also somewhat of a millstone around the neck.

Right from the beginning, the premise for the reconstructed outfits was that once the results of the fibre and dye analyses were ready, they should not be disputed, but rather incorporated in the design of the outfits to the largest degree possible, no matter what modern aesthetics would say. On the other hand, dye results primarily indicate the dye source used, but not the actual hue or intensity of the colour. The choice of colours in a reconstruction will thus always be a qualified guess. Likewise, it turned out to be very difficult to find the right type of wool that matched the standards of Viking Age textile production. Even so, the *Fashioning the Viking Age* project has firmly demonstrated that the raw materials influence and make an important and decisive difference in the visual appearance of a fabric, and the choice and use of fibres and materials as correct as possible cannot be overstressed.

During the two-year time-frame we had set to produce the outfits, it was not always possible to await the scientific test results. In the tight reconstruction process, some decisions were therefore made on old or preliminary results that later came out differently, but too late for the outfit designs to be changed. This was definitely frustrating, but also an important lesson, and a reason not to see the current reconstructions, or any reconstruction, as final truths.

As an example, the protein analyses for species identification conducted on the fur and skin fragments from the two graves were not ready when the reconstruction work of the fur and leather objects began. We therefore chose materials based on first results and other criteria such as the feel and appearance of the fur and leather. The fur coat for the male outfit was crafted fully in Canadian beaver fur in such a manner that the garment can be turned inside-out and worn in flexible ways. The choice of this species was later identified with certainty. The female cape was crafted in American pine marten with edges in beaver fur which, at that time, we thought were the most likely materials used. A further advantage of using these two fur types is that they are not protected species, which would have made it difficult for the final clothing items to cross country borders. We now know that the female fur garment, if the fur was indeed used for a garment, should have been made fully in beaver fur or in a combination of beaver and European squirrel. Even if we had known this, the use of squirrel would under no circumstance have been an option, as such fur is very difficult to get hold of. Knowing all of this now, we are very pleased with the result of the two fur garments, which in their own way demonstrate the potential and beauty of exotic fur, that few people have any experience with today. The furs were crafted using simple, but effective hand scraping and curing methods, and they have obtained a fascinating lightness and flexibility, that will probably become even greater with use.

We think it is important to show that the Viking Age population had a long tradition of using animal skins and fur for all kinds of products, clothing as well as accessories, interior decoration and transport. They would definitely know how to use all their skills in processing the skins and fur for optimal use. The idea of wearing a full animal carcass over the shoulder, such as a sheep, fox or a wolf skin, is often depicted in various Viking Age films and re-enactments, but it does not acknowledge and respect the potential, value and craftsmanship of processing skins. There is no reason to believe that skin and fur items were less well-crafted and fitted to the wearer than is the case with textiles.

The male outfit

Based on what is known about the Bjerringhøj grave, which unfortunately was badly looted when it was found in 1868, it has been a difficult task to find a logical and possible use and position for all the well-preserved features in the grave in the reconstructed male outfit. As can be seen from fig. 11.2 and fig. 11.3, it now has a wholly different appearance compared to the replica from 1991 (see fig. 2.3) (Munksgaard 1991) with a different way of using the wrist cuffs, the rouleaus and the pendants (see chapter 5). The angle cuffs, linked to the trousers, not known in 1991, is a feature entirely new for this reconstruction.

From the beginning, it was the intention for the male outfit to contain a pair of wide breeches and leg wrapping bands, commonly used in Viking Age re-enactment groups. This type of leg covering is also known from Viking Age iconography (Mannering 2017a, 115) (fig. 11.1). The open tabby weave, C135b, was meant to be the main textile for a pair of trousers of this kind. However, the recovery of the long-lost bones of the Bjerringhøj man changed the interpretation of the legwear completely (Rimstad et al. 2021). Textiles still attached to the bones showed that the trousers were long-legged and that they ended in padded cuffs similar to the wrist cuffs. The tablet-woven bands used on the wrist cuffs and the leg cuffs are however not identical, and neither is it known which type of weave covered the leg wool rolls. The wool rolls themselves on the other hand, turned out to be of the same kind as the obviously unfolded textile C135b, and even identical to the fabric used inside the wrist cuffs.

▼ Fig. 11.1: A 3.4 cm high silver pendant unearthed with a metal detector in 1996 at Uppåkra in Sweden, dated to the Viking Age. The figure is wearing baggy knee breeches with many folds, and on the basis of the clothing, it is most likely a male.

Illustration: Pernille Foss

As an inspirational source for the long trousers, it was thus decided to use an adjusted version of the Skjoldehamn trousers. During the reconstruction process, new solutions to the bad fit of the crotch came up, as also suggested by Dan Løvlid. Hopefully others will continue experimenting with a better and more likely design solution. Altogether, the many similarities between the details recorded in the Bjerringhøj textiles and the Skjoldehamn find, not only in the trousers, but also in the kirtle, is an aspect which has the potential for further examination.

For the kirtle, the embroidered 2/1 twill from Bjerringhøj was used. As mentioned above, this textile shows clear signs of being reused, as exemplified by the secondary reworked neck opening (C135a fragment 64, see fig. 5.3). Other pieces also show signs of other types of repair and mending (fig. 5.9). The fact that these are executed in silk threads could indicate that these various repair or alteration processes took place in other use-stages of the textile. It is, therefore, very likely that the embroidered textile from Bjerringhøj in its primary stage functioned as a kind of household textile, perhaps a decorative wall hanging, a tablecloth or a blanket, which at a later stage was remade into a kind of garment. It is further likely that the textile was already old and had been repaired several times before the final remaking took place. The preserved fragments do not reveal when this functional alteration took place, but the embroidered textile could, in theory, have been used as a household textile for a long time before the funeral.

The question is then, what kind of garment was the household textile turned into? Some clues are available for guidance. After the looting of Bjerringhøj in 1868, the farmers explained that the embroidered textile was one of the first things visible to the eye in the grave (Vellev 1991, 21). During the analysis of the recently rediscovered human bones from the grave, it was discovered that small remnants of the embroidered textile still adhered to the lower leg bones (Rimstad et al. 2021), indicating that the textile covered most of the body and thus was much longer than a traditional male kirtle are expected to be. It is therefore also a possibility that the V-shaped neck opening was constructed only to keep a funeral garment/shroud in place around the body. This may also explain why only few of the 64 preserved pieces contain traces of sewing or seams, although these, in theory, should be the most durable in clothes. Another explanation for this could be that the looters only saved the most beautiful pieces and discarded the simpler pieces with hems and seams.

The interpretation of a long funeral garment did not affect the pattern made for the reconstructed kirtle, but it could affect the embroidery design. Based on archaeological textile finds from the Viking Age, it can be documented with certainty that it was generally uncommon to decorate clothing items with large-scale embroidery in this period. Sewn yarn decorations were instead primarily seen in the shape of reinforcements of edges and seams and not as surface-covering decorations (Mannering & Rimstad forthcoming a). It was therefore decided that the reconstructed embroidery design should embrace both the first and the second stage of use. Further, it was

► Fig. 11.2: The finished male outfit with the kirtle, belt, trousers and shoes.

Photo: Roberto Fortuna

◄ Fig. 11.3: The finished male outfit with the caftan, trousers and shoes.

Photo: Roberto Fortuna

designed to only fit onto the front and back pieces of the kirtle while no embroidery was placed on the sleeves. This is, of course, not the final truth or the only way that the design may have been like, but the best suggestion at the moment. Further, it was decided to place all fragments on the same clothing item, as opposed to the Mammen costume from 1991, where selected motifs were placed on two different items, the kirtle and the cloak (Munksgaard 1991).

To work with the 64 pieces of the embroidered 2/1 twill digitally has definitely been a rewarding method, but in spite of very thorough analyses, it still proved to be extremely difficult to decode the design, primarily due to the fact that many fragments are still missing, and the overall composition does not seem to be symmetrical. The different motifs move in all directions on the ground weave and there seems to be no obvious narrative composition following the direction of the ground weave or any other horizontal lines that could be connected to its use as a decorative textile. A dominant feature in the embroidery design is the nearly circular rows of acanthus vines which encircle some of the other motifs. But even when trying to place the fragments in accordance with the supposed secondary use, the embroidered motifs were so different in size, composition, and style, that the original textile must have been quite chaotic and lively in its design, no matter how the pieces were connected. The composition does, in this way, seem to build on several different design principles with an overall plan that is difficult to grasp, but also exemplifies a great pleasure in storytelling. It is not unlikely that several people took part in creating the embroideries, and that the embroidery evolved during its lifetime. Differences in the size of the embroidery stitches also implies this. Further, the new analyses have successfully proven that important parts of the embroidery design are now invisible to the eye, as exemplified by the many empty stitch holes in the ground weave. Most likely, a much more complicated and surface covering pattern would emerge if all stitch holes were included in the design. This is an interesting task for the future.

The two pendants (C137) have been interpreted in various ways until now, as remnants of a head band (Hald 1980, 108) to endings for a cape band (Munksgaard 1991), and as liturgical vestments (Ræder Knudsen 2007). In this new reconstruction, we interpreted them as a belt, combining them with two other textiles. The silk samite and wool strips have similar widths and fit perfectly as the front textile and lining respectively, in the belt. We are confident that this design is just as possible as the previously suggested ones. Further, as the current male outfit does not comprise a textile cloak, a use as cape bands would not be appropriate here. However, the belt can also be worn as a decoration over the shoulders.

The heart silk strip (C140 fragment 2) is another fascinating textile item, that until now has been totally overlooked in regard to its importance and interpretation. Based on the folded edges it was sewn onto something, a textile or another material, and most likely a kind of clothing item. In the reconstruction it is sewn onto the fur coat. Both the previous and recent dye analyses have identified madder as the dominant dye source in this textile, and most likely, the textile originally had a white heart pattern on a red background (see fig. 5.46). Similar silk finds have been found in several male and female high-status graves in Denmark, Sweden and Norway and the interpretation of these silk textiles should not just be as pretty luxury products. They should rather be seen as a kind of hard currency, possibly linked to the Viking voyages and perhaps used as a payment or salary for services during these important travels. This may in fact explain, in a more satisfactory way than just as a decorative feature, why many silk textiles were cut into sometimes minute pieces, very similar to the practice of cutting coins and silver jewellery into pieces (Vedeler 2014).

As such, it is clear that the abovementioned clothing items represent the same overall design idea although they most likely do not represent a single unified production scheme. Further, it has indirectly been suggested that some of the objects, like the wrist cuffs and the pendants, could be objects originally coming from different contexts, i.e., as non-local gifts or stolen goods. For instance, it has been suggested that the pendants could have been parts of liturgical vestments, such as the stole and maniple which are integrated into Roman Catholic religious practice (Ræder Knudsen 2007, 3-9). Examples of this type of vestment are known from several more or less contemporary contexts often linked to the graves of saints or reliquary finds. On the other hand, most of these examples are made in completely different techniques to those of the present finds, such as silk embroidery or the tablet-weaving technique (Coatsworth, E. & Owen-Crocker, G. 2018). Other finds of wool rolls and paddings decorated with similar tablet-woven bands, indicate that the use of this design idea was more deeply rooted in the local clothing production scheme than previously anticipated. Although the padded decorative features are linked primarily to the Bjerringhøj context, similar details are found in the Hvilehøj grave, and wool rolls were also recovered from the graves in Jelling and Skindbjerg (Krogh & Leth-Larsen 2007, 127-128; Hedeager Krag 2013). Altogether, this new discovery and interpretation urges us to look into other contemporary find contexts with fresh eyes.

The female outfit

The female outfit, based on the Hvilehøj textiles, was definitely less complicated to recreate, merely because there were fewer textiles in this grave. However, each individual textile still presented challenges in the design and reconstruction process. Contrary to the very yellow and pink male outfit, the female outfit ended up with a design dominated by the bright red colour of the wool dress (fig. 11.5, 11.6).

As the Hvilehøj grave does not contain any oval brooches it was obvious that the dress had to function without these pieces of jewellery. In the Danish area, female clothing without oval brooches is found from the mid-10th century AD, whereas oval brooches have a longer use in, for instance, Norway (Petersen 1928, 74-75). This means that the reconstructed dress does not necessary match a design appropriate for the whole Viking Age period or for all areas in Scandinavia. As such there are still many unsolved questions about the design of the strap dress, that remain to be addressed.

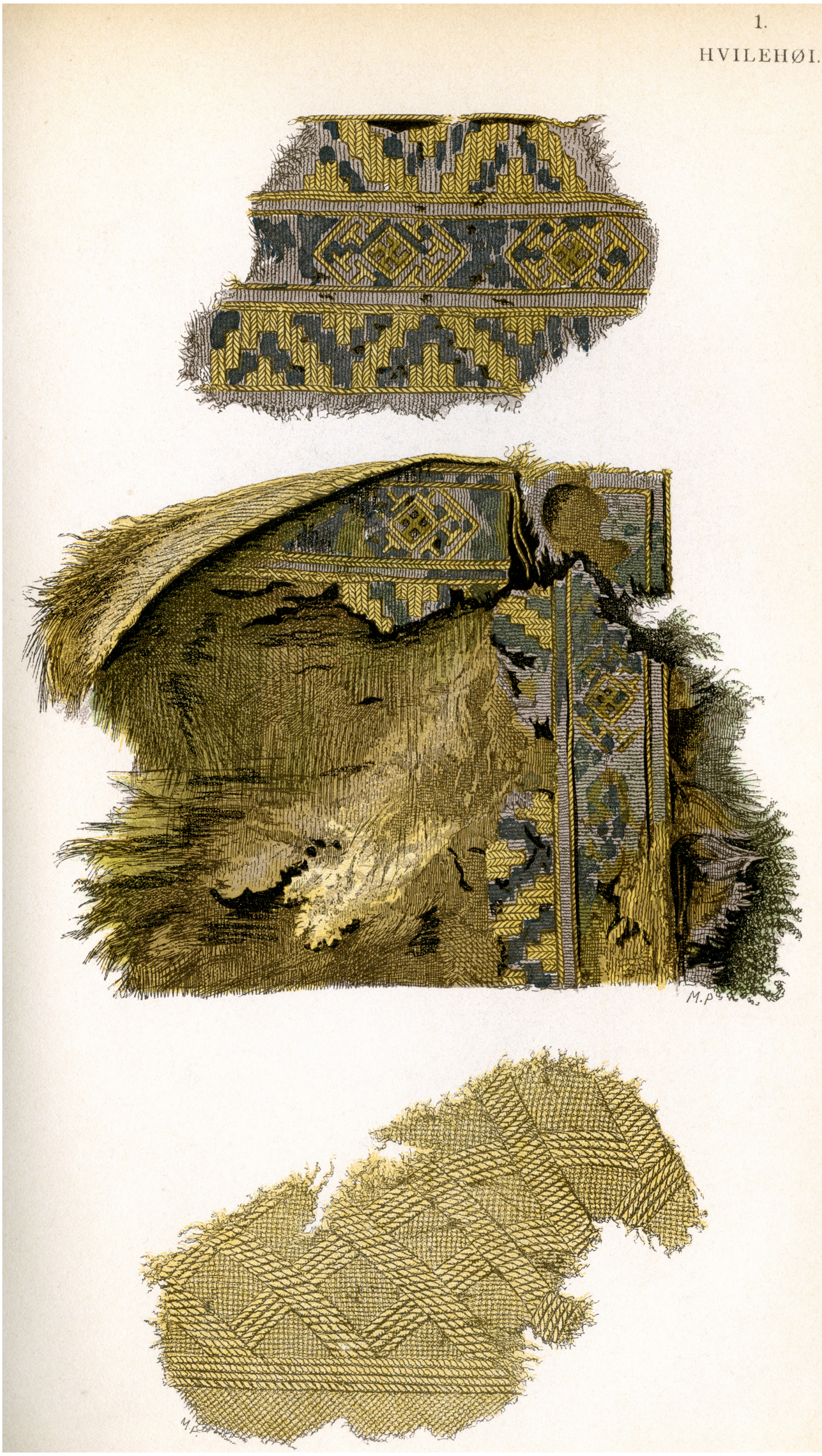
The very fine wool tabby, found on the chest of the Hvilehøj woman, was used as ground weave for the dress. At first glance, it confirms the overall present knowledge of Viking Age textile production but is nevertheless unusual in several ways. The first issue is, of course, the kermes dye, which could have led us to believe that the textile was an imported piece. As the dye analyses further documented that the pattern yarn was not dyed, it was obvious that dyeing took place on a yarn level. This means that yarns for the ground weave and the pattern respectively could have different origins. The wool analysis, on the other hand, shows that all three yarns, warp, weft and pattern weft, only have slightly different wool fibre compositions. This indicates that the yarns for this textile were prepared and sorted for specific uses. A very controlled and complicated production process is thus evidenced, where spinning and dyeing most likely took place in one coherent process. The fact that another textile from the Hvilehøj grave, a 2/1 twill wool strap (C4280b fragment 17), was also dyed with kermes, is the final argument for the interpretation of this textile as part of a local textile production with local resources alongside exclusive and unusual raw materials. It is interesting to consider that the same colour would have been obtainable with dye sources more easily available than the kermes, such as madder and cochineal (Cardon 2007), which were used for the reconstructed dress. However, colour was surely more than just a shade in the Viking Age, and the origin of the dye stuff must have mattered and emphasised the status of the woman.

Compared to the embroidered textile from Bjerringhøj, which is a rare decorative technique in the Viking Age, the use of in-woven patterns as in the Hvilehøj tabby is much more in line with Scandinavian Late Iron Age and Early Medieval patterning techniques (Nockert 1991; Lester-Makin 2019). Although the reconstruction process has shown that it would have been much easier to make this pattern using the embroidery technique, it was created during the weaving of the ground weave. The recreated design, seen on fig 6.3, is composed of the pieces that were found on the chest of the deceased, and as there are no remains of this textile in other places in the grave, it is uncertain if the pattern covered all parts of the textile and even if it was originally used for a garment. Based on the strict and symmetrical design of the preserved pattern, this could in fact also be a decorative household textile, placed on top of the body. Once again, this possibility challenges and complicates our interpretation of textiles found in graves as always belonging to clothing.

Although the dye analyses of the many complicated band sequences placed on the fur cape came out with many different results, they do in fact match and support each other beautifully within the red-purple-blue spectrum. The placement of the band was another matter for discussion. When the Hvilehøj grave was excavated, the illustrator of the National Museum of Denmark, Magnus Petersen, made some lovely drawings of the textiles (fig. 11.4) (Engelhardt 1881). They

► Fig. 11.4 Magnus Pedersens illustration of the textile fragments.

Illustration: Magnus Pedersen 1881



show fragments with tablet-woven bands and the 3/1 twill band, seemingly attached to the fur at a 90° angle. After analysing the real textiles, it is, however, obvious that Magnus Petersen drew the two bands out of scale when compared to each other. A different drawing supposedly shows the red tabby with in-woven crosses, but the direction of the warp, weft and pattern weft threads are also shown incorrectly here. Magnus Petersen had clearly observed the finds, but was not really aware of what he was looking at. Therefore, the drawings cannot be trusted as to the details, but they were still to some extent used as inspiration for the placement of the bands on the fur garment. Moreover, the fragments themselves were placed in the most logical way in order to make the complicated sequences of tablet-woven bands, other woven bands and cut silk strips fit. It would definitely be interesting to see other suggestions for their use, and there are also further important parallels to pursue. Nevertheless, despite the fact they may appear exotic at first glance, the construction details seem to match a well-known Viking Age style.

As in the Bjerringhøj grave, wool rolls for padded decorations also occur in Hvilehøj, but using other materials. In this case, it is not known if the preserved wool rolls were covered by a layer of, for instance, a silk textile, or if they were used like they are now. In the coarse wool rolls, traces of alizarin, i.e. a red dye, were found in one sample, while a sample from one of the other rolls did not show any evidence of dyes. Considering the coarseness of the wool rolls compared to the silks, to our mind, it most likely that they were covered with a non-preserved silk textile, as suggested in the reconstruction.

The hair-on goat skin shoes which were created for the outfit, were a surprise to both researchers and craftspeople. It is unusual to find remains of shoes in graves, and the fact that remnants of both shoes were present and that they have an obviously very simple design compared to most other Viking Age shoe designs is really interesting. The hairs on the surface are almost completely worn down or degraded. It is therefore difficult to say if they were worn or almost new when they were placed in the grave, but they most likely represent a use linked to indoor rather than outdoor activities.

Altogether the design and decorative elements linked to the Hvilehøj dress seem unique, but we can already pinpoint parallels that can help decipher whether the textile was produced in the Nordic area using exotic and foreign dye stuffs, or it was a true piece of import. At the moment, we believe that the textile was crafted in Scandinavia. The weave, the wool quality, and the fact that another textile, a small strap made in a 2/1 wool twill (C4280b fragment 17) dyed with kermes was found in this grave, supports this interpretation. The Hvilehøj woman was definitely familiar with all the well-known European high-status signals and materials, such as silk textiles, metal yarns and exotic fur. On the other hand, the in-depth analysis of the production reveals that techniques and execution are firmly grounded in a Nordic and local textile production tradition. This is an important aspect of Viking Age cloth culture, which will be investigated further in the years to come.

Concluding remarks

When analysing archaeological textiles, the analysis begins with the threads and fibres, but often only ends with a written interpretation of how the textile was used. In this project it has been possible to go all the way from tiny fragments to two whole, wearable outfits. We have in this work learned so much about practical textile making that we can incorporate in a whole new way into future analyses of the original textile and skin finds. Further, in this project we have been so fortunate to have had the expertise of numerous skilled crafts people and the dialogue between researchers and craftspeople has been very rewarding. Altogether, the two outfits express the combined forces and skills of more than 50 minds and hands. We have had specialists to spin yarns or give extra twist to already machine spun yarn by hand using a spinning wheel, to plant dye the many different yarns and fabrics, to weave silk and wool textiles, to braid, make naalbinding and weave the complicated and extremely time-consuming tablet-woven bands, to cure the furs and tan the leather, and to sew and decorate the many textile and skin items. In some cases, pre-dyed, pre-spun or pre-woven materials have been used to make the production of the outfits faster and cheaper. In the Viking Age, all of these processes would have been done by hand and have been the work of many months, seasons, and skilled people. Without the talent and enthusiasm of all the participants, this project could not have succeeded.

► Fig. 11.5: The finished female outfit with the dress and shoes.

Photo: Roberto Fortuna

◄ Fig. 11.6: The finished female outfit with the cape, dress and shoes.

Photo: Roberto Fortuna

Nevertheless, it is important the keep in mind that the outfits do not represent the ideal outfit of an average Viking Age male or female. We chose these two graves because they contain the most and largest assemblages of archaeological textiles from any archaeological context in Denmark, but, in fact, we know very little about their actual use in the graves. The textiles have certainly been used together and represent one context, but not necessarily one outfit. Particularly when it comes to the male outfit, it is also worth remembering that the new reconstruction reflects a lifetime of use. Despite the huge amount of research, analysis, and craft work put into each garment, they remain possibilities, not final truths (fig. 11.7).

The Bjerringhøj grave has more than seven different silk textiles and four different tablet-woven bands made in silk, silver and gold threads, and a unique embroidered wool textile, and it sits in the absolute luxury class in a Viking Age context. We have no other finds that can be compared to this grave in complexity and richness. Also, the content of the Hvilehøj grave is special with its delicate and time-consuming tablet-woven band, the other silk band and strips and the rare kermes dye. Nevertheless, it is primarily on the basis of the wool analyses of all the different textiles, ground-weaves as well as wool rolls used for the various paddings, that makes us certain that all the wool textiles were crafted in a Nordic environment, and that all items in the two graves were made locally. Of course, the silk fabrics and silk yarns for the tablet weaves must be considered imports, but this does not exclude a local production. Generally, we can conclude, on the basis of all analyses that silk fabrics, even in a high-status context, are a decorative feature that was only used in a very limited amount in the Viking Age, and primarily as thin strips of fabric sewn-on as decoration.

In the Viking Age, the tablet-weaving technique was primarily used for narrow bands. Even the tablet-woven bands made in wool are narrower compared to earlier periods, but seem to use more or less the same kind of patterns. This makes us believe that, in spite of the exotic materials, all of the tablet-woven bands reported here were crafted locally somewhere in Scandinavia.

The two quite large wool textiles preserved in Bjerringhøj, the embroidered 2/1 twill (C135a) used for the male kirtle and the tabby (C135c) used for the trousers, were, according to the dye analyses, both yellow. The presence of so much yellow fabric in the same context, compared to previous analysis, challenges the generally accepted idea that high-status garments in the Viking Age were usually blue or sometimes red (Walton 1989). In the Bjerringhøj and Hvilehøj contexts the colour blue is primarily linked to decorative features such as tablet-woven bands or textiles used for non-visible wool-roll paddings, or household textiles, like the blue cushion in Bjerringhøj or the coarse 2/2 twill in Hvilehøj which is interpreted as the cover of the mattress on which the woman was placed (Rimstad forthcoming). Blue is in the Bjerringhøj and Hvilehøj contexts thus not at all linked to textiles that can be securely ascribed to clothing. Our current knowledge about Viking Age colour aesthetics is thus challenged by the many new dye results obtained in the *Fashioning the Viking Age* project, and the results call for a rethinking of Viking Age colour codes and traditions. In the best of all worlds, we should have made many different reconstructions, that could represent parts of the reality in different ways. A first mistake to correct would be the make the embroidered male kirtle yellow in the ground weave. Because physical reconstruction work is so time consuming and expensive, this was unfortunately not an option.

Now that the outfits are in the exhibition at the National Museum of Denmark, we can see how strong a statement and contribution they are to the visualization of the past. They are simply an eye-magnet, that can be easily understood by museum visitors, while this report hopefully can help the interested reader to see all the hard, and sometimes inconsistent, decisions that lie behind their creation. So with a glint in the eye we say: do not copy our work at home, do not repeat our mistakes, and make your own decisions regarding comfort, wear and visual appearance. Resist stereotypes and remember to honour the development in textile production, the chronology and, last but not least, all the prehistoric craftspeople.

◄ Fig. 11.7: The finished male and female outfits without the cape and the caftan.

Photo: Roberto Fortuna

12. Researchers and craftspeople

In this project, analyses of the archaeological finds from Bjerringhøj and Hvilehøj are the basis for all design decisions. This process turned out to be much more time consuming and complicated than first anticipated, but luckily many skilled researchers and craftspeople agreed to assist us along the way with their many kinds of expert knowledge. We therefore also thank the craftspeople who have delivered detailed reports which have been used as a foundation for much of this publication. Some were already employed at the National Museum of Denmark, while others came from collaborating institutions such as University of Copenhagen, the Technical University of Denmark and University of Aarhus. Other analyses had to be done abroad. The dye analyses were conducted in Brussels, while some were conducted by independent researchers in Denmark or abroad.

When analysing the textiles from these two fascinating Viking Age burials, one is in awe of the extremely skilled craftspeople who produced these items more than a thousand years ago. The details and exquisite execution of the work is striking, and it is clear that materials were valued over working hours at the time. Much experience was needed to produce items of this kind of quality. Finding modern craftspeople with the same skills therefore proved to be a challenge, though luckily not impossible. Land of Legends in Lejre already housed several experienced craftspeople within the fields of spinning, weaving, dyeing, embroidering, braiding, and pattern construction. However, time proved to be a challenge, as one craftsperson can only work on one thing at a time, and it was therefore necessary to look for expertise in other places as well. Experts on silk weaving, tablet weaving, needle binding, fur tanning, shoe and bead making had to be found elsewhere in Denmark, and the rest of Europe, such as in Sweden, Norway, Czech Republic and the UK. Often, the different craftspeople could recommend each other and at other times skills and materials were searched for on the internet. We are very satisfied with and grateful to all the gifted people who became a part of the project:

Andreas Jæger Manøe Schäfler, Student Assistant, National Museum of Denmark: correction of publications

Anne Batzer, Textile Dyer: dyeing of textiles

Anne Lisbeth Schmidt, Conservator, National Museum of Denmark: microscopy of skin and fur

Arne Jouttijarvi, Materials Scientist, Heimdal-archaeometry: analysis of iron and gold objects

Bente Phillipsen, Physicist, National Museum of Denmark: sampling

Bernard Gratuze, Scientist, University of Orléans, France: analysis of beads

Birgitte Kjelstrup, Seamstress, Denmark: sewing of garments

Carla Dove, Zoologist, Smithsonian National Museum of Natural History, USA: analysis of feathers and down

Carsten Gundlach, Physicist, Technical University of Denmark: CT-scanning

Chiara Villa, Forensic Anthropologist, Department of Forensic Medicine University of Copenhagen: CT- scanning

Espen Kutschera, Skin Craftsman, Norway: shoe-making

Fria Gemynthe, Textile Technician, Denmark: embroidery

Ida Demant, Archaeologist and Leader of the Textile Workshop in Land of Legends: weaving and pattern design

Ida Rebekka Mikkelsen, Student, University of Copenhagen: photo model for the female outfit

Ina Vanden Berghe, Scientist, KIK-IRPA, Belgium: dye analysis

Irene Skals, Conservator, Denmark: fibre analysis and sewing of garments

Johan Zakarias Gårdsvoll, Student Assistant, National Museum of Denmark: correction of publications

Julia Hopkin, Skin Craftswoman, UK: sewing of skin garments

Kateřina Křížová, Textile Craftswoman, Czech Republic: tablet weaving

Kathrine Sode Vest, Denmark: production of gold pendants and bead necklace

Line Maria Mørch, Student, University College Copenhagen: intern at CTR and illustrator

Lise Ræder Knudsen, Conservator, Vejle Conservation Centre: analysis and production of tablet weaves

Lone Bjørnskov-Bartholdy, Textile Craftswoman, Denmark: naalbinding

Lone Brøns-Pedersen, Clothing Constructor, Land of Legends: construction of patterns for the skin garments

Luise Ørsted Brandt, Archaeologist, University of Copenhagen: species identification of skin and fur

Mads Dengsø Jessen, Archaeologist, National Museum of Denmark: size and photo model for the male outfit

Mads Lou Bendtsen, Curator, National Museum of Denmark: layout of publications

Malene Lauritsen, Skin Craftswoman, UK: sewing of skin garments

Marie Kanstrup, Physicist, Aarhus University: 14C-analyses

Marie Louise Schjellerup Jørkov, Forensic Anthropologist, Department of Forensic Medicine University of Copenhagen: CT-scanning

Marie Wallenberg, Weaver, Sweden: tablet and band weaving, sewing of garments

Mary Harlow, Textile specialist, UK: language editing of project publications

Mia Lohse, Textile Craftswoman, Denmark: fibre preparation and spinning

Michelle Taube, Chemist, National Museum of Denmark: XRF analysis

Pernille Højfeld Nielsen, Student, University of Copenhagen: intern at the National Museum of Denmark

Rikke Søgaard, Student Assistant, National Museum of Denmark: correction of publications

Roberto Fortuna, Photographer, National Museum of Denmark: photo and documentation of objects

Signe Nygaard, Conservator, National Museum of Denmark: X-ray

Signe Vind, Student, University of Copenhagen: spinning

Sigrid Mannering, Student, University of Copenhagen: size model for the female outfit

Theresa Emmerich Kamper, Archaeologist, University of Exeter: analysis, tanning of skin and fur, sewing of fur garments

Tilde Yding Abrahamsen, Student Assistant, National Museum of Denmark: correction of publications

Torben Sode, Conservator, Denmark: production of gold pendants and bead necklace

Ulla Lund Hansen, Archaeologist, Denmark: analysis of bead necklace

Ulrikka Mokdad, Hand weaver, Centre for Textile Research, University of Copenhagen: beaming assistance

Vivi Lena Andersen, Archaeologist, Museum of Copenhagen: analysis of shoes

Åse Eriksen, Hand Weaver, Norway: production of samite and silk tabby weaves

▲ Fig. 12.1: A part of the team, gathered at the finising reception which took place in the King´s hall at Land of Legends, the 14th of April of 2023.

Project participants from the left to the right, back: Ulla Lund Hansen, Torben Sode, Kathrine Sode Vest, Mads Dengsø Jessen, Inger Heebøll, Mads Lou Bendtsen, Ida Demant, Jens Barnkob, Birgitte Kjelstrup, Søren Ravn, Lone Brøns-Pedersen, Åse Eriksen, Lise Ræder Knudsen, Luise Ørsted Brandt, Anne Batzer, Vivi Lena Andersen, Irene Skals, Anne Lisbeth Schmidt. Front row: Ulla Mannering, Charlotte Rimstad, Sigrid Mannering, Jakob Maarbjerg Toft-Hansen, Eva Andersson Strand, Arne Jouttijärvi

Photo: Ole Malling, Land of Legends

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