Understanding woollen cloth production through reconstructions: a case study from Shetland

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ABSTRACT
Reconstructions of archaeological garments can take many forms – from 'look-alikes' to near copies in materials, qualities and techniques. The more exacting is the reconstruction process, the more is learned about the way textiles were made. Shetland Museum reconstructed woollen garments found in a late 17th century burial. One aim of the project was to make replicas as close to the originals as possible, to better understand the origins and construction of the archaeological examples. Each of the original garments' construction was closely studied and visually analysed from the view of craft specialists, from the quality of the wools to sewing techniques and finishing processes. The fabrics were carefully reconstructed by testing fabric construction processes using various wool qualities to achieve an accurate copy in quality, handle, and appearance. Detailed visual analysis was a vital part of the methodology, which allowed for investigations into construction methods and wool behaviour. A number of key discoveries were made about the original garments, and the project shed light on the way in which everyday clothing was made and worn in the late 17th century.

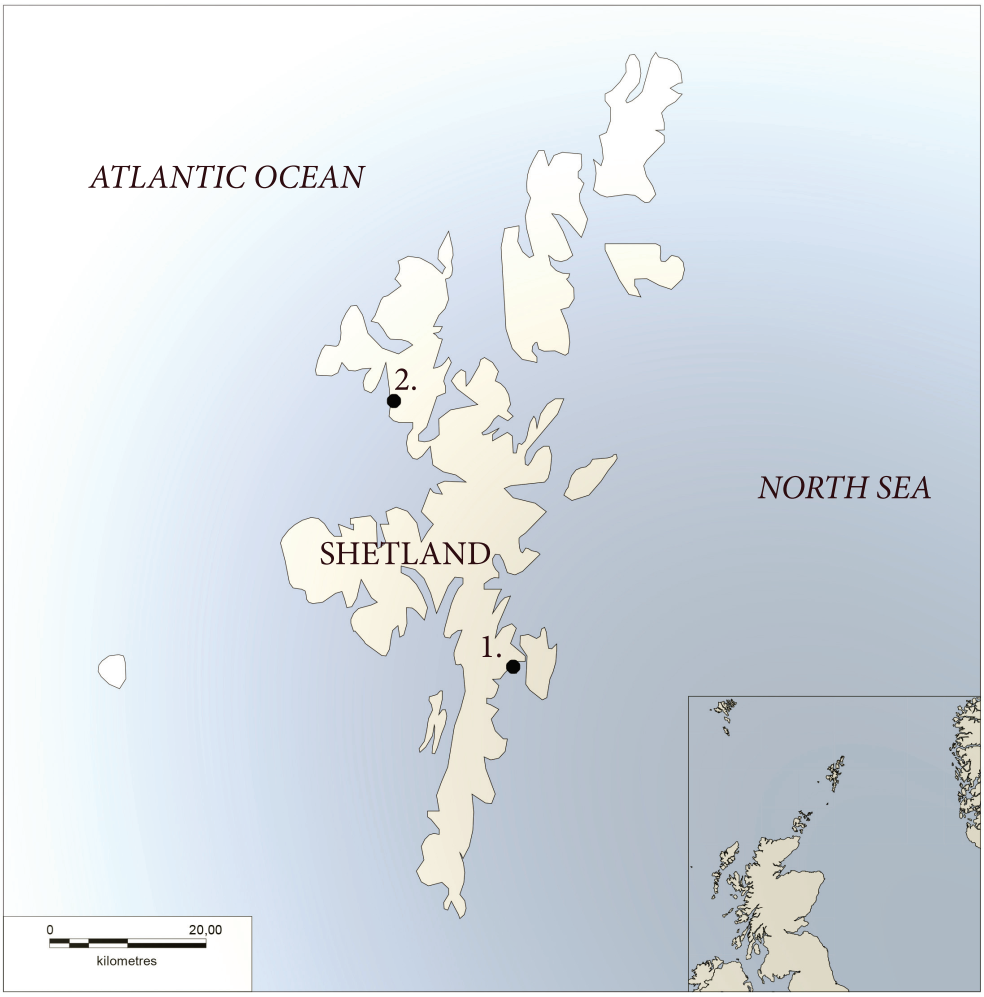
Keywords: wool, fibre, fibre diameter, visual analysis, craft-based knowledge, knitting, Shetland, 17th century.

1. Introduction

Between 2008 and 2012, Shetland Museum and Archives led a project to recreate the finds from a bog burial found in Shetland in 1951 and now part of the National Museums Scotland in Edinburgh. Coins found with the burial date the well-preserved clothing and implements to about AD 1700. The clothing ensemble comprised fourteen different garments made from twenty different woollen textiles, including patches and linings, and yarns used for sewing and mending. The project was an ideal opportunity to use experienced-based handicraft knowledge to accurately reconstruct different types of woollen fabrics, and address detailed questions about how clothing was made in the late 17th century. Through the project, a method was practiced which led to a realistic understanding of how wool choice ultimately determines finished fabrics.

1.1 Human agency in fibre selection

A woollen textile is made from a mixture of fibres which determines many aspects of the textile's quality, such as softness, prickliness, and how resistant it is to wear. The composition of the fibre mixture historically was determined by human agency, through breeding, grading and sorting wool after harvest, and selection during fibre processing and spinning (Fig. 1). In modern textile industry, wool production and selection are done on a large scale with fleeces that are highly uniform, so that direct and constant human agency in the selection of specific wool fibre for textiles is decreased significantly, and in many cases is provided only indirectly by the setting of controls on machinery. For most archaeological textiles, however, wool production processes were done on a minute level, by eye and hand, which allowed for much closer scrutiny of wool quality. This way of working provided the possibility for much tighter controls over wool selection for each textile, and was particularly useful when textile making relied on fleeces containing a range of fibre qualities to choose from.



1. Lerwick
2. Gunnister

Map 4. Placenames mentioned in the article of Christiansen, Hammarlund and Ciszuk. Illustration: K. Vajanto.

1.2 Fibre diameter analysis: a Rosetta stone for textile study?

In the past 50 years, archaeologists have studied the wools in textiles mainly to understand cloth qualities. The standard methodology used for wool analysis is by measuring the diameters of (usually 100) fibres in a short (three to four mm) section of one or possibly two yarns from an archaeological fabric. The results are measured against categories of fibre composition, which have been created to reflect various qualities of fleece. This method is valid when the surviving fabric quality makes other methods impractical or impossible, as is the case with mineralised textiles. But as will be discussed below, fibre diameter analysis is scientifically weak in terms of sampling objectivity and statistical robustness, as an indicator of all fibres used in the whole of the original fabric.

Some archaeologists have gone further with this method, and used fibre diameter analysis as a means to shed light on past practices of species evolution, breed development, animal husbandry, resourcing of raw materials, textile processes, tool use, handicraft skill levels and economic exchange and trade (Ryder 1983, Bender Jørgensen and Walton 1986, Maik 1990). How accurately the results of such a method can address wider craft practices, or to a larger extent, social and economic life in the past, has been questioned in recent years (Christiansen 2004; Rast-Eicher and Bender Jørgensen 2013: 1226–1227).

2. Visual analysis of fabric and fibre behaviour

An alternative methodology for analysing fabric composition and construction was used in place of fibre diameter analysis for the Gunnister Man reconstructions. The method is based on experienced-based handicraft knowledge and uses the fabric's visual appearance and impression as a starting point to understand fibre composition, spinning quality, weaving and finishing processes, and changes or degradation through wear and burial (Hammarlund 2005; Hammarlund, et al. 2008). This method employs a careful visual examination of the textile, beginning with an overall description of the textile's appearance and what impressions it gives. Then features are noted in the following categories:

- Fibres: coarseness/fineness, colour, lustre
- Yarn: single or ply, twist direction, twist degree (angle), yarn diameter
- Weave/knit: type of weave and pattern or knit stitch and pattern, thread count/gauge
- Finishing: surface appearance, with details that may indicate finishing treatments
- Wear: indications of wear, reaction of fibre, yarn and fabric to wear

Fig. 1. Landrace Shetland sheep. Photo: C. Christiansen

2.1. Benefits of visual analysis

This approach was possible because of the excellent preservation of the finds and was appropriate for this particular reconstruction project for several reasons. First, because of the large number of woollen textiles in the ensemble, it was important to understand how the fabrics differed from one another and why. What did these differences have to do with the wool quality mixtures the textiles were made from, and the way the wool was worked during the making of the textile?

Secondly, the Gunnister textile collection contained knitted as well as woven textiles. Very little analysis has been done on knitted textiles, whose structure can require a different fibre composition or quality than woven cloth, and there was little material with which to compare using fibre diameter analysis.

Thirdly, one of the aims of the project was to identify the probable hand manufacturing processes required to make each of the fabrics and garments, in order to use these processes and tools to recreate the textiles accurately. Fibre diameter analysis would not provide this information. Therefore, it was necessary *to approach the reconstructions as the original craft persons would have done for each of the textiles*, from selection of the wool from specific fleeces to the finishing processes used for each garment.

3. Determining a baseline wool selection

The foundation of a woollen textile is the fibre mixture it is made from. Subsequent processes in the manufacturing of the textile build on that foundation, manipulating the fibre mixture to form yarn, fabric, and garment. How closely a reconstructed garment will resemble the original depends largely on the qualities inherent in the wool fibres contained in the mixture. Some of these qualities are visually identifiable (the relative ratio of coarse to fine fibres, colour, and surface behaviour which hints at fibre length), others become apparent only as the fibre is worked and manipulated during the making of the textile.

Although the burial was found in Shetland, it was not known where the textiles originally came from. In the late 17th century, Shetland was a crossroads for fishermen, traders, whalers, and sailors from all parts of Europe (Map 4). The buried man wore a highly fashionable grey-brown suit of thick wool, with shoes common to rural areas. It was highly probable that most of the original wool was from a type of North European 'peasant' sheep. One aim of the project was to use Shetland wool as a starting point for each of the textiles, to test whether all of the garments could have been made from wool of the landrace breed where the man lived his last days.

3.1. Draft descriptions

For each of the fabrics, a provisional picture or 'first draft description' was made. For example, a woolly impression in a fabric can indicate that it was made of finer fibres, and fibre length and crimp affects a textile's texture and smoothness. These characteristics and behaviours were noted and recorded for each of the original textiles using the naked eye or hand lens. Each quality was compared with reconstruction samples from a fabric archive developed over many years by Hammarlund, to pinpoint the characteristics in each textile and narrow the parameters for each step in the construction process.

3.2. Sample testing

The next phase of the project involved making test samples for each fabric, beginning with the draft descriptions. Hand- and machine-spun yarns were used, the fabrics knitted or woven according to relevant gauge or thread count and then subjected to the appropriate finishing treatments. During the making of each test sample, behavioural characteristics were noted. If the wool, yarn, or fabric behaved differently than that in the original textile, this was noted and alterations were made in the way the sample was created, until a matching fabric was achieved. The testing process also involved simulating wear, by shaving a section of the finished fabric to remove fibres that appear on the surface, but are worn away during use. Assessing each test sample and matching them to descriptions and photographs of the original fabric was done with the naked eye and hand lenses.

4. Choosing the correct wool

The test sampling stage of the project revealed how important it was to select wool with similar properties as those in the original textiles. It became clear that wool, even from the same animal or breed of sheep, could behave in very different ways using the same handicraft methods. Conversely, wools from different sheep breeds could respond in similar ways, but obtain different visual appearances through the processes of making. Two examples illustrate the way wool was examined in the original garments, decisions were made about its characteristics, and choices were made for the wools of reconstructed garments.

The deceased wore a fashionable suit comprising a pair of short, wide breeches and a long coat with wide skirt and wide sleeves with large cuffs. The fabric was the same for both garments: a grey-brown wool, woven in 2/2 twill and well-fulled (Fig. 2). The yarn was the same in both warp and weft: s-spun with hard twist. The garments were extremely well-preserved, with only a very small amount of wear on the edges of the garments and the upper front thighs.

4.1. Wool behaviour and precise wool mixture

It was important to find an accurate quality of wool that would look and behave in a similar manner as in the original fabric. The wool was a mix of mainly coarse fibres, so wool from various breeds of sheep, including North Ronaldsay, Herdwick, and Shetland were tested. The results showed that the North Ronaldsay contained too much kemp (very coarse, short fibres), the Herdwick wool was far too coarse. The primitive Shetland had fibres that were too long, so they formed a loopy surface to the fabric, which was not in the original fabric. From these tests, and observing wool behaviour throughout the making processes, it was determined that the fibre in the suit fabric was relatively short, between five and eight centimetres. The wool mix contained a large amount of coarse fibres, but also required some fine fibres to achieve the same surface quality after fulling. We settled on parts of Shetland fleeces that were coarse and short with some fine fibres in the mix (some of the wool being heterotype fibres) and also that would provide the right shade once it was blended. A fabric that looked and behaved like the original was achieved.

4.2. Choosing original wool colours for peat-stained textiles

The permanent exhibition in Shetland Museum was designed to show the deceased, nicknamed the Gunnister Man, as a living person rather than as post-burial. To choose the correct shades of wool colours for the reconstructions, the effect

Fig. 2. The original breeches fulled fabric, with worn area to lower right exposing twill weave. Photo: C. Christiansen

Fig. 3. Natural and tea-stained wools. Photo: C. Christiansen

of colour change due to burial in peat had to be eliminated. Yarn samples made by Hammarlund from different colours of natural wool were stained in strong tea, which contains similar tannins as peat (Fig. 3). The samples provided a key to understanding the wool colours selected by the original makers of each of the fabrics.

The original suit of long coat and breeches has a slight greenish tint to the fabric. Previous dye analysis had not made a definitive conclusion about whether dyes were used on this fabric (Surowiec et al. 2006). However, the samples soaked in tea indicated that some grey-brown wool may take on a green or khaki shade when stained with tannin. From this information it was possible to choose a grey-brown mix of wool for the suit garments. For some fabrics, however, the stained samples did not provide an obvious answer to choice raw wool colour. For example, light grey and light brown were very difficult to differentiate after staining.

5. Identifying intentional design features

One of the advantages of using visual analysis and sample testing is that it may help to identify how unusual characteristics in fabrics were made, and moreover, whether they were made intentionally. Intentionality in textile qualities is very difficult to recognise, because aspects that may have been created for a specific purpose by the original maker may not be obvious now, especially if the textile survives as only a small fragment or its use is not known. But the complete survival of Gunnister Man's woollen garments allowed an attempt at understanding intentional fabric design qualities.

5.1. Understanding a special surface texture

One of the knitted caps, possibly a nightcap, had looped fibres on the inside of the fabric, which created a type of surface pile (Fig. 4). Such a surface would provide additional warmth, and therefore was possibly an intentional design feature. The analyst in 1951 could not determine how this fabric was made (Henshall and Maxwell 1954, 37) and one of the aims of the project was to understand the nature of this surface structure. From visual analysis, it was clear that the loops were caused or created by the fibres behaving in a certain way, rather than an embellishment.

During visual analysis it was noted that the cap wool was unpigmented, smooth and relatively long, and that most of the loops formed

Fig. 4. Detail of looped surface structure inside cap. Photo: C. Christiansen

on the purl side. The fabric had been fulled hard as a finishing treatment, so possibly the loops were related to the fulling process. Attempts were made to recreate this behaviour from wools of different breeds, spinning different qualities of yarn, knitting to different gauges, and fulling more, or less. It was concluded that a loop surface can be formed when long, smooth fibres are forced outward from the surface of the purl stitches during the squeezing action of shrinkage. But it also depended on natural qualities in the wool itself, since the exact same methods used on wools from different breeds of sheep did not always create loops. It has been noted by wool scientists that wool crimp appears in two forms: sinusoidal and helix, and that fulling ability is related to crimp form, with the sinusoidal fulling more effectively than the helix form (Whiteley 1966). Perhaps crimp also influences whether wool will form loops or not in fabric during fulling. Similarly, we noticed that tannin or peat staining colour was somehow related to factors which were not visible, since some grey-brown wools became slightly green tinged when exposed to tannin for long periods, and other grey-brown wools did not. Like felting abilities, loop formations and colour changes are possibly genetically-affected. This information can be understood by testing different wools, but not by microscopic analysis.

6. Conclusion

At the end of a project it is useful to conduct a 'post-mortem' – a review of methods and procedures measured against outcomes. We asked ourselves: if we had the opportunity to analyse Gunnister Man's clothes again, but this time using fibre diameter measurements, would we still have done visual analysis and sample testing? Our first answer is yes, because we have shown that visual analysis of the textile is crucial to understanding the qualities and behaviour of that textile. Without this methodology we would not have been able to understand the important differences in quality among all of the woollen textiles in the Gunnister ensemble. Specifically, we would not have understood what wool qualities each textile may have been made from, how extensive or different the fulling process could be, or how certain elements in the fabrics, such as the loops in the cap, were made. This knowledge would not have been possible with relying only on fibre diameter measurements of the wool mix in each of the original textiles.

6.1. Choosing visual analysis, sample testing, and fibre diameter measurements

But if we had the opportunity, we would measure fibre diameters, in addition to visual analysis, with the diameter results for each textile revealed *after* the test phase for that fabric reconstruction. In this way, we could test how well fibre diameter measurements can provide a realistic reflection of fibre quality. One way to do this is to compare fibre diameter measurements from original and recreated yarns of 'matching' fabrics, to determine how fibre diameter distributions compare between fabrics with similar appearance and wool behaviour.

But the question following this decision was: how would we choose what part of the reconstructed yarn should be sampled to obtain a representative sample of that yarn's fibre mixture? 9 000 metres of yarn was spun from selected parts of more than twenty fleeces to make the replicated coat and breeches. Following standard fibre diameter sampling methods, we would take no more than three to four millimetres from a single yarn. In other words, the fibre diameter test would sample no more than 1/2 000 000 of the yarn used to make the cloth. This is a statistically insignificant measurement of the total fibre mixture used in the fabric, and therefore cannot be relied on as an accurate representative sample of fibre quality. Furthermore, this sampling method would not identify the fact that so many different colours and qualities of fibres were used in a single fabric.

6.2. Understanding textile history through reconstructions

The purpose of reconstructing a textile is to create a replica of the original. This can be done with varying degrees of accuracy and authenticity, from a simple 'look-alike' garment, to one that is as close as possible to the original in quality, handle, response to wear, as well as appearance. With the Gunnister Man Project, we tried to do the latter, for two reasons: we would learn far more about the original garments, and, by extension, the people associated with them: the makers and the wearer. By going through such a detailed methodology, we gained much more than just copies of garments for a display case. We gained better insight into the types of wools used and where they may have originated, and we were able to recognise similar techniques, possibly from the same textile tradition, workshop, or maker. We concluded that all of the clothes probably did not originate in the same place, and certainly not in the place of burial, but were acquired from different places in northern Europe. These insights into the origins and manufacturing methods of the clothes were far better understood by doing thorough visual analysis of the original garments and creating test samples until a close match fabric was achieved.

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