Current techniques of ancient textile analysis: a critical review

Henry, Philippa Anne

ABSTRACT

Current Techniques of Ancient Textile Analysis: A Critical Review

Philippa Anne Henry
Thesis submitted for the degree of Master of Arts
University of Durham
Department of Archaeology
1994

Throughout pre-history and historical times few items produced by people have been as central to daily life as textiles. Textiles have been produced in the majority of archaeological periods and in most geographic regions of the world. Their analysis thus has significant implications for the technological, cultural and social development and diversity of our ancestors.

Over the last two decades unprecedented advances have taken place in the analysis of ancient textiles. It is the purpose of this study to critically examine these advances, and to assess their significance to meaningful cultural investigation. To ensure a coherent structure to the research, Scandinavian period textiles from York and Scotland are utilised. The data are particularly appropriate for this purpose as the different types of preservation, burial contexts and geographical areas in which they were found enables investigations into reactions to burial conditions and conservation techniques, as well as cultural-historical issues.

When examining archaeological textiles it is necessary to have clear aims on the nature of the information required and how such information can be used. The fundamental reason for the analysis of textiles is to further an understanding of technological and culture history. To ensure optimum information is gained to facilitate cultural investigation and interpretation, an understanding of the conditions under which textiles survive and techniques of conservation is necessary. The use of appropriate analytical techniques to obtain technical details sufficient for full an accurate description of textiles is also essential. Finally, an awareness of the obstacles preventing us gaining this information is desirable. This thesis is therefore concentrated on these issues to form a base for future research.

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Declaration

The research undertaken for this thesis has built on work undertaken for my undergraduate dissertation, submitted for the degree of BA (Hons) Archaeology, University of Durham, 1992. The following maps, illustrations and plates are therefore necessarily duplicated: Maps 1.2, 3.1, 3.2 and A2.1; Illustrations 4.8, 4.9, 4.10, 4.11 and 4.12; Tables A2.1 and A2.2; Plates III, VI, VII, VIII, XIV, XXIII, XXIV and XXV. In addition, the glossary of textile terms is an enlarged version of the one that appears in my dissertation.

Statement of Copyright

ACKNOWLEDGEMENTS

The help, advice and support I have been given during the research for and writing of this thesis has come in many guises.

From the Department of Archaeology, University of Durham, I thank: first, my supervisors Dr Helena Hamerow and Dr Martin Millett for their advice, general encouragement and support throughout my period of research; secondly, Jennifer Jones and Phil Clogg who gave up their time to show me how to conserve, analyse and photograph archaeological textiles; thirdly, Trevor Woods for the photographic work he carried out on my behalf; finally, Yvonne Beadnell for her help and suggestions in the preparation and presentation of maps, illustrations and photographs.

My thanks must also go to those working with ancient textiles from both home and abroad. The advice and encouragement I received from Dr L. Bender Jorgensen (University of Gothenburg, Sweden), Dr W.D. Cooke (UMIST), P. Walton Rogers (Textile Research Associates, York) and Dr J.P. Wild (University of Manchester) during the initial stages of my research increased my understanding and enthusiasm for my chosen area of study considerably. I especially thank Lisa Bender Jorgensen and Penelope Walton Rogers for their generosity in sending me off-prints and allowing me to use unpublished material, as well as sharing their knowledge of Scandinavian period textiles so readily. Dr M.L. Ryder (Southampton) gave up his time to discuss the methods he employs to fleece-type fibres and suggested relevant publications to enlarge my knowledge of wool and its use in ancient textiles. Dr G. Edwards (AML, London) increased my understanding of the processes involved in the mineralisation of textiles and the procedures necessary to conserve and analyse them. Ro Bailey (God's House Tower Museum, Southampton) showed me techniques of ancient textile production, namely the use of the drop spindle and the warp-weighted loom. The experience enhanced my understanding and appreciation of the techniques involved in the production of ancient textiles. I am grateful to Dee De Roche (University of Cambridge) for sharing with me the trials and tribulations of postgraduate research into archaeological textiles. Finally, I wish to thank Kim Nissan for the information she gave me about the textiles from Scar, Sanday, Orkney and AOC (Scotland) Ltd. for allowing me to examine this group of textiles prior to their publication.

In conclusion, the continual support and encouragement received from colleagues, family and friends must be acknowledged.

Maps, illustrations, tables and plates from or after the following people/institutions are - maps 1.3, A1.1: Tweddle 1986; maps 3.1, 3.2: Bender Jorgensen 1986; figs. 4.1-4.3, 4.7: Burnham 1980; fig. 4.4: Cook 1968; fig. 4.5: Ryder & Stephenson 1968; fig. 4.6: Ryder 1983; figs. 4.8, 4.10, 4.12: Walton 1989; figs. 4.9, 4.11: Wild 1988; table 4.1: Ryder 1983; table 4.2, 4.4: Walton 1989; table 4.3: Ryder 1868a; plate I: Barber 1992; plates II, XXVI: Janaway 1989; plates III, VI-VIII, XIV, XXIII-XXIV: Royal Museum of Scotland; plates IV, XXXV: Nissan 1992/Historic Scotland; plates V, IX, XI, XIII, XXVII, XL-XLI: York Archaeological Trust; plates X, XII: North West Museum Service; plates XV-XVI, XX-XXI, XXVIII, XXX, XXXVI: Ryder and Gabra-Sanders 1985; plates XVII, XVIX, XXII, XXIX: Buchanan 1990; plate XXV: Manx National Heritage; plates XXXII-XXXIV: Ryder and Gabra-Sanders 1987; plates XLIII-XLVII: Cooke and Lomas 1990; plates XLVIII, L-LI: Cooke 1990. The remaining maps, figures and plates are the authors.

ABBREVIATIONS

Abbreviations used in this thesis.

Organisation and Institutions:

AML	-	Ancient Monuments Laboratory
AY	-	Archaeology of York
NESAT	-	North European Symposium for Archaeological Textiles
UKIC	-	United Kingdom Institute for Conservation
UMIST	-	University of Manchester Institute of Science and Technology

Analysis and Conservation:

ATR	-	attenuated total reflectance
EDTA	-	disodium ethylenediamine tetra acetic acid
EDXA	-	energy dispersive x-ray analysis
ESR	-	electron spin resonance
HPLC	-	high performance liquid chromatography
IR	-	infra red
SEM	-	scanning electron microscope
TLC	-	thin layer chromatography
XRF	-	x-ray fluorescence

CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO TEXTILES

Warmth, shelter and food are vital to human existence. Textiles have always featured in providing for all three and are thus of fundamental importance. The intertwining of fibres is one of the oldest practices known that is still in use today, with its roots in the Palaeolithic. The production of fabric by intertwining threads of animal and vegetable derivation is one aspect of this ancient technology. The earliest probable evidence of the production of textiles is representations of string skirts on 'Venus' figures from Lespugue, France and Gagarino, Upper Don dating to the Upper Palaeolithic (Barber 1991, 256). Finds of fishing nets from Finland and Germany have been dated to the Early Mesolithic (Bender Jørgensen 1990, 3), and evidence that Asiatic nomads were using felted animal hair to produce tents dates to the 3rd Millennium BC (Barber 1991, 221). Indeed throughout pre-history and historical times few manufactured items were as central to daily life as textiles.

The earliest evidence of weaving comes in the form of impressions on clay from Jarmo, north-east Iraq, where plain tabby- and basket-weave are displayed (plate I) (Barber 1991, 126-127). The finds date to c 7000 BC and show a degree of expertise that suggests an already well developed technique. Until recently, the earliest known actual woven textiles were excavated from the settlement site of Çatal Hüyük on the Anatolian Plateau, and are dated to c 6000 BC (Barber 1991, 127). The samples show variations of loom-woven plain tabby-weave and weft-twining produced from flax yarn (Barber 1991, 127-130; Burnham 1965, 171-173; Ryder 1965, 175-176). The innovative way in which the tabby-weave was utilised and the variety of cloth quality and yarn diameter displayed, suggests an established technology.

Within the last year a weft-twined textile sample of even older date, possibly produced from bast fibres (probably flax), has been examined. It was excavated from the settlement site of Çayönü in south-east Turkey and has been dated to c 7000 BC, making it contemporary with the Jarmo examples. A shedding device is not necessary for the production of weft-twined weaves, which can be manufactured in the hand or on a simple frame. Thus the presence of both weft-twined and tabby-weave (which requires a more complex weaving apparatus) at Çatal Hüyük suggests that weft-twining was the antecedent of loom-woven textiles. Their contemporaneousness at Çatal Hüyük, and the woven impression from Jarmo, indicates however, that the different techniques necessary to their production existed in parallel over millennia (Vogelsang-Eastwood 1993, 4-7). Weft-twining is a standard technique used in the production of baskets. It is possible therefore, that the manufacture of textiles utilising this technique has its own ancestry in basketry.

The use of vegetable fibres for the production of textiles appears to have predominated until at least the Late Neolithic. In addition, the archaeological evidence implies that tabby-weave was the only loom-woven technique exploited, although this did not limit the ingenuity of the weavers who produced a wide variety of effects (Barber 1991, 127-130, 134-137). The use of wool in the production of textiles first appears in the archaeological record during the Late Neolithic, with the first evidence in northern Europe excavated at the mouth of the Elbe and dated to c 2400 BC (Bender Jørgensen 1990, 8). The selective breeding of sheep to produce fleece suitable for cloth production provided the means to create warm clothing, thus reducing the reliance on animal skins for protection from the elements (Ryder 1964; 1969; 1974; 1987). This development in animal husbandry had profound implications for the production of textiles.

From the Bronze Age, wool becomes a common feature in European contexts, and with it a new technology. From c 1200 BC twill-weaves begin to appear in the archaeological record. Such weave-types heralded an important phase in the development of textile production, with a wider variety of weave-effects being possible. Twills dictate the use of more sophisticated techniques in the weaving process, thus indicating the introduction of a new technology or the adaptation of an existing one (Bender Jørgensen 1992, 120). Evidence of starting borders and loom-weights from Neolithic contexts suggests the use of the warp-weighted loom for the production of tabby-weave fabrics (fig. 4.9). Where tabby-weaves require two sheds to be lifted alternately to form the binding unit, a simple procedure on the warp-weighted loom, the production of twills necessitates the use of at least three sheds to ensure the successful formation of the binding unit. This is a more complex operation requiring a higher level of sophistication in the warping of the loom (Appendix 3: Glossary of Terms). The production of twills therefore implies that either a new loom-type was developed to accommodate the more complex procedures, or that the existing warp-weighted loom was modified. Experimental work has verified that the warp-weighted loom can be successfully utilised for the production of twills, including complex ones (Batzer and Dokkedal 1992). In addition, the continued use of the warp-weighted loom is evidenced from excavations via loom-weights. It is not possible to ascertain however, if this was for the production of both wool and linen fabrics or for linen only.

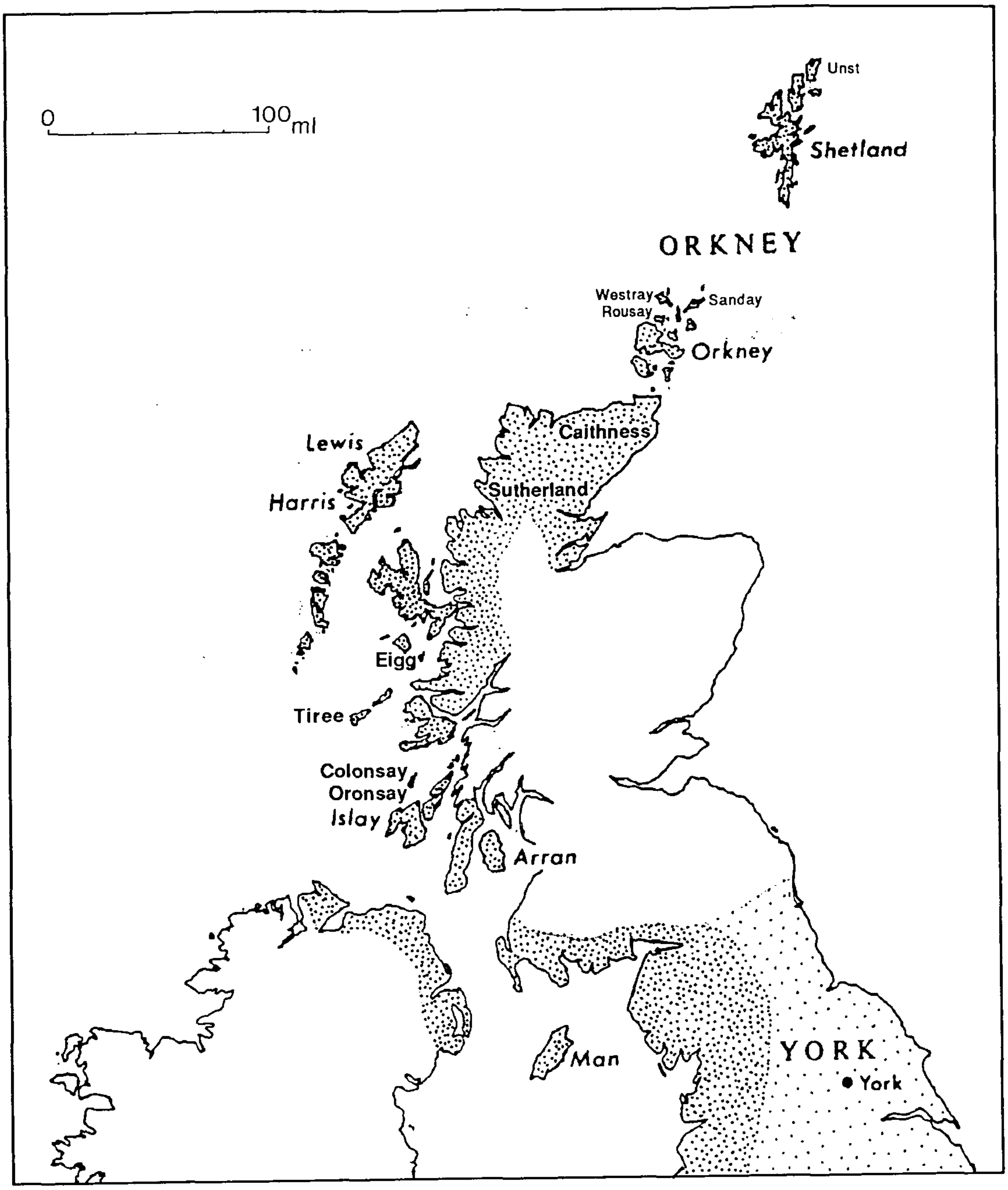
The emergence of twill-weaves during the Bronze Age, complemented the well established tabby-weave, which even today continues to be an essential element of woven fabric. Thus these two weaves formed the foundation for all future textile production. The basis for the extensive and innovative variations of weave-type which appeared over succeeding millennia was now in place.

The long genesis of textiles and textile production gives a rare opportunity to investigate an area of archaeology that is evidenced in nearly every period, and in most geographic regions of the world. The analysis of ancient textiles thereby has significant implications for the technological, cultural and social development and diversity of our ancestors. Unprecedented advances in ancient textile studies have taken place in Britain over the last two decades. It is the purpose of this study to examine critically these advances with particular reference to the textiles of Scandinavian period Britain.

1.2 BACKGROUND TO THE ANALYSIS AND DATA USED

Analysis of ancient textiles is carried out for two reasons: to investigate the structural properties of textiles and how they react under certain burial conditions and respond to different conservation treatments, and to gain technical details of the production of textiles to facilitate meaningful cultural investigation. To refer to a specific set of data in an examination of current techniques of ancient textile analysis adds a coherence to the study. The textiles from Scandinavian period Britain are particularly pertinent to this investigation as the widely varying states of preservation, burial contexts and geographical areas in which they have been found allows for both investigations into the reactions of textiles to burial and conservation, and for cultural studies to be undertaken. Textile evidence from the Anglo-Scandinavian levels of York and from pagan graves in the Scandinavian settled areas of Scotland, including for historical reasons, the Isle of Man is thus utilised to this end (Morris 1982, 84; Sellar 1975, 23) (map 1.1).

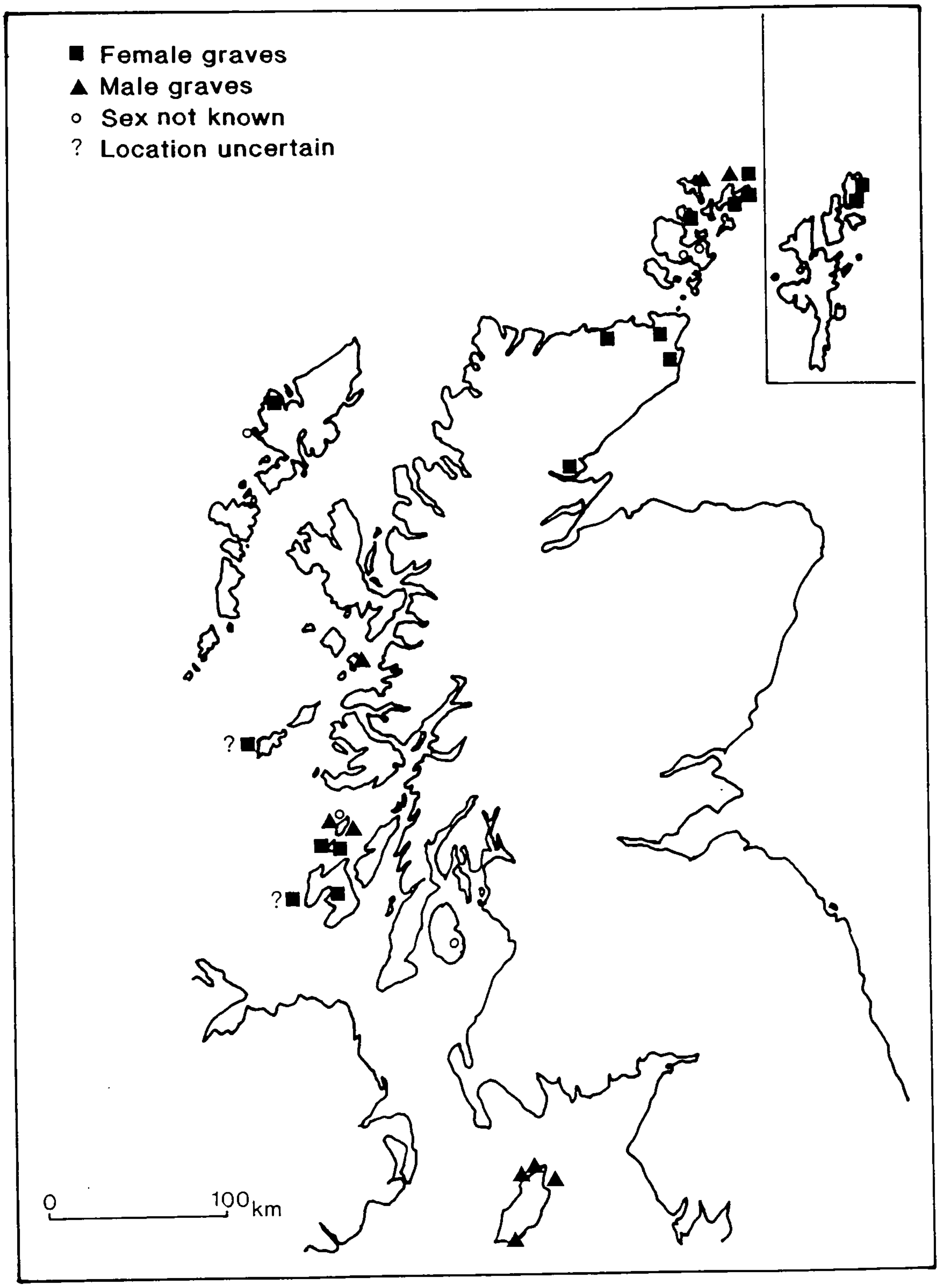
The textile evidence from Scotland and the Isle of Man, coming mainly from graves (map 1.2), was deliberately deposited, and the majority is preserved due to contact with metal. In contrast, the evidence from York, excavated from sites at Lloyds Bank, Pavement, Parliament Street, and 5 and 16-22 Coppergate (map 1.3), is largely



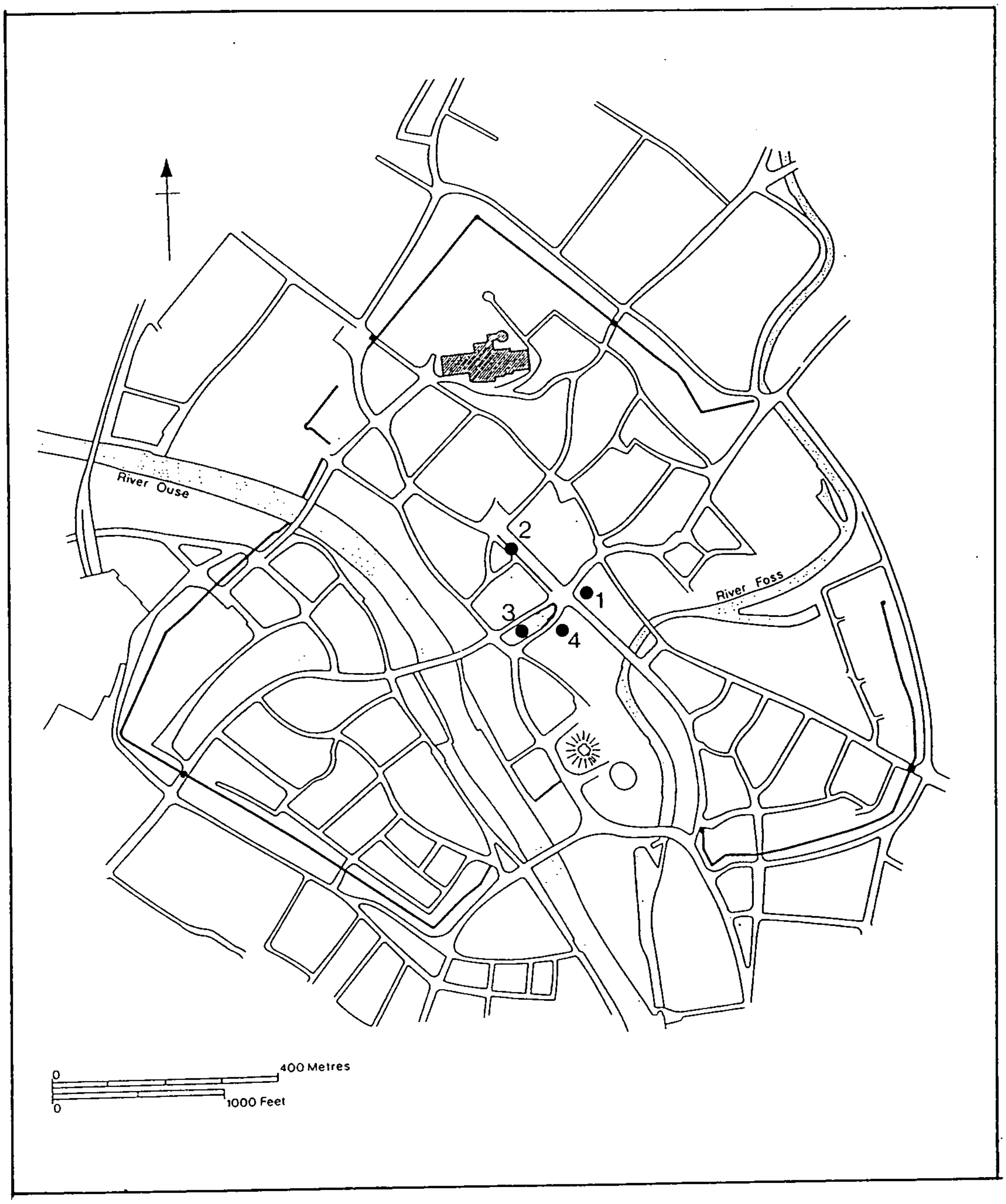
Map 1.1. Area of Britain covered in the study.

= mainly Norwegian settlement

= mainly Danish settlement



Map 1.2. Distribution of Norse textile finds from Scandinavian Scotland.



Map 1.3. Sites with Anglo-Scandinavian textile finds from York.
1 Lloyds Bank, Pavement. 2 Parliament Street.
3 5 Coppergate. 4 16-22 Coppergate.

made up of unintentionally deposited textiles, preserved in their original form in waterlogged environments, or due to charring.

In addition, the Scandinavian settlement of York and Scotland had differing economic and political backgrounds, and cultural affinities. The settlement of Scotland was one of colonisation with, it is thought, only a short spell of raiding. Archaeological, documentary and linguistic evidence indicates that the Scandinavian community came largely from Norway and that the economy was centred on farming and fishing (Crawford 1975, 16; 1987, 16; Eldjárn 1984, 7-8; Nicholaisen 1975, 6-7; Wilson 1976, 110-111). The settlement of York on the other hand was an aggressive political take-over initiated mainly by Danes (Morris 1982, 84-86). The economy was urban based with the attendant craft activities, and local, Continental and long distance trade associated with such settlements.

The textile evidence from the two areas therefore reflects not only the differing burial environments and modes of preservation, but also the nature of settlement and cultural affinities. The implications of these differences will be discussed in detail in the following chapters.

1.3 RATIONALE OF APPROACH

In order to exploit the information that can be gained from the study of archaeological textiles it is essential to have an understanding of the current techniques used in their analysis. The aim of this thesis is therefore to examine the theory and methodology behind the analysis of archaeological textiles as the basis for future research.

A number of issues have to be addressed and my methodology is dictated by these. The overriding issue involves the essence of textile studies: what information do we hope to gain from examining archaeological textiles and how can we use such knowledge? The information is dependent on the questions asked and the special interests and pre-suppositions of the analyst. Textile research falls broadly into four overlapping categories: conservation; analysis; technology of production; cultural and social aspects. Specialists working in these fields necessarily ask very different questions and consequently employ different methodologies.

My research employs methodologies suitable to the questions I intend to ask: first, how should we view textiles from the past - what are we looking for and why do we need to ascertain certain things?; second, what are the problems preventing us gaining the information we require with special reference to Scandinavian period textiles from Britain? and finally, what is the present state of textile research and analysis and how should the discipline develop in the future?

To answer these questions the work will follow two interrelated strands. The first considers three areas: a) an appraisal of the work of other analysts of ancient textiles; b) the development of the analytical techniques employed in textile analysis; c) the problems presented by the nature of the material being examined, and some possible solutions. Such research is based upon a literature survey of current work and discussions with textile specialists.

The second section examines the technology available for the analysis of ancient textiles. This involves the examination of modern textiles of known type as well as ancient textiles to gain the expertise necessary to facilitate future research.

1.4 OUTLINE AND METHODOLOGY

To ensure optimum information is gained from the analysis of ancient textiles, an understanding of the various conditions under which textiles are preserved and the techniques employed to conserve them is essential. In Chapter Two, I therefore examine modes of degradation and preservation, and techniques of conservation. The burial environments in which textiles survive are numerous; these and the various types of preservation that ensue are also discussed. The techniques employed in the conservation of ancient textiles is dependent on the mode of preservation and the level of post-excavation handling. I examine the techniques available to the conservator and the appropriateness of certain treatments to particular types of textile preservation. Included is an examination of the requirements of exhibition-standard conservation and the implications of this for future research.

In Chapter Three, I investigate levels and problems of analysis, including the appropriate use of primary- and high-level analysis and the design of characterisation schemes to ensure the use of the correct analytical technique and thus complete textile description. The problems associated with analysis include the nature of preservation and the terminology used to describe textile attributes. I examine these problems in detail and suggest possible solutions to ensure rigorous analysis and accurate description, thus making possible meaningful cultural investigations.

An understanding of the levels of analysis, the problems and possible solutions should yield maximum information. In Chapter Four, I present a critique of and commentary on the techniques of analysis and their application based on the above premise. If textile analysis is to contribute to cultural studies it is necessary to obtain technical details sufficient to characterise textiles accurately. I examine the analytical processes necessary to identify and assess fibre-, yarn- and fabric-type, as well as the identification of dye substances and types and levels of wear, all essential to accurate characterisation. As the mode of preservation affects the level and type of analysis necessary to obtain optimum information, I investigate the use of appropriate analytical techniques to particular types of survival. The implications for cultural studies forms an integral aspect of the chapter.

The concluding chapter involves an appraisal of the methodology employed in the examination of current techniques of ancient textile analysis. I re-examine the questions: how should we view textiles from the past; what are the problems preventing us from gaining the information we require and what is the present state of textile research and analysis? Finally, suggestions will be made about the direction in which ancient textile studies should be moving and the contribution such work can and should make to the wider issues of archaeological research.

CHAPTER 2

MECHANISMS OF DEGRADATION AND PRESERVATION, AND TECHNIQUES OF CONSERVATION

CHAPTER 2

MECHANISMS OF DEGRADATION AND PRESERVATION, AND TECHNIQUES OF CONSERVATION

2.1 INTRODUCTION

The mechanisms of degradation and preservation of ancient textiles are complex, yet a knowledge of these processes is essential to ensure the application of appropriate conservation techniques. In addition, information pertaining to the conservation techniques employed and the degradation and preservation processes should be available to analysts as both can alter the dimensions, structure and colour of textiles. Without access to such information the data can be misrepresented. Most importantly, interpretation of textiles is inevitably affected by the mode of preservation, yet this bias frequently goes unrecognised.

Of the Scandinavian period textiles presented in this thesis, only the reports on the textiles from York contain details of burial contexts, state of preservation and the conservation processes employed. This enables analysts to present more informed assessments, and it also allows researchers to interpret the material in a more meaningful way. The majority of the reports on the Scottish material omit such information. This however, is due to the date of discovery and the nature of preservation of the Scottish material. The York textiles are extant and were excavated, conserved and analysed during the 1970s and 1980s. In contrast, with a few exceptions, the textile finds from Scotland are mineralised and are nineteenth- or early twentieth-century discoveries. Such variations greatly affect the level of information that can be obtained, and consequently affects critical assessments and comparisons when reviewing the two data sets. Recent finds from Scotland have however, gone some way to redress the balance. There is nonetheless, an inevitable bias towards the treatment of textiles from York in the following discussion.

2.2 MODES OF DEGRADATION AND PRESERVATION

Textile fibres survive in a variety of burial contexts; the nature and extent of preservation is dependent on the chemical structure of the fibres and the micro-environment in which they are buried (Janaway 1985, 30). An understanding of the chemical structures and micro-environments is essential to a comprehension of the mechanisms of decay of archaeological textiles. Little systematic research has however, been undertaken into how the chemical and biological elements in certain archaeological environments affect the degradation of different fibre-types, in particular in waterlogged, anaerobic conditions. Publications pertaining to this area of textile research are therefore based largely on incomplete information. Further work is thus urgently required to enable textile specialists to fully understand the disparity of textile evidence in certain contexts. For instance, in northern Europe, there is a high percentage of textiles produced from protein-based fibres in comparison to cellulose-based ones (see 2.2.3.1 below).

2.2.1 FIBRE-TYPES

The three main textile fibre groups used in the Scandinavian period are wool, silk and bast-plant stems, particularly flax. Each have a unique chemical structure and react to burial environments in different ways.

2.2.1.1 Wool

Wool consists of the protein keratin and is a polymer of amino acids. The keratin consists of low-sulphur and high-sulphur elements, the low-sulphur constituting the crystalline portion of wool and the high-sulphur the amorphous area. The sulphur content affects degradation rates. Wool therefore decomposes in two stages, with the amorphous portion of the fibre degrading more rapidly than the crystalline. Chemicals attack the amorphous area, which makes up a larger proportion of the fibre, more quickly than the crystalline section. The stronger, low-sulphur part of the fibre, although the smaller component, enables wool to retain its strength unless it is subjected to stronger chemicals. Wool fibre is also susceptible to bacterial attack and as keratin-protein is slightly acid, micro-organisms that flourish in high pH (alkaline) environments are thought to attack its structure to a greater extent than those that survive in low pH (acid) soils (Jakes and Sibley 1984, 21).

2.2.1.2 Silk

The main protein constituent of silk is fibroin. It has fewer amino acids than keratin, with a more ordered, tightly packed crystalline structure. It thus reacts with chemicals at a slower rate. Sericin, another protein, coats the fibroin filaments protecting the yarn during its formation and during the preparation of the fibres for the production of yarn. Sericin is water soluble and is removed easily when it comes into contact with warm water. In contrast, fibroin is less susceptible to water and its degradation takes place more slowly. Decay is however, thought to be accelerated by high temperatures and high or low pH values where micro-organisms in the soil attack the crystalline structure of the protein (Jakes and Sibley 1984, 24).

2.2.1.3 Bast Plant Stems

Bast plant stems - flax, hemp, nettle - consist of cellulose-based cells with heavily lignified walls. Lignins, hemicelluloses and pectic substances form a proportion of the cellular-base of bast-plant stems. Their level depends on the growing conditions of the plant - soil, moisture and environment - and the production processes necessary to create fibre. It is thought that the quantity of these lignins, hemicelluloses and pectic substances in a fibre, affects its rate of degradation; the higher the level, the more rapid the decay. In acid conditions, bast-plant fibres appear to be more susceptible to chemical and biological attack than wool and silk, in contrast, anaerobic environments with a high pH seem to favour their survival to a greater extent than wool or silk (Jakes and Sibley 1983, 34).

2.2.2 MECHANISMS OF DECAY AND PRESERVATION

It is essential to understand the effect that the environments in which textiles survive have on decay processes, so that differential preservation can be taken into account when assessing the range and use of textiles in antiquity (Janaway 1989, 21). Textiles, like all organic matter, are subject to decay over time. Their survival therefore indicates that during deposition, the agents for decay either were not present or that conditions existed which were favourable to preservation. For textiles to survive, decay must be reduced or halted in the early stages of decomposition. The presence, absence or inactivation of the agents of decay are therefore important considerations when investigating mechanisms of degradation and preservation (Cronyn 1990, 17).

To establish if textiles produced from particular fibre-types are likely to have been present on a site, a knowledge of cultural traditions, climate, purpose of site and when in use is also advantageous (Jakes and Sibley 1983, 31; 1984, 25). For instance, did the climate favour the use of wool or linen? Were exchange networks sufficiently established within a culture for textiles produced from certain fibre-types to be found outside their area of origin, for example silk? Was a particular fibre-type exploited when the site was in use? For example, linen produced from flax does not appear in the Scandinavian archaeological record until the Iron Age. Finally, was the site used for industrial, ceremonial or domestic purposes? All affect the probability of the presence of particular fibre-types. It is desirable to incorporate such considerations into excavation strategies to ensure that any textiles likely to be present are not overlooked.

Literature relating to textile preservation normally includes discussions on the general burial environment, for example, the effect of wet acid soils on textile survival in northern Europe. Although a knowledge of the wider environment is important, such information is misleading unless the micro-environments in which the textiles were found are also considered. In inhumation graves for instance, the acidity of the soil in the immediate environment of a body increases due to the processes involved in its decomposition. It is the conditions prevailing in this micro-environment that will enhance or reduce the survival capacity of any textiles within it and not the wider environment (Janaway 1985, 33-34). Any investigation of textile survival must therefore include an examination of the micro-environment. For example, a knowledge of the micro-environment of the Scandinavian period grave from Scar, Sanday, Orkney greatly enhanced the detection and interpretation of the textile evidence found in association with the sword (Appendix 2: table 1, map 1) (Nissan 1992, 46). Iron salts from the sword heightened the survival capabilities of any fabrics in its proximity, in this case, in mineralised form.

The formation of micro-environments is dependent on several variables: temperature, relative humidity, pH (acidity/alkalinity), Eh (oxidisation/reduction), salinity and the presence of heavy metals. Each reacts with the others and affects the level and rate of decay of textiles (Jakes and Sibley 1984, 26). Soil conditions play a considerable role in the survival rate of textiles, as differing chemical structures in the soil inhibit certain micro-organisms thus arresting decay. Soil conditions also effect the survival rate of differing fibre-types (Janaway 1985, 30). Protein-based fibres for instance, appear to survive to a greater degree in acid conditions whereas cellulose-based fibres seem to have better survival rates in alkali deposits.

Although textile fibres are decomposed by soil chemicals the principal agents of decomposition are biological: fungi and bacteria (Janaway 1985, 30). Fungi are only active in aerobic conditions, but bacteria are dynamic in both aerobic and anaerobic ones (Cronyn 1990, 16-17). Fungi and bacteria affect both proteinic and cellulosic fibres, protein-based fibres appear however, to be more resistant to the micro-organisms that flourish in slightly acid, anaerobic conditions; common to urban sites in northern Europe. The Anglo-Scandinavian levels at York display this form of environment, which is almost certainly the reason for the bias in survival towards protein-based textiles (Walton 1989, 300).

To assess the likelihood of survival rate of different types of fibre under different conditions it is necessary to look at evidence from several micro-environments and compare the results. In addition, interaction of the characteristics that create micro-environments must be considered; while one characteristic may inhibit degradation, another may negate the effect of this inhibition (Jakes and Sibley 1984, 25). For instance, where fibres are degraded in unfavourable soil conditions, if metal salts are present their survival rate is often enhanced. To aid such assessment Jakes and Sibley (1983, 37; 1984, 19) pose several questions. Why does one fibre survive and another not in the same micro-environment? What encourages the survival of the same fibre-type in very different micro-environments? What causes fibres to decay or degrade? What sets of circumstances favour archaeological survival? Can survival of certain fibre-types from specific sites be predicted?

2.2.3 BURIAL ENVIRONMENTS

To answer these questions it is necessary to examine the differing environments in which textiles survive which range from the waterlogged sites of northern Europe to the dry desert environments of Egypt. Fibres also survive in the permanently frozen regions of Siberia and Greenland and in salt laden situations such as the Hallstatt salt mines. Circumstances not related to climatic or soil conditions also 'preserve' textiles in some form: imprints on pottery, metal and soil, and charred fabrics all produce valuable visual information. In addition, mineralised textile evidence survives due to its proximity to metal.

Scandinavian period textiles from Britain survive almost exclusively in waterlogged urban environments or in inhumation graves where metal preserved or replaced textiles form the major body of evidence. Impressions and charred textiles are present but to a lesser degree.

2.2.3.1 Waterlogged Conditions

Textiles survive in waterlogged conditions when they are sealed from the air permanently and at an early stage (Geijer 1979, 266). Anaerobic conditions and the pH of the soil affect the level of micro-biological activity, and are therefore important factors when assessing the possibility of the survival of particular fibre-types. The processes of degradation in waterlogged environments are not yet fully understood however, so to date, the information available is less than complete. This must be borne in mind when assessing textiles from such environments.

Micro-organisms in soils with a mildly acid pH appear to have little effect on wool, a low pH environment will therefore damage wool but not dissolve it, hence the complete and near complete costumes found in the peat bogs of northern Europe. In contrast, if wool is in contact with slightly alkaline conditions over a long period, it is more likely to degrade and dissolve. Silk reacts in a similar way to wool although its chemical structure makes it more susceptible to attack in both high acid and alkaline conditions than wool (Jakes and Sibley 1984, 25). The presence of tannins and humic acids which act as biocidal agents, is thought to increase the survival capacity of protein-based fibres, as evidenced in the complete costumes found in association with oak coffin burials in north European peat bogs (Forbes 1964, 1). The possible preservation properties of tannins and humic acids are also evident in the waterlogged Anglo-Scandinavian and Late Saxon levels in York and London where wool and silk survive to a greater extent than linen (Crowfoot, Pritchard and Staniland 1992, 2; Walton 1989, 300).

Cellulose-based fibres are poorly represented in acidic waterlogged conditions because bacteria in combination with the acid in the soil is thought to break down the cellulose, with the eventual break-down of the fibre (Geijer 1979, 265; Jakes and Sibley 1983, 34). In contrast, cellulose-based textiles from Neolithic lake dwellings have survived in Swiss lakes, probably due to the high pH, anaerobic conditions.

Where cellulose-based fibres do survive in acid waterlogged conditions it is due to the micro-environment in which they are buried. At Viborg, Denmark a considerable portion of an eleventh-century linen shirt survived in a post hole, possibly due to the presence of charcoal in the immediate burial environment, thus slightly raising the pH value (Fentz 1992, 84). Where cellulose-based fibres have not survived, negative evidence can though be used to suggest their presence. Pierced stitch-holes in wool and silk textiles may be indicators of a cellulose-based sewing thread and as such should be recorded during analysis (Crowfoot, Pritchard and Staniland 1992, 2; Geijer 1979, 265).

2.2.3.2 Mineralised Textiles

The information available from textiles preserved or replaced through contact with metal has become an increasingly important aspect of textile studies in recent years. The importance of mineralised textiles increases when fabrics are preserved under conditions which would not normally be conducive to their survival. For instance, textile evidence produced from bast fibres survive in this form in northern Europe, where it is otherwise scarce. Such survival reduces the bias towards protein-based fibres, although wool and silk remain the prominent groups of surviving fibre-types. For fibres to survive in mineralised form, a sufficient concentration of metal ions has to be liberated into solution in the proximity of the fibres before they are destroyed by natural degradation (Janaway 1983, 48; 1989, 21).

Whether or not textiles are preserved in some form depends on the rate of fibre degradation and the speed at which sufficient quantities of metal ions are liberated. Metal ions must be released rapidly to prevent micro-biological degradation or to facilitate the deposition of enough corrosion products to form positive structures. If textile fibres degrade at a faster rate than the release of metal ions, the textile will not be preserved. The early stages of the decay and preservation process are therefore critical in determining whether an identifiable structure will be formed or whether sufficient corrosion is deposited prior to the fibres being destroyed in the natural decay process (Janaway 1985, 30; 1989, 23-24).

Textiles are mineralised through close proximity to, or contact with metal via a number of mechanisms which produce differing preservation characteristics. Copper alloy and silver favour metal preserved textiles. Metal salts coat the textile leaving a proportion of actual fabric. In contrast, textiles buried in close proximity or in contact with iron are frequently completely replaced by metal corrosion products, producing positive replicas (pseudomorphs) or negative casts (Edwards 1989, 5; Janaway 1983, 48; Watson 1988, 65-67)). The sword from Claghbane, Ramsey, Isle of Man has negative casts (plate II; Appendix 2: table 2, map 1) (Janaway 1989, 23) and the one from Scar, Sanday, Orkney, a combination of negative casts and positive replicas (Appendix 2: table 1, map 1) (Nissan 1992, 47).

Metal ions from copper alloy and silver act as biocidal agents. Biological decay is limited, thus preserving the actual textile (Cronyn 1990, 28). Preserved linen is regularly found in this form in association with the copper alloy artefacts found in graves from northern Europe (Janaway 1983, 48; 1989, 21). Linen surviving due to contact with copper alloy has been identified on oval brooch 2 (IL 856) from the late tenth-/early eleventh-century female grave from Kneep, Lewis, Western Isles (plate III; Appendix 2: table 1, map 1) (Bender Jørgensen 1983, 7; 1987, 166) and on an oval brooch (IL 219) from a tenth-century female grave from Tiree, Argyll (Appendix 2: table 1, map 1) (Bender Jørgensen 1983, 4). In the ninth-/tenth-century cemetery at Birka, Sweden (map 3.1) the silk warps of tablet-woven braids have been preserved due to the silver wefts that interwove them, the salts emitted from the silver preserved the silk (Geijer 1979, 266).

Where complete replacement has taken place, metal corrosion products are absorbed by the fibres which harden, a positive replica of the structure of the material is thus created (Jakes and Sibley 1984, 25; Janaway 1983, 48; Watson 1988, 67). Negative casts are formed when metal corrosion products cover the fibres which then decay, creating a cylindrical mould. The interstices of the mould fill with fine soil producing a solid matrix. When the mould is cracked open a negative cast of the fibre is revealed (Janaway 1983, 48; Watson 1988, 67). It is not always possible to identify fibre-type in metal replaced textile evidence, although technical details can be distinguished. In some cases however, fibre is identified by taking a cross-section of the replaced fibre and examining it under an SEM. Such a method was used to identify the fibres of metal replaced textiles on the Scandinavian period iron swords from Scar, Sanday, Orkney (plate IV; Appendix 2: table 1, map 1) and Claghbane, Ramsey, Isle of Man (Appendix 2: table 2, map 1). In both cases the fibre was identified as linen, which is not as commonly identified in association with iron as is wool (Janaway 1982, 455-456; 1989, 23-24; Nissan 1992, 40).

2.2.3.3 Carbonised Textiles

Charred textiles are preserved through carbonisation which alters the structure of the fibres. Carbonisation occurs where textiles are subject to intense heat, the textiles become chemically inert and therefore no longer susceptible to bacterial attack (Burnham 1965, 169). Textiles subject to carbonisation are normally black, stiff, brittle and extremely fragile (Ryder 1965, 175; Walton 1989, 300). They do however, survive in virtually all archaeological environments. For example, the textiles from Çatal Hüyük (see 1.1 above) were found under low clay platforms of buildings that had been destroyed by fire. Due to their location, they were exposed to intense heat, which carbonised but did not destroy them (Burnham 1965, 169). From 16-22 Coppergate, forty-five of the fifty-two textile finds identified as vegetable fibre are carbonised (plate V; Appendix 1: table 6, map 1). The majority of these textiles are thought to be linen which is significant in terms of statistical analysis, the survival of linen in this quantity is unusual in urban sites in Britain (Walton 1989, 300 & 312). These carbonised textiles therefore form an important set of data in the study of north European textiles. They decrease the bias towards the survival of protein-based fibres and also give a rare opportunity to examine fabric-structure in greater detail than is possible where linen survives in mineralised form.

2.2.3.4 Impressions

Textile impressions are formed in three ways: first through the contact between textile fibres and a pliable material during their active life; second, where completely decayed textiles form imprints in soil or objects in the burial environment; finally, where fabric is used as part of the manufacturing process in the production of metal artefacts. It is not possible to identify fibre-type from impressions but technical details are often extremely clear. It is important however, to be aware of possible changes in the dimensions of the 'host' material when assessing thread count, yarn diameter and textile dimensions. For instance, fired clay shrinks, thereby making accurate assessment of the textile impossible. Such considerations should not detract from the use of textile impressions as a form of evidence however, they provide a valuable source of information in terms of spin-direction and weave-type.

Textile impressions are numerous and date from the earliest known example from Jarmo (see 1.1 above). The impressions from Jarmo represent the oldest known evidence of weaving, with impressions of plain and basket tabby-weave clearly identified on two pieces of clay (plate I) (Barber, 1991, 126-127). Other examples include an impression of a Z/S 2/2 diamond or herringbone twill on a shard of pottery from the eighth-/ninth-century trading centre of Hamwih. It is probable that the impression came off the weaver's trousers when the pot was being removed from the wheel (Hedges 1981, 97-98). From 16-22 Coppergate, an impression of plain Z/Z tabby weave with a count of 12x12 threads per cm was found on a piece of lead (1458). The lead has been dated to the 13th century but it is not known how or when the impression was made (Walton 1989, 300 & 442).

Evidence from impressions where textiles form part of the manufacturing process in the production of metal artefacts are numerous from the ninth- and tenth-century Scandinavian graves from Scotland. The majority are on the back side of oval brooches, which were produced with a two part mould. Eleven of the thirteen textile impressions on the oval brooches are plain Z/Z tabby weave with thread counts ranging from 13x12 to 14x24 threads per cm. The two remaining impressions are of particular interest however. They represent both woven and non-woven techniques and raise questions as to the origin of the fabric and the use for which it was originally intended (Henry 1992, 59). From a ninth-century female grave from Clibberswick, Unst, Shetland, the textile impression on the back side of one of the brooches (IL 223) is sprang, a non-woven technique (plate VI; Appendix 2: table 1, map 1) (Henshall 1951-2, 16; Bender Jørgensen 1983, 4). At Chaipaval, Northton, Harris a fragment of oval brooch (IL 750) has an impression of a 2/2 herringbone twill weave with a thread count of 27x20 threads per cm (plate VII; Appendix 2: table 1, map 1) (Bender Jørgensen 1983, 7). A further textile impression from Scandinavian period Scotland was found in the late tenth-/early eleventh-century female grave from Kneep, Lewis, Western Isles. A belt buckle (IL 853) has an impression of a high thread count, unbalanced *Birka-type* 2/2 diamond twill (plate VIII; Appendix 2: table 1, map 1) (Bender Jørgensen 1983, 7; 1987, 166).

When assessing the value of this form of information, certain questions have to be asked. Is it necessary to use fabric displaying certain properties, for example, are some weave-types more suited to the rigours of metal object manufacture than others? The predominance of tabby weave on the back side of the oval brooches from Scotland could indicate a preference for this form of weave. It could equally however, simply be coincidence or recovery bias. Is high fibre density cloth preferable? Certainly the thread count of the textile impressions from Scotland is fairly high, but without a knowledge of the yarn diameter it is not possible to assess fabric density (see 3.3.6.1 below). Is it preferable to use textiles produced from animal or vegetable fibre? It is not possible to positively identify the fibre from the Scottish oval brooches, although it is probable that the sprang and both twills were produced from wool. It can be seen here, that an assessment of the Scottish evidence does not assist to any great extent in such an investigation if examined in isolation. Comparable material should therefore be assessed to see if there is a correlation in the evidence presented here. Experimental work will also help to ascertain the fibre- and weave-types, and the cloth quality most suited for metal artefact production.

As to the origins of the sprang and twills, it seems probable that they were off-cuts, possibly from centres of brooch and belt-buckle production in the Norwegian homelands. The twill impressions are paralleled at the trading centres of Kaupang, Norway, Hedeby, Schleswig and Birka, Sweden (map 3.1). The predominance of find spots of the *Birka-type* twill in Norway, does point to a Norwegian origin for the impression on the belt-buckle from Kneep (see 4.4 below). The herringbone twill, sprang and tabby weaves could however, have come from any of the Scandinavian areas producing oval brooches; all of these fabric-types were produced throughout Scandinavia during the ninth- to eleventh-centuries.

2.2.3.5 Frozen, Saline and Desiccated Conditions

Textiles preserved in frozen, high salt and arid conditions do not feature in the material from Scandinavian period Britain. It is nevertheless important to review briefly the processes that lead to the decay and preservation of textiles buried in such environments.

Freezing is an excellent means of preserving all textile fibre-types as the effect of the ice prevents micro-biological activity. If rapid and permanent freezing occurs, a high level of preservation will be evident with, in some cases, complete pieces of textile and costumes surviving. Fabrics preserved in this way are commonly found in the North Atlantic Arctic region and Siberia.

Textiles found in the frozen conditions of Greenland are of particular relevance. Tenth- to thirteenth-century evidence from this region of the Norse world, enhances the cultural and social aspects of Scandinavian period textile studies. Recent work in the southern part of the Norse medieval Western Settlement has produced evidence of textiles and weaving equipment preserved due to drifting sand and frozen conditions. A length of cloth for instance, has undergone little deterioration. Both the textiles and weaving equipment are synonymous with the warp-weighted loom and will contribute to the growing knowledge of textile production in the Norse controlled areas of the North Atlantic region (Arneborg 1992, 3).

Siberia also has excellent examples of textiles preserved due to freezing. At Pazyryk in the Altai region of southern Siberia, c. 400 BC Scythian Princely graves have produced a wide range of preserved textiles: silk, tapestries, woollens, embroideries and pile carpets. In addition to preserving the textiles, dyes have retained much of their original colour; an unusual feature in archaeological textiles (4.5.2.1) (Geijer 1979, 267; Ryder 1987, 20).

A high salt content will preserve textiles if the conditions are moisture free with a neutral pH. Protein-based fibres survive particularly well in such conditions. An important group of textiles has survived in the salt mines of Hallstatt due to this type of environment (Forbes 1964, 1; Jakes and Sibley 1983, 36; 1984, 25; Ryder 1992, 103-104).

Where the environment is dry and the soil conditions are high in alkaline salts, textiles of all fibre types survive to a high degree of preservation. The combination of salt and dryness inhibits bacterial activity thus preventing decay (Forbes 1964, 1; Geijer 1979, 268; Jakes and Sibley, 1983, 36). The best known examples of textiles preserved in such desiccated environments are from the tombs of Egypt where complete costumes and other textiles survive. Original colours also survive well under these conditions (Geijer 1979, 268).

2.3 TECHNIQUES OF CONSERVATION

A knowledge of the burial environments from which textiles originate helps to determine the correct conservation procedure. It is therefore essential, where possible, for the conservator to have complete information on the micro- and wider environment from which a sample has come.

As all conservation destroys a certain level of information minimum intervention is essential if alterations to structure and technical details are to be lessened (Peacock 1990b, 200). The level and type of conservation techniques employed are dictated by various factors. Where textiles are to be stored and used as part of a reference collection, minimum conservation is desirable to prevent further degradation. If however, textiles are to be displayed in museums, a higher level of conservation is required (Cronyn 1990, 12; Hillyer 1990, 19; Walton 1982a, 12-13). Conservation at this level can alter dimensions, colour and structure of a textile, so a balance between the dictates of museum display and needs of academic research have to be continually borne in mind (Hillyer 1990, 19). Different fibres require different methods of treatment; it is therefore essential to identify fibre-type before cleaning commences (Walton 1982a, 11; 1989, 427). Variables in the survival rates of fibres also requires decisions to be made when considering suitable cleaning methods (Hillyer 1990, 19-20). The same treatments are often applied to both cellulose- and protein-based fibres and severely-degraded and well-preserved textiles, such action can adversely effect the conservation results. Non-aqueous solvent-cleaning agents such as oxalic acid will for instance degrade cellulose unless buffeted with another solution and disodium ethylenediamine tetra acetic acid (EDTA) is thought to create changes in some dyes (Peacock 1990a, 25-26).

To assess possible changes in dyes, Taylor tested dye samples from two of the wool textiles from York before and after treatment with EDTA. No decrease in the amount of dye was detected after treatment. Madder was the only dye recorded in the samples tested however. Whether the same lack of reaction would be present in all dyes and mordents or indeed all madder dyed ancient textiles requires further research before conclusions can be reached. Taylor has also carried out research using EDTA on modern dyed samples; the results show that there are no adverse effects on dye-stuffs (Walton 1989, 426). Changes in dyes and mordents during burial may react differently to modern samples however. Until conclusive results are obtained, where dye is present, EDTA treatment should thus be used with care.

Whatever the choices, cleaning methods need to be carefully applied to prevent irreversible damage. For example, wet-cleaning textiles from dry sites is normally an inappropriate method and carbonised fibres are usually too fragile. In such cases dry-cleaning methods are employed. (Hillyer 1990, 19).

2.3.1 POST-EXCAVATION HANDLING

Conservation begins at the post-excavation stage; a knowledge of the level and nature of post-excavation handling is therefore essential as it has a direct effect on decisions made during the cleaning and drying of textiles (Cronyn 1990, 5; Peacock 1990a, 24; 1992, 197). Poor handling on excavation, results in further degradation of textiles with the subsequent loss of valuable evidence and unnecessary problems for the conservator. Where biocides are used to prevent fungal growth, the same compound is often used for all fibre-types regardless of its suitability. Cellulose-based fibres require a neutral to slightly alkaline environment and protein-based, a neutral to slightly acid one. The use of the same biocide is therefore inappropriate and may be responsible for unacceptable results during and after conservation (Peacock 1990a, 24; 1992, 197). To inhibit fungal growth until cleaning commenced, the Anglo-Scandinavian textiles from York were treated with a weak solution of panacide (Walton 1989, 424). Whether or not such treatment had detrimental effects on the final conservation results was not reported. In view of the problems that may result from the use of fungicides however, it is where possible, preferable to avoid their use at the post-excavation stage altogether, although this is not always practicable (Cronyn 1990, 289).

It is desirable, at the time of excavation, to record the state of textile preservation: if it is intact, carbonised, metal preserved or an impression. In addition, the level of fragility of the textile and fibres should be noted as well as dimensions, colour, details of sewing, folds, pleats etc. (Walton and Eastwood 1988, 2-3). Where textiles are evident through contact with metal it is important to note the way up the object is in the ground, its exact position in relation to other objects and any skeleton, and whether it was underneath or overlain by another object. Such details aid the later interpretation of textile traces (Edwards 1989, 5). Careful recording of this nature occurred when the boat grave at Scar, Sanday, Orkney was being excavated, which resulted in the identification of several different fabrics even though, on first sight, at least four displayed similar technical details and were of the same fibre-type (Appendix 2: table 1, map 1) (Nissan 1992, 37).

2.3.2 ANALYSIS DURING CONSERVATION

Analysis of textiles is essential at all stages of the conservation process to ensure that details are not irreversibly lost. Dye samples should be taken for analysis before cleaning as the fibre-mordant-dye complex can break down in the burial context resulting in the removal of dye during the cleaning process (Walton 1982a, 11; 1989, 426). Technical information such as seams, selvedges, pleating and stitch-marks can also be lost in the cleaning process, with the movement of the weave during cleaning often obscuring stitch-holes or blurring folds or pleats. If systematic examination at every stage of conservation is carried out such information can be preserved or at least recorded before destruction. Using an SEM during cleaning enables changes in fibre structure and information on wear and fibre damage to be detected. Without this high-level analysis such information can be irreversibly damaged or completely destroyed, although the cost of such examination has to be considered (Hillyer 1990, 18-19).

Where textiles are preserved through metal corrosion products, and if the textile is not to be removed from the metal object, analysis should occur before the conservation process has progressed to any extent (Walton 1982a, 11). In addition, as wetting may shrink and distort metal preserved textiles, and stabilisers obscure technical details, as well as damaging the structure of the textiles, it is essential to record the details before and after such conservation processes take place (Edwards 1989, 5-6).

2.2.3 CLEANING

The level of decay and nature of the fibre must always be considered when forming cleaning strategies, the three main methods of cleaning textiles being aqueous-, non-aqueous solvent- and dry-cleaning. Aqueous- and non-aqueous solvent-cleaning methods are frequently used in conjunction with each other to facilitate cleaning that will cause the least damage to fragile textiles. Mineralised textiles are normally dry cleaned with the methods employed generally those used to clean metal artefacts.

2.3.3.1 Aqueous- and Non-aqueous Solvent-cleaning

Aqueous-cleaning is usually applied to textiles that are already damp, wet or frozen. The fibres are already relaxed, with the water in the cells and hollows structurally supporting the fibre system. It is necessary though to physically support and restrain the textile during cleaning to prevent a disruption of the structural balance of the fibres (Peacock 1992, 198). The use of water over other cleaning methods has advantages for several reasons: its careful application can reduce the level of inter-fibre friction, which enables the re-alignment of warp and weft threads; water releases degradation products, resulting in the reduction of the accumulation of acidity; it is easier to remove soluble dirt and stains; finally, it improves the handling and feel of brittle fibres (Hillyer 1990, 18; Peacock 1992, 198). The majority of the textiles from York were robust enough to accommodate aqueous-cleaning without the need for non-aqueous additives (Spriggs 1982, 156; Walton 1989, 425). Some of the textiles were in such good condition that the cleaning process was speeded up by using an ultra-sonic tank (Walton 1989, 425).

Where textiles are fragile they can be pre-treated with non-aqueous solvents before cleaning. Pre-soaking allows fragile fibres to relax slowly in a viscous, supportive solution. It acts as an emulsifier, releasing trapped dirt where mechanical action must be kept to a minimum and improves the handling of brittle fibres (Hillyer 1990, 20; Spriggs 1982, 156). Non-aqueous solvent-cleaning is appropriate where textile fibres are too fragile to withstand the mechanical action necessary with aqueous-cleaning. The method is not as effective as aqueous-cleaning but does ensure that cleaning is able to take place. Solvents do however, result in fewer dimensional changes to the textile, which creates a less problematic drying phase; surface tension is reduced, causing less stress to the fibres (Hillyer 1990, 18; Peacock 1992, 197). This method of cleaning is also appropriate where textiles are heavily encrusted with soil. Fabric from cess-pits at 16-22 Coppergate were treated in this way, where EDTA dissolved the soil without damaging the textile. Current research suggests that EDTA does not harm either cellulose-based or protein-based fibres (Walton 1989, 425-426). One of the problems of non-aqueous solvent-cleaning is the removal of fats and waxes which can result in the brittleness of fibres. Movement of dyes also occurs with some solvents which negates the possibility of chemical dye analysis (Peacock 1992, 201-202). The use of solvents must therefore be employed with extreme caution with the level of analysis required borne in mind continually.

2.3.3.2 Dry-cleaning

Textiles from dry sites are normally dry-cleaned as immersion in water, with the resulting sudden expansion of the fibres, can have a severe effect on the structure of fibres and textiles (Peacock 1992, 197). Dry-cleaning is also used on wet textiles where fibres are too fragile to withstand the rigours of wet-cleaning; both aqueous and non-aqueous solvent methods. The carbonised fibres from Coppergate were cleaned in this way because of their fragile state (Walton 1989, 245).

2.3.3.3 Cleaning Mineralised Textiles

The cleaning methods of metal replaced textiles are normally those that are applied to the cleaning of metal objects. Before cleaning commences however, it is often difficult to detect the presence of textiles. Examination at this stage is therefore essential. X-radiography in conjunction with microscopic analysis is normally employed to this end. It was through such methods that textiles were detected on the swords from Scar, Sanday, Orkney (plate IV; Appendix 2: table 1, map 1) and Claghbane, Ramsey, Isle of Man (Appendix 2: table 2, map 1). After such examination mechanical cleaning, with constant reference to x-rays was carried out (David 1982, 452; Nissan 1992, 6-8 & 37). Post-cleaning treatment - stabilisation and consolidation - blurs technical details and makes detailed analysis impossible, it should therefore be avoided until full analysis of any textile evidence has been undertaken (Edwards 1989, 5-6). The Claghbane sword did receive post-cleaning treatment, although the report does not indicate if this last process was carried out before or after analysis of the textile evidence. Based on the information Janaway was able to obtain during his analysis of the textile evidence it would appear however, that it was carried out after examination (Janaway 1982, 455). Two of the metal artefacts, the shears and sickle, from Scar were also stabilised which has blurred the technical details of the textiles considerably (Appendix 2: table 1, map 1).

Metal preserved textiles can, in some cases, be removed from the object to which they adhere. They are then conserved using one or more of the methods discussed above for extant textiles (Watson 1988, 75). As wetting can cause shrinkage, measurements must however, be taken before and after cleaning metal preserved textiles (Edwards

1989, 6). A metal preserved linen fragment from Kneep, Lewis, Western Isles (IL 856) was in such good condition that it was possible to remove it from the copper alloy brooch on which it was found (plate III; Appendix 2: table 1, map 1) (Bender Jørgensen 1987, 166; 1983, 7).

2.3.4 DRYING

The complexity and influence of drying on cleaned textiles can greatly affect the final result. It is therefore essential to consider which drying process will have the least detrimental effect, depending on the condition of the textile and fibre-type, before cleaning commences. Drying must be regarded as an integral aspect of the conservation process (Hillyer 1989, 15; Peacock 1992, 197). There are three methods of drying textiles: air-, solvent- and freeze-drying. Air-drying is the most commonly used method but recent experiments with freeze-drying have produced good results.

2.3.4.1 Air-drying

Air-drying involves two stages: the removal of excess liquid water and the evaporation of the remaining moisture. The removal of textiles from the cleaning tank is a crucial stage in the conservation process. Surface tension occurs which can cause various degrees of damage, usually irreversible; fibres can collapse, fracture and shred, thus becoming brittle and stiff. In addition, dyes may move, textiles can shrink and the surface fibres may become matted (Peacock 1992, 198 & 200).

Changes to textiles during drying are exacerbated by the nature of the interactions of fibres and yarns. For various reasons, the extent of fibre degradation within a textile is rarely uniform. Surface fibres are normally more fragile because they are exposed to the atmosphere, the abrasive action of laundering during active use and biological attack in the archaeological context (see 4.6.1.2 below). In addition, where textiles are a mixture of cellulose and protein fibres, one fibre can be well preserved and the other heavily degraded. Non-uniform degradation of this nature causes neighbouring fibres to swell and contract at differing rates, increasing stresses on the fibres. When wet, the fibre structure is supported so damage is kept to a minimum but on drying it collapses and shrinks. Damage can also occur where there is uniform degradation. Boring hyphae of fungi and ice crystals cause perforation of the fibre wall, which can also be weakened by waterlogging and oxidisation. The fibre is thus as susceptible to collapse on drying as those fibres that have undergone non-uniform degradation (Peacock 1992, 198-199).

The textiles from York were in sufficiently good conditioned to be air-dried, initially on absorbent paper between sheets of glass and then for the final process, exposed to air (Spriggs 1982, 156; Walton 1989, 426). Although straightforward, great care has to be taken when drying textiles in this way. Placing between glass counteracts shrinking and buckling but flattens the crowns of the worked surface and alters the structure of the textile. In addition, further restraining techniques are often employed where severe buckling is evident. Stainless-steel pins placed intermittently between threads is one technique used but results in localised zones of stress, causing fibre and thread breakage (Peacock 1992, 200).

2.3.4.2 Solvent-drying

To solvent-dry, textiles are treated with non-aqueous solvent before air-drying takes place. This prevents contraction and the breaking of individual fibres during drying (Hillyer 1990, 20). The water is exchanged for solvent and then the process of drying is the same for aqueous wet textiles. Solvents evaporate more rapidly than water however, reducing both drying time and the level of surface tension. In addition, less hydrogen-bonding to fibres occurs with solvents, thereby reducing the potential for fibre collapse. The need to restrain with glass and pins decreases as drying stresses are reduced. There are disadvantages to solvent-drying however; the removal of fats and waxes can occur and in some cases the movement of dyes takes place (Peacock 1992, 201).

2.3.4.3 Freeze-drying

Freeze-drying has traditionally been used to dry wet leather and wood from archaeological contexts. Recent research in Trondheim, Norway and at UMIST (University of Manchester Institute of Science and Technology) has shown that both cellulose- and protein-based fibres can also be successfully freeze-dried. It has been especially valuable in the drying of multi-period textiles from Svalbard (Spitsbergen) where conventional drying methods were not appropriate due to poor post-excavation handling (Peacock 1990a, 23; 1990b, 202).

Freeze-drying is most commonly carried out on already damp, wet or frozen textiles. This method of drying reduces the stresses associated with air-drying, with textiles retaining their shape, appearance and structure to a greater degree. By freezing textiles the water is removed in solid form, transforming from ice to vapour without going through the liquid stage. This method by-passes the associated stresses present when fabrics are air-dried (Peacock 1990a, 22 & 24; 1990b, 202; 1992, 202).

2.3.5 ADDITIVES

Treatments occur at every stage of conservation, from post-excavation to post-drying, as evidenced in the preceding pages. For the sake of clarity however, the use of additives has been allocated a separate section, although they must be seen as an integral aspect of cleaning and drying.

The use of additives in textile conservation is necessary to prevent further deterioration and to facilitate cleaning and drying where fibres are in a fragile state or are heavily encrusted with dirt. The long term effect of non-aqueous solvent treatments is not fully known however. It is therefore essential to use them sparingly and only when unavoidable. If additives are necessary it is important to ensure that they are appropriate to the chemical and physical state of the textile, the cleaning and drying method to be employed, and the level of conservation required (Peacock 1992, 205).

The disadvantages of using additives are numerous but so too are the advantages. A balance therefore has to be achieved between conserving textiles sufficiently to prevent further degradation while at the same time, retaining as much detail as possible for analysis.

Treatments during cleaning are normally employed where textiles are too fragile to withstand aqueous-cleaning, where dirt is so heavily encrusted that it has to be dissolved using non-aqueous solvents or where textiles are being conserved for display purposes (Hillyer 1990, 18; Peacock 1990a, 25).

Pre-treatments are used to achieve maximum benefit to the structure of the textiles depending on the conservation process being employed and to protect fragile fibres from the rigours of conservation. Such treatments can occur prior to cleaning or drying. Additives used prior to cleaning allow fragile fibres to relax gently while supported by the solvent (Hillyer 1990,15). The textiles from York were robust enough not to require pre-cleaning treatment but some of the weaves with low thread counts from both Pavement and Coppergate were treated with glycerine before drying to stabilise the fabric-structure (Spriggs 1982, 156).

After drying, textiles are frequently treated to lubricate and consolidate brittle and fragile fibres (Peacock 1992, 205). There are drawbacks to such treatments however, with the blurring of technical details, causing the loss of valuable information. For this reason the majority of the carbonised finds from York, although extremely fragile, were not consolidated; the exception being particularly fragile diamond twill fragments from 16-22 Coppergate, (1404) (Appendix 1: table 6, map 1). Some of the textiles, pre-treated before drying, also received extra treatment when dry to remedy powdering of brittle fibres. Both groups of textile were consolidated with soluble nylon. It has since been discovered that soluble nylon deteriorates with time and not only severely obscures technical details but attracts dirt and dust (Sease 1981, 106-108; Spriggs 1982, 156; Walton 1982a, 13; 1989, 425). To what extent this will affect the textiles from York has yet to be quantified.

2.4 DISPLAY

After conservation and further analysis, textiles are either appropriately packed for storage and additional research, or conserved to a higher level for display.

2.4.2 EXHIBITION-STANDARD CONSERVATION

Where textiles are to be used for display, the additional conservation necessary negates further detailed analysis. High-level conservation techniques can alter structural features and dimensions of the samples. It is therefore essential that full analysis and measurement takes place before final preparation for exhibition. Where textiles are to be displayed, all residual dirt has to be removed and at times a certain level of reconstruction is necessary.

Two important samples from 16-22 Coppergate, further conserved for display at the Jorvik Viking Centre in York, are the silk head-dress (1372) (plates IX & X,

Appendix 1: table 7, map 1) and the nålebinding sock (1309) (plates XI & XII; Appendix 1: table 11, map 1). The head-dress is significant, when used in conjunction with the other silk textiles excavated from York. It verifies trade contacts with the Near East, and cultural contacts with Lincoln and Dublin. The sock is one of the few textiles from York that displays direct Scandinavian influence. In addition, both garments furnish valuable information on aspects of dress. Analysis before and after high-level conservation revealed that alterations to the dimensions of the garments occurred during additional conservation and in both, a degree of reconstruction was necessary (Glover 1989, 427-431). Obviously display of certain archaeological textiles is not only desirable, but essential if the importance of this class of artefacts is to gain wider acceptance. It is important however, to weigh this need for display against the irreversible alterations that occur during high-level conservation and the implications of this to further meaningful research.

2.5 SUMMARY

From the discussion above it is clear that the degradation and preservation of archaeological textiles, and the techniques necessary to conserve them, are far from straightforward. Yet an understanding of both is essential to analysts to ensure optimum information is obtained and to facilitate meaningful cultural investigations.

The mechanisms of decay and survival of textiles are extremely complex. An understanding of the burial and micro-environment helps to ascertain if textiles are likely to survive, and is dependent on several factors: temperature, relative humidity, pH, Eh, salinity and the presence of heavy metals. The rate of and extent to which textiles degrade is dependent on the reaction of these factors with each other, which also affects the level of chemical and bacterial activity, the principal agents of textile degradation. For example, the slightly acid waterlogged environments of north European urban sites favour the survival of protein-based fibres to a greater extent than cellulose-based ones. Micro-organisms that survive in such environments appear to affect cellulosic structures more readily than proteinic ones. Climatic conditions also determine the level of survival of archaeological textiles, frozen and desiccated environments, not only preserve fabric but also the original dye colours. As well as soil conditions and climate, other agents can 'preserve' textiles in some form. For instance, impressions, charring and mineralised textiles provide information on textiles where evidence would not normally survive. The presence of mineralised linen textiles from graves in northern Europe for example, decreases the bias towards the predominance of wool in the archaeological record. From such evidence, it is possible to obtain a more balanced picture of the textiles used in past cultures.

In addition to burial environments, a knowledge of the chemical structure of different fibre-types is essential to facilitate informed prediction as to the possible presence of textiles on any given site. Wool and silk are protein-based fibres, which improves their survival rate in slightly acid anaerobic soils. In contrast, bast-plant fibres - flax, hemp, nettle - have a cellulose base and appear to survive more readily in alkaline soils. Such diverse survival creates a bias in the data from particular areas and thus presents a far from complete picture to the analyst.

To establish if textiles are likely to be present on a site, an appreciation of the cultural traditions, purpose and age of site is also advantageous. If trade networks are well established certain fibre-types may be present outside their area of origin. For instance, from Scandinavian period sites, silk has been found as far west as Iceland. The date of a site has significance for the use of certain fibre-types. For example, linen produced from flax does not appear in the Scandinavian archaeological record until the Iron Age.

If a knowledge of fibre-type and micro-environment is used in combination with cultural evidence the predictive ability of textile survival will thus increase. If proper excavating strategies are to be implemented in relation to surviving textiles, these factors must therefore be considered.

The techniques of conservation are far from straightforward and several variables have to be considered at all stages of the process. Careful decisions are continually being made to ensure that the correct procedures are carried out to suit both fibre-type and level of degradation. To aid such decisions, a knowledge of the burial environment and post-excavation handling is highly desirable. Textiles that have been excavated from desiccated environments for instance, are normally dry-cleaned. In addition, if a textile has been treated with an inappropriate biocide on excavation, it can not only cause further degradation, but may affect the success of conservation.

The procedures employed in the cleaning and drying of archaeological textiles affect the overall success of conservation, appropriate techniques are therefore essential. Cleaning comprises aqueous-, non-aqueous solvent and dry-cleaning, which is followed by air-, solvent- or freeze-drying. The method utilised is dependent on the state and mode of preservation, and the environment from which the textile was found. Well-preserved textiles from the waterlogged urban sites of northern Europe are for instance normally aqueous-cleaned and air-dried.

The level of conservation necessary is often dictated by the use to which textiles are to be put; either for exhibition or research. Where textiles are to be used for display, they require a higher level of conservation and often undergo a certain level of reconstruction, both procedures normally negate the possibility of further research. If material is to remain accessible for further research however, conservation should be at a level sufficient to prevent further degradation, without blurring technical details. Whatever the level of conservation, there has to be a balance between the needs of preventing further degradation and the requirements of display, with the needs of future research.

The analysis of textiles at every stage of conservation is essential. If analysis occurs at all stages, those technical details that become blurred or destroyed, and any dimensional changes that take place can be noted. Such details and changes can occur for various reasons: certain conservation procedures, including the use of bulking, consolidating and lubricating agents, may irreversibly alter and blur technical details; stitch-holes, creases and pleats can be obliterated during the normal cleaning process; and dimensions can be altered when high-level conservation takes place. Full analysis at all stages of conservation is not always possible however. The time allocated for conservation, the expertise of the conservator and financial restraints all affect the level of analysis feasible. Where rigorous analysis is not possible, it is essential to carry out a basic level of examination before conservation commences. If the results of such investigation are made available to the analyst, any alterations that have occurred or details that have been obliterated can be noted and properly recorded.

If analysts are to obtain maximum information from textiles, it can be seen that modes of degradation and preservation, and the techniques employed in conservation must be readily accessible. Such knowledge will ensure that correct textile characterisation takes place.

CHAPTER 3

LEVELS OF ANALYSIS: PROBLEMS AND SOLUTIONS

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LEVELS OF ANALYSIS: PROBLEMS AND SOLUTIONS

3.1 INTRODUCTION

Ancient textiles can be used like other artefacts to examine cultural continuity and change, technical developments, contact with other cultures and the exploitation of environments (King 1978, 94; Nelson & Johnson 1988, 27-28). The primary function of analysis is to answer questions about past cultures and not simply to clarify technical details. It is essential therefore that the analytical levels employed are appropriate to the questions being asked.

This chapter will be divided into three interrelated sections. A discussion of the different levels of analysis and the difficulties associated with them will be followed by an examination of possible solutions to the problems of analysis and interpretation caused by the methodological inconsistencies employed by textile specialists.

As discussed in the previous chapter, analysis begins as soon as textiles have been excavated. Accordingly it must be borne in mind that many of the techniques of analysis investigated are implemented before and during the conservation process as well as after it. Before analysis begins it is important to ascertain the type and range of information that is required to facilitate an examination of the past. The level of information required will have a direct bearing on the level and type of analysis carried out. Forward planning is therefore essential in terms of excavation strategies, post-excavation handling and conservation. In addition, the emphasis on textile findings in the excavation report must be considered.

The strategy employed at Scar, Sanday, Orkney for instance, although a rescue excavation, included these considerations. The survival of organic remains through mineralisation was predicted and incorporated into the excavation plan. This strategy and the techniques employed in post-excavation handling and conservation resulted in the recognition of textile evidence on several of the metal artefacts. The quality of this evidence has enabled detailed analysis of the textiles that will form an important part of the final excavation report (Gabra-Sanders, forthcoming). Close co-operation has been evident between excavation director, conservator and textile specialist throughout. The textile specialist has been able to ascertain exactly where and how the artefacts lay in the grave and their relationship with other objects (Nissan, June 1993, pers. comm.). Such co-operation and information has greatly enhanced the interpretation of the textile evidence from Scar (Appendix 2: Table 1, map 1) and has added considerably to the existing data from Scotland.

3.2 LEVELS OF ANALYSIS

There are two levels of analysis; primary- and high-level. The level necessary to gain the information required is thus a crucial consideration at all stages of analysis.

3.2.1 PRIMARY-LEVEL ANALYSIS

The first and less complex form of analysis can be performed using relatively simple techniques and equipment. To assess the structure of textiles and yarn, namely weave-type, thread count, spin direction, plies and cordage, as well as yarn diameter and twist, light microscopy using low-power binocular microscopes with a zoom facility is sufficient. It is also possible to assess some details with the naked eye. Low-power microscopes can, in addition, be used to gain basic knowledge of fibre-type. The differentiation between animal and plant fibres is possible, but not normally exact fibre identification, although differences in fleece-type and quality can be assessed (King 1978, 89-90; Ryder 1985, 128-130; March 1993, pers. comm.). When examining textile and yarn structure, samples do not have to be removed from the artefact for analysis. But when assessing fibre-type, and fleece-type and quality the removal of some of the fibres is required. This makes analysis a destructive technique. Although generally termed low-level analysis, examination at this primary-level requires a considerable amount of expertise if the evidence is to be examined rigorously and interpreted in an informed way.

3.2.2 HIGH-LEVEL ANALYSIS

The recording of details associated with macro-structures remains the core of textile studies but micro-structures are increasingly being investigated. This second mode of analysis, requires the use of more sophisticated equipment and by its nature is normally destructive. Exact fibre identification, fibre wear and use, and the presence of dyes and mordants necessitates the use of laboratory techniques, where samples are removed from the artefact to facilitate examination. A greater degree of skill is required to operate the equipment and, in general, the technical expertise necessary for accurate analysis increases (Cooke & Peacock 1992, 218; King 1978, 90; Nelson & Johnson 1988, 16).

Scanning electron microscopes (SEM) are used to identify fibre and to assess the level and type of fibre wear. Research at UMIST (University of Manchester Institute of Science and Technology) using SEM has illustrated how different fibres can be identified by the morphology of wear and breaks. Such work has enhanced fibre identification considerably and can be employed where other methods fail, for example, where fibre surfaces are badly eroded, and in carbonised or mineralised textiles. In addition, by assessing fibre wear, it is possible to ascertain how heavily a fabric has been used in antiquity, or if re-use has occurred. Work of this type has been carried out on textiles from Vindolanda: soldiers' leg bindings were shown to be heavily worn and the insole of a child's shoe was shown to be made from re-used fabric, possibly a cloak (Cooke & Lomas 1990, 215-226). Research of this kind enlarges our knowledge of the use and re-use of textiles in antiquity.

As discussed in the previous chapter (2.3.3.3), X-radiography is used mainly where textiles are preserved through mineralisation. The presence of textiles on heavily encrusted metal artefacts in the graves from Claghbane, Ramsey, Isle of Man and Scar, Sanday, Orkney were identified using such equipment in conjunction with optical microscopy and SEM (Cubbon 1982, 443-446; Janaway 1982, 455; Nissan 1992, 6). Examination of this nature facilitated textile analysis both during and after conservation.

To ascertain if dyes and mordants are present, several techniques are employed. Analytical techniques such as thin layer chromatography (TLC), absorption spectrometry, x-ray fluorescence (XRF) and diffraction, as well as SEM (EDXA) (energy dispersive x-ray analysis), ultraviolet and infra-red spectroscopy are applied. The results obtained can vary depending on the technique used. It is therefore essential, where possible, to use the process most applicable to the information that is required. To illustrate the varying results obtainable, Green and Daniels (1990, 10-14) have experimented with both XRF and SEM (EDXA) to analyse mordants. Their research, using non-destructive techniques, has shown that each method produces differing results. Alum for instance, does not show up well with XRF but does with SEM (EDXA). Such varying results highlight the importance of careful pre-analysis planning and the necessity to clearly state the analytical techniques used to give future researchers a full picture of the results.

The higher the level of analysis, the more costly it becomes, both in terms of equipment and time. It is therefore important to decide if the information being sought is essential to resolve the questions being asked. With advances in the techniques of analysis, there is a danger of it becoming technology driven with levels of investigation far outreaching the degree of information necessary to make informed assessments about past cultures.

3.3 PROBLEMS OF ANALYSIS

Problems relating to the analysis of ancient textiles fall into two interrelated categories: the nature of the preserved textile and the methodologies employed in its examination.

3.3.1 NATURE OF PRESERVATION

The main problem is the perishable character of the material under examination. Textile preservation is highly variable resulting in a biased data base. Degradation occurs during the active life of fabric, after burial and after excavation. Furthermore, physical degradation prior to and during burial, may affect post-burial biological and chemical degradation. The original chemical and physical properties of a textile can be altered, either through the effects of light damage and wear during use or by the take up of chemicals from the surrounding environment after deposition. In severe cases these properties can be completely obliterated. Analysis of dyes and mordants and the identification of fibres may then yield spurious results. Such inaccuracy is often not considered or recognised by analysts (Nelson and Johnson 1988, 12-14). The possibility of this form of physical and chemical change is rarely discussed in textile reports, thus omitting a vital piece of information.

The mode of preservation also varies considerably (see 2.2.2 above). The textiles from York for example, and the majority from Scotland display very different forms of preservation. Actual textiles survive from York and, in general, the material from Scotland consists of impressions or mineralised forms of evidence. Such differences create problems for analysts as each require a different approach to examination.

3.3.2 IMPRESSIONS AND MINERALISED TEXTILES

Accurate analysis is often confounded by the nature of preservation, especially where the evidence takes the form of impressions or mineralised textiles. In these cases, fibre-type can rarely be identified and the examination of plies and cordage is usually not possible. Secondly, the obscuring of either the obverse or reverse of the fabric makes the detailed examination of fabric structure difficult (Bender Jørgensen 1992, 129; King 1978, 90). It is often difficult to differentiate between weaving, close-set twining and wrapping and it is not always possible to distinguish braiding, embroidery and brocade. These problems are exacerbated where one fabric is overlain by another during degradation. Thirdly, colour and colour patterning is not discernible. Finally, impressions and mineralised textiles often show negative imprints. Spin, ply, twining and weave patterns therefore have to be reversed for correct identification (King 1978, 90).

The accuracy of measurements from mineralised samples and, to a lesser degree, actual textiles also has to be considered. With possible shrinkage and expansion due to levels and forms of mineralisation and degradation it is important to assess if measurements of yarn diameter and thread count actually mean anything (Cooke December 1992, pers. comm.). Edwards maintains that some forms of metal preserved or replaced textiles do not shrink or expand. Her findings come from her work on the mineralised textiles from the Anglo-Saxon settlement at Mucking, Essex. Textile fragments preserved through iron corrosion products were compared with actual textiles; both thought to have originated from the same fabric, based on the similarities of design and their close proximity in the ground. The measurements from both were the same, indicating that no changes in dimensions took place through mineralisation or if they did, at the same rate for both mineralised and actual textile (March 1993, pers. comm.). Although probably not representative of all mineralised textiles, evidence of this nature must be borne in mind when measuring metal replaced or preserved textiles. The possibility of spurious measurements therefore has to be considered. This should not however, discourage analysts from taking measurements or detract from the value of assessing weave-type and spin-direction, as both are essential for fabric characterisation.

3.3.3 SIZE AND STRUCTURAL DISTORTION

Size of sample and structural distortion of textiles also affects the level and nature of analysis selected. Many textile fragments are extremely small (< $1cm^2$) and often heavily matted or structurally altered by shrinkage or expansion. This obscures many details relating to weave-type, spin-direction, fibre diameter and fabric quality as well as any evidence of stitch-holes, pleats and seams, resulting in a less than clear picture. In addition, to accurately identify complex weave types, such as diamond twill, reasonably large fragments showing at least one pattern repeat are necessary (Bender Jørgensen 1986, 287).

To obtain a more complete structure characterisation the sample needs to be of a size that enables enough measurements of fibre and yarn diameter, angle of yarn twist and thread count to be taken from different areas of the textile to give a representative figure and overall picture. (Cooke & Peacock 1992, 220). Such luxuries are rarely available to the archaeological analyst.

El-Homossani (1988) maintains that to assess fabric quality, at least ten measurements of thread count, yarn diameter and angle of yarn twist is required for each textile to achieve accurate results. Work at UMIST by Cooke and Peacock shows however, that in most instances, ten measurements are too few. Such a small number of measurements can say little about overall yarn diameter and angle of twist due to the variability of these features. It is thus not appropriate for accurate assessment and results in incomplete information for future researchers. To gain accurate results of changes in yarn diameter and angle of twist, a minimum of one hundred samples is required, but to assess thread count per centimetre, ten measurements is acceptable for each sample. Cooke and Peacock (1992, 220-223) stress that all such measurements should be listed in reports to afford maximum information. An illustration of the fabric to indicate the points at which measurements were taken is also beneficial.

In addition to assessing fabric quality and strength, partial destruction is necessary to obtain information on exact fibre-type and morphology, fibre wear and the presence of dyes and mordants. The level of destruction necessary for this detailed level of research is however, in most cases unacceptable, as it negates the possibility of future research (Cooke & Peacock 1992, 222). Problems of analysis thus also relate to the destructive nature of some forms of analysis.

Before analysis requiring partial destruction takes place the eventual use to which a sample will be put must be decided. If it is to be used for display purposes, minimum destruction is desirable. If, on the other hand, a sample is to be stored or used for future research, a small amount of destruction may be justifiable as long as proper recording is carried out before and after such work. It is therefore necessary to reach a balance between the need for research and the acceptable level of destruction.

3.3.4 SELVEDGES AND STARTING BORDERS

For accurate assessments of fabric structure and identification of warp and weft threads, selvedges and starting-borders are required (King 1978, 90). Selvedges confirm the vertical edges of the cloth and starting-borders, the horizontal, thus by ascertaining the warp and weft threads, it is possible to establish weave-type, particularly where weaves are complex. Selvedges and starting-borders therefore greatly enhance rigorous analysis but their presence is the exception rather than the rule. In consequence, it is often not possible positively to identify the two systems, warp and weft, and twill weave patterns. When discussing textiles however, warp and weft threads are frequently referred to, when in fact there is little or no information to verify which is which. This lack of verification is rarely noted in the literature, thereby providing incomplete data. Bender Jørgensen and Walton acknowledge this problem and each has devised her own way of solving it. Bender Jørgensen (1986, 288) clearly states her methodology for overcoming the problem, which she adheres to in all her analysis. She attributes the higher number of thread counts to the warp and lower to the weft. Where the spin direction differs, with one system Z-spun and the other S-spun, the Z-spun yarn is, in most instances, defined as the warp. Although where identified, the warp normally has the higher thread count, and where spin direction differs, it is usually Z-spun, there are exceptions. For this reason, such an approach has its shortcomings. Bender Jørgensen's clear statement of her methodology does however, enable researchers to allow for the possibility of lack of positive identification when assessing the material. Walton (1989, 318) prefers to refer to unidentified warp and weft threads as 'system 1' and 'system 2'. If analysis is to be seen to be rigorous, Walton's methodology and terminology should be adopted wherever there is the slightest doubt.

3.3.5 TEXTILES FROM GRAVES

Graves in which many different fragments are present in the same burial, presents problems of distinguishing the different textile items originally deposited in the grave, especially as the evidence tends to be mineralised or of a very fragmentary nature (Bender Jørgensen 1986, 287). Yet the closed nature of grave analysis enables hypotheses to be made regarding funerary customs and dress, so these textiles are of great importance when examining culture and society. The difficulties relating to the fragmentary nature of the textiles have yet to be fully resolved, but rigorous examination with defined criteria and accurate recording will go some way to reduce the problems highlighted above. For instance, work on fleece-typing carried out on textiles from the late tenth-/early eleventh-century rich male grave from Mammen (Bjerringhøj), Denmark illustrate how rigorous analysis can, where the textile samples are suitable, allow for meaningful interpretation. Hald's initial research of the textiles, identified three fragments of 2/1 twill as originating from the same garment. The fragments were examined without the application of fleece-type analysis (Hald 1980, 102-117). Further analysis by Munksgaard, using this form of investigation, led to their identification as coming from two different fabrics (Munksgaard 1984, 162). Fleece-type analysis also confirmed that fabrics produced from five different fleece-types were deposited in the grave (Walton 1991, 141-142).

3.3.6 TERMINOLOGY

Accurate description and interpretation is often confused by textile terminology. In many instances individual specialists use different terms for the same concept or use the same term but interpret it in differing ways. Exact classification in conjunction with illustration, both diagrammatic and photographic, is therefore needed in place of jargon (King 1978, 90). This is especially pertinent where non-textile specialists are using textile reports to further their research.

3.3.6.1 Fabric Quality

Terminology relating to fabric quality is particularly confusing and requires standardisation. The work of various specialists on Scandinavian period textiles clearly illustrates the use of the same terminology with different interpretations (table 3.1). All use the terms fine, medium and coarse to describe fabric quality which is based on the number of threads per centimetre for each textile. Walton's definition of fabric quality describes cloth with counts of > 15x15 as fine, 9x9 to 14x15 as medium and < 9x9 as coarse. Walton (February 1993, pers. comm.) stresses that she uses these terms as a rough guide, exact definitions being difficult due to the nature of the material under examination. Bender Jørgensen (1986) on the other hand varies her definition of fine, medium and coarse quality cloth according to the group and the period of textiles under study. For textiles from York and Birka, Sweden, counts of up to 18 threads per centimetre are classed as medium quality. She describes the Coppergate textiles with counts of 7-11 as medium coarse and < 3-5 as coarse. In terms of Scandinavian period textiles in general, counts of > 16 are classified as fine, with counts of > 20 as very fine. Hedges' categorisation (1982, 102) is >19x12 for very fine, > 16x10 for fine, > 8x7 for medium coarse and < 5x5 for coarse (table 3.1).

	very fine	fine	medium	medium coarse	coarse
Walton	-	> 15x15	9x9 - 14x15	-	< 9x9
Bender Jørgensen	>20	>16	<18	7-11	<3-5
Hedges	> 19x12	> 16x10	-	> 8x7	< 5x5

Table 3.1: Fabric quality based on thread count.

For the non-specialist such definitions can be at best confusing and at worst indecipherable, especially as Walton and Hedges include both warp and weft in their descriptions and Bender Jørgensen does not. Walton stresses that thread counts remain the primary data, with verbal descriptions given to enlighten those who are not aware of what thread counts per centimetre signify (February 1993, pers. comm.). But what does it actually mean? There is no agreement of how many threads per centimetre constitute fine, medium and coarse quality, so even if the terms are fully understood they still remain ambiguous.

Hedges (1982, 103) describes textiles in terms of 'very fine/fine... - hard to feel' and 'coarse... - soft to feel', thus causing more confusion. Both are contradictions in terms particularly the latter description. To add to the confusion, it is possible to have a low thread count with a high yarn diameter, as in sample 583 from Lloyds Bank, Pavement (Appendix 1: Table 1, map 1), or a low thread count with low yarn diameter, for example in textile 1272 from 16-22 Coppergate (Appendix 1: Table 6, map 1). In the former, the weave is a well balanced, even close one and the yarn soft but it is still defined as of coarse quality, suggesting a fabric with a rough feel and low standard of production. In fact such a textile is more synonymous of high standard production with a soft feel. The latter example, produces a loose weave which is again termed coarse in terms of Walton's, Bender Jørgensen's and Hedges' definitions. It may however, not feel coarse to the touch so is an ambiguous description. In addition, the two textiles, although both defined as coarse are very different in appearance. Just as readily a fabric with a high thread count is described as being of fine quality, suggesting a soft textile, but it could be produced from a hairy yarn which gives a rough texture. If the accepted definitions of the meaning of 'fine' are considered, even if the weave is balanced and even, to define it as fine is bestowing incorrect qualities. It is thus clear that the appearance and feel of a textile are crucial to accurate description.

Geijer (1980, 210-211) for example, when describing the fabric quality of the Birka textiles, uses the terms fine and coarse to define the feel and general appearance of the material. She encompasses thread counts in her discussion but uses them to describe technical rather than visual details. Her description is certainly more readily understandable and more accessible to non-specialists. If generally adopted it would greatly enhance the clarity of textile classification.

Another way of describing fabric quality more clearly, is the inclusion of yarn diameter alongside thread count. This will indicate the thickness of thread and thus put thread count and fabric quality more into perspective. Furthermore, if the fibre density/cover factor is quantified using this information, confusion in terminology would be considerably lessened.

Schølberg (1988, 228) suggests the use of scatter diagrams to indicate the relationship between thread counts, yarn diameter and fibre density/cover factor (the percentage of cover per unit area). Schølberg omits to clarify the preferred technique to ascertain cover factor, but Marsural (1988) in the same publication, propounds a method similar to one currently being worked on by the author. Masural's technique is complex and time consuming, my method, although in its early stages, is less complicated and more rapidly implemented. Whatever the method employed, Schølberg (1988, 230) maintains that fibre density is indispensable for objective descriptions of textiles, and for assessment of the relationship between different fabrics. The closeness of the threads should thus be seen as more significant in ascertaining fabric type and quality, than the counting of threads per centimetre.

To quantify fibre density/cover factor, it is necessary to calculate the actual area taken up by the yarn, including the cross-over point of the warp and weft threads. This necessitates the multiplication of the thread count of system 1 with the sum of the multiple of the yarn diameter and length of thread. To this is added the sum of system

2, which undergoes the same calculation. From the total of system 1 and system 2, it is necessary to subtract the total density of thread cross-over. The multiple of the two thread counts is multiplied by the multiple of the two yarn diameter measurements. By subtracting this from the total of the first calculation, it is possible to ascertain the cover factor (fig. 3.1), thereby elucidating the closeness or looseness of the weave. Thus facilitating a more accurate description of the fabric.

Fig. 3.1 Formula to Calculate Cover Factor.

Formula: $N^{S1} \times (d \times l) + N^{S2} \times (d \times l)$

$- \quad (N^{S1} \times N^{S2}) \times (d \times d)$

$= \quad$ fibre density/cover factor

Legend: N = number of threads per cm

s1 & s2 = system 1 and system 2

d = thread diameter in mm

l = length of thread in mm = 10mm

Example: sample 567 from Lloyds Bank, Pavement - wool 2/1 Z/Z diamond twill (Appendix 1, Table 1, map 1).

Technical details: 18/11 threads per cm, 0.4/.05 mm yarn diameter =

$18 \times (0.4 \times 10) = 72$

$+ \qquad = 127$

$11 \times (0.5 \times 10) = 55$

$- \quad (18 \times 11) \times (0.4 \times 0.5) = 39.6$

$127 - 39.6 =$ cover factor of **87** (to nearest whole number)

By utilising fibre density/cover factor to assess fabric quality , it becomes clear that the terms fine, medium and coarse are not appropriate for such evaluations. The examples in Figure 3.2, taken from the York textiles, illustrate the value of basing fabric quality on fibre density/cover factor. Sample 583 (Appendix 1: table 1, map 1), would be considered a coarse weave (i.e. loose) based on thread count. It is in fact closely woven due to the yarn diameter measurement, as verified by the cover factor. Conversely, sample 1400 (Appendix 1: table 6, map 1), is designated a fine weave (i.e. closely woven) based on thread count but when the yarn diameter measurement is brought into the equation, it can be seen that it is loosely woven with a lower cover factor than sample 583, which has a lower thread count per centimetre.

Fig. 3.2 Example of Cover Factor in Two of the York Textiles

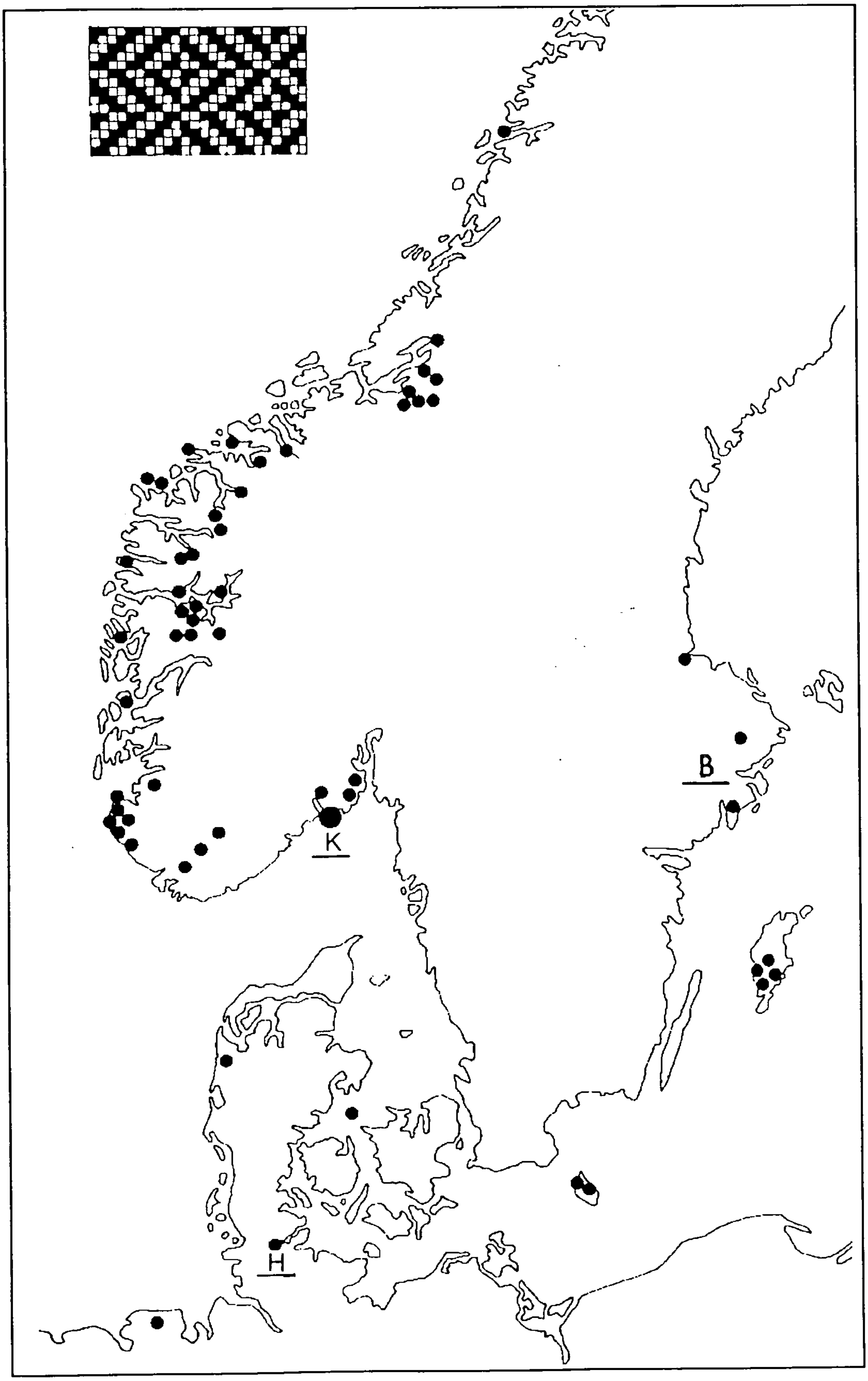
sample 583	wool 2/2 twill	4/3 thread count	3.0/3.25 yarn diameter
		= cover factor of **100**	
sample 1400	bast fibre tabby	28/27 thread count	0.2/0.2 yarn diameter
		= cover factor of **80**	

More work on quantifying fibre density/cover factor is required to refine the technique and speed up the procedure. These examples clearly show however, that accurate descriptions of fabric quality must be based the quantification of yarn diameter as well as that of thread count.

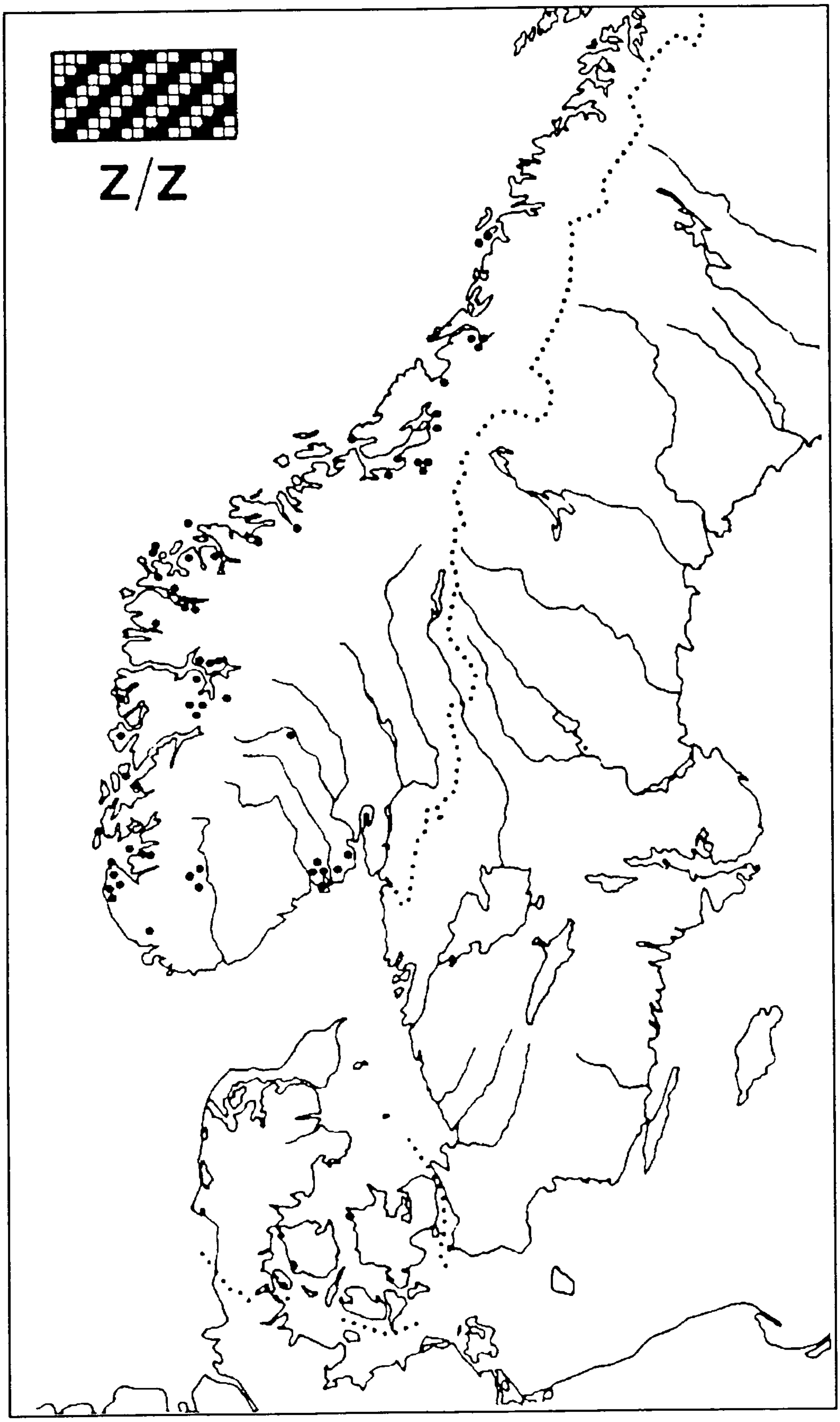
It is necessary to define the terms 'balanced' and 'even/uneven' accurately in any discussion on textile quality. A balanced weave signifies that a textile has a similar number of warp and weft threads per centimetre. 'Even/uneven', as well as 'uniform', refer to the regularity of the weave in terms of thread count per centimetre over the whole area of the fabric. The terms are vital to the accurate description of textiles but are often interchanged or not clearly defined, thus confusing interpretation. Clear illustration of examined textiles will go some way to alleviating this problem but only the standardisation of the use of the terms will solve it completely.

3.3.6.2 Weave-Types

Another area where terminology can cause confusion, is the naming of specific weave- and textile-types. These are regularly named after the site or area in which they were first recognised, or most commonly found. In principle, such a means of identifying weave- and textile-type is sound. The problem arises where a name is changed, where there is disparity in usage in different publications or if there is no explanation as to why a term is applied to a particular weave- or textile-type. In many instances, the name can give a false impression as to the origin of its place of manufacture. Of the Scandinavian period textiles, the so-called *Birka-type* Z/Z-spun diamond twill is a case in point (plate XIII). The weave, as with the majority of the other textiles from the period, was given the term by Bender Jørgensen. It was named after the ninth- to tenth-century cemetery at Birka, Sweden where it was first identified by Geijer in the 1930's (map 3.1). In fact, many more examples of this weave type have been excavated in western Norway, where Bender Jørgensen suggests they originated (map 3.1). In earlier publications Bender Jørgensen used *Norwegian-type* twill to describe another weave type, a Z/Z-spun 2/2 plain twill (plate XIV), found most commonly in Norway (map 3.2). She now describes the *Norwegian-type* twill as a *Veka-type* twill, after one of the Norwegian sites in which it was found (Bender Jørgensen 1986, 358-361; 1992, 138-140 & 160). There is little real standardisation of the terms used to describe weave-types; some are adopted generally, while others are used only by the specialist who coined them and few others. In addition, there is often no explanation as to why a description was used in the first place, or why the name has been changed or that a change has occurred. For instance, in many publications it is not made clear that the *Norwegian-type* and *Veka-type* twill is one of the same. When looking for parallels in comparative material, this can create problems of identification, especially for the non-specialist. Some form of agreed terminology is therefore necessary.



Map 3.1. Distribution of *Birka-type* Z/Z-spun 2/2 diamond twill.
B = Birka. K = Kaupang. H = Hedeby.



Map 3.2. Distribution of *Veka-type* Z/Z-spun 2/2 plain twill.

3.3.6.3 Yarn

The terminology used to describe yarn and its preparation is frequently borrowed from the modern textile industry (Madsen 1988, 249). It is therefore not appropriate for the description of yarns from ancient textiles, in particular when terms are misinterpreted or inappropriately paired.

'Woollens' and 'Worsteds'

Analysts regularly use the terms 'woollen' and 'worsted' when describing the feel and appearance of archaeological textiles, equating soft 'woollen' yarn with carded fibre and hard 'worsted' yarn with combed fibre. Carding separates and mixes the fibres, irrespective of length. The result is a mass of soft, loose fibres lying in all directions. In contrast, combing removes the short fibres and aligns the longs ones, creating a smooth, firmer mass of fibres (Appendix 3: Glossary of Terms) (Cook 1968, 94-5).

It is commonly assumed that, when spun, carded fibres produce a soft, loose yarn ('woollen') and combed fibres, a hard, firm yarn ('worsted'). Madsen, basing her scepticism on the work of modern hand-spinners, disputes this. Hand-spinners have found that soft, loose yarn can be just as readily spun from combed or teased wool, as from carded. It can even be spun direct from the fleece if the wool is suitable. Equally, hard, firm yarn does not have to be produced from combed fibres alone. It is highly probable therefore that spinners in antiquity also had the expertise to produce yarns of varying qualities from fibres prepared in a variety of ways. Madsen (1988, 249) maintains that it is the degree of twist that determines the feel and appearance of the yarn, not the method of fibre preparation. Although the feel and appearance is undoubtedly affected by the degree of twist, the method of fibre preparation must however, have some influence on both the feel and appearance of the spun yarn. The unaligned fibres of carded wool protrude from the yarn more readily than aligned combed ones, thus creating a different appearance and feel (plates XV & XVI).

The terms 'woollen' and 'worsted' first appear in English documents in the fourteenth-century (Walton 1989, 316). As such, the terms should be used with extreme caution in any discussion on pre-fourteenth-century textiles. In addition, carders are not known in the archaeological record until the twelfth-century. It is therefore inappropriate to talk of carded wool prior to this (Madsen 1988, 249; Walton 1989, 316). Walton does however, suggest that some form of primitive carding was carried out before the twelfth-century, possibly using thistles set in a frame. 'Woollen' and 'worsted' yarn and textiles, and combed and carded wool are though harder to differentiate prior to the fourteenth-century, when the English textile industry formed two branches, one of which produced smooth 'worsted' fabrics and the other soft, fulled 'woollen' ones (Walton 1989, 316). The use of the terms are therefore not really applicable for textiles produced before this.

The Scandinavian period textiles from York present many intermediate yarn- and textile-types that can not easily be described as either 'woollen' or 'worsted'. Walton (1989, 316) therefore omits the terms from her discussion on the textiles from 16-22 Coppergate. 'Woollen' and 'worsted' are however, used to describe the Scandinavian period fabrics from Lloyds Bank (Hedges 1983), 5 Coppergate (Walton 1982) and Parliament Street (Walton 1986). When viewing the material from all of the sites as one body of evidence, it is therefore necessary to be aware of the disparity of usage of 'woollen' and 'worsted' as descriptive terms . What is termed 'woollen' and 'worsted' from Lloyds Bank, 5 Coppergate and Parliament Street has counterparts from 16-22 Coppergate, but without access to such information, misinterpretation may occur.

Degree of Twist

Terms relating to the degree of twist can cause as much confusion as those pertaining to feel and appearance. The use of 'softly' spun and 'tightly' spun may confuse interpretation. 'Soft' is normally equated with 'woollen', carded yarn and 'tight' with 'worsted', combed yarn. As demonstrated by Madsen this is not the case.

To prevent misinterpretation, measurable features as outlined in Table 3.2 should be used for objective description of yarn quality and appearance in preference to subjective terminology (Madsen 1988, 249). It is preferable therefore to base description on the properly documented examination of the angle of twist/spin, as well as yarn diameter and twist/spin direction (Schølberg 1988, 230). Feel and appearance is of course an element of yarn description that should not be ignored but it must be used in conjunction with objective classification.

	Sample No.	Sample No.	Sample No.
Material/Fibre			
Diameter			
Number of Fibres			
Diameter of Fibres			
Length of Fibres			
Direction of Twist - Z or S			
Degree of Twist			
Ply or Cable and Direction			

Table 3.2: Yarn Analysis - Criteria for Objective Description (after Madsen 1988)

Schølberg (1988, 230-31) suggests that fibre-type and diameter, and yarn diameter largely dictated the structure of yarn types before the advent of wool carders. The tension on fibres during the spinning process has a direct effect on the structural characteristics of yarns, in particular the elasticity of the thread. A high degree of twist produces a yarn with less elasticity than one with a low level of twist. The higher the degree of twist, the sharper the angle of twist, twist angle is therefore a good indicator of the level of elasticity of a yarn. The angle of twist, when seen in relation to fibre-type, its mean diameter, and yarn diameter, can also be used to examine how yarns produced from different fibre-types react to spinning.

Spin Direction

Even where definitions have been agreed internationally, confusion can still occur. This is the case with spin and ply direction. Agreed definitions and notations for spin direction are: 'Z' for clockwise twist and 'S' for counter-clockwise twist (fig. 4.7). Plies are notated as 'Z2S' (S-ply from two Z yarns) and 'S2Z' (Z-ply from two S yarns) (fig. 4.8). Ullemyer and Tidow however, prefer to use lower-case to denote yarn twist and notate ply as 'z/S' (S-ply from two Z yarns) and 's/Z' (Z-ply from two S yarns) (Bender Jørgensen 1986, 288 & 362). To confuse matters even more, Bender Jørgensen in her 1992 publication uses lower-case to indicate spin direction. Such divergence from the accepted definition can cause considerable confusion if these differences in conventions are unknown to the researcher.

One reason for the confusion created by non-standardised terminology and definitions is that the majority of textile specialists are self-taught and, for the most part, work alone. In addition, the relatively small number of people working with ancient textiles has, through necessity, encouraged a degree of individualism. The founding of NESAT (North European Symposium for Archaeological Textiles) in 1981 has been instrumental in bringing together textile specialists from very different backgrounds and with varying degrees of experience, thus facilitating the standardisation of terminology, and enhancing textile studies in general. There is still work to be done however, before textile descriptions become readily accessible to specialists and non-specialists alike.

3.4 PUBLICATION

The inconsistencies in the methodologies employed by different textile specialists of course affects the usefulness of published analysis. Analytical methods are often not documented, limiting the ability of the reader to make an informed assessment (Nelson & Johnson 1988, 13). What constitutes 'publishable' data varies widely depending on the expertise and opinions of the specialist. It is rare for instance, to find information on all the measurements made or where presented, whether they denote the mean, mode or only measurement taken. It is essential to have such information to make meaningful comparisons, especially between more than one set of data. The inclusion of fibre diameter measurements in Ryder's and Walton's reports on the textiles from York for instance, considerably enhances the usefulness of the information to researchers (Ryder 1982, 128; Walton 1982, 132; 1989, 302 & 305). All analysis of this sort should therefore be included somewhere in the textile report to give a full and clear picture of the evidence.

If full recording is not possible, the minimum information that is acceptable in reports must include at least the following basic data: the dimensions of a sample; assessment of the structure of both woven and non-woven textiles, with details of weave-type, non-woven processes and thread count per centimetre, where appropriate; information on the fibre and yarn, including fibre-type, the direction of the spin/ply and yarn diameter; finally, colour and evidence of selvedges, starting-borders, pleats, and sewing or mending should be noted. The angle of spin and number of twists per centimetre is also useful as it gives some indication on the tightness of the yarn thus indicating its strength (King 1978, 91).

Discrepancies in the available information in reports is not the fault of varying methodologies and expertise of textile specialists alone. A major problem relating to the reports on the textiles from Scotland for instance, is the date of their discovery and publication. Many were reported before the advent of the regular use of sophisticated equipment or rigorous analysis. As such, the information is far from complete, and even where recent examination of the artefacts has taken place (by Bender Jørgensen in 1983), much of the vital original information is lost. The textiles from the relatively recent, and recent excavations of the Scandinavian period sites of Claghbane, Ramsey, Isle of Man (Appendix 2: table 2, map 1); Kneep, Lewis, Western Isles and Scar, Sanday, Orkney (Appendix 2: table 1, map 1) have however, all been analysed using sophisticated techniques. The information obtained has thus greatly enhanced the level of information now available to researchers of the Scottish material.

In addition, textiles are often sent for analysis with little information on the site from which they came. Without such details, the material is examined out of context. No matter how rigorous the analysis, such situations will necessarily result in a less than complete picture and thus incomplete interpretation. The reports on the York material do not fall into this category; excavation details were readily available to the analysts.

Finally, constraints of finance and time are of course a major consideration in the preparation of textile reports. Textile analysis, at whatever level, is extremely time-consuming if it is to be carried out rigorously. When the number of textile fragments to be analysed is great, if too much time is spent on any one aspect of the process, it ceases to be cost-effective (Walton & Taylor 1991, 5). Walton, for instance (1990, 187), calculates that adequately to test one fragment for dyes and mordants, when combined with the identification of fleece-type in warp and weft, can take at least five hours. The amount of information that can be obtained in the time available has, therefore, to be carefully planned. Certain aspects of analysis may have to be less rigorously carried out than others or, in an ideal situation, than would be acceptable; for instance the taking of multiple measurements. As long as such omissions are clearly stated and the material is available for future research, this situation, although undesirable, is tolerable. In addition, financial restraints often curtail complete analysis. In particular, decisions have to be made concerning high-level analysis and whether its application is vital to informed assessments.

Despite the problems of analysis described above, textile reports have improved considerably over the last decade. More publications contain at least a basic level of interpretation and in an increasing number, interpretation is seen as a major element of the report. Such is the case in the York Archaeological Trust textile reports, where the material is accorded the same degree of importance, and in consequence finance and time, as other artefacts. Many reports still include incomplete data but those that contain technical details only are becoming the exception rather than the rule.

To complement the improved textile reports, articles relating to textile studies have in the last decade become more common in journals not restricted to textiles alone. It is noticeable however, that to date, papers on interpretation and theory have appeared in Scandinavian and American journals with greater regularity than in British ones. The most likely reason for this is the longer history of textile studies in Scandinavia and the greater emphasis on anthropological and theoretical aspects of textile studies in the United States of America. Articles in British journals tend to place more emphasis on the analytical techniques employed in textile studies, which is probably due, in part, to the pioneering work carried out in this field by textile and fibre specialists from Britain. All areas of ancient textile studies are covered in a wide variety of journals however. Articles encompass both technical and cultural aspects: preservation and conservation, fleece evolution and identification, and methods of analysis, as well as information on culture and society, history of textiles and textile technology. Problems of textile studies and possible solutions are also covered. Through such publications, the varying aspects of textile studies is made available to a wider audience, thereby highlighting the value of this type of artefact study.

3.5 PROBLEMS OF ANALYSIS: SOME SOLUTIONS

Most of the difficulties relating to methodology highlighted above are not insurmountable. Cooke and Peacock maintain that detailed guidelines for recording and research would reduce the problems considerably and suggest the adoption of those proposed by Nelson and Johnson (Cooke & Peacock 1992, 218 & 223).

3.5.1 ATTRIBUTE SELECTION AND CHARACTERISATION SCHEMES

Nelson and Johnson concede that the limitations on accurate analysis due to the material under examination are difficult to control, but they maintain that the methodologies employed in its investigation are easier to manage. To eliminate as many sources of error as possible and to facilitate accurate description and comparison, they stress the necessity of a sound methodology and the design of characterisation schemes; the analytical processes appropriate to characterise a textile. The first step to this is the selection of indispensable attributes. These should encompass distinctive features, necessary, sufficient and relevant to the accurate description of textiles (Nelson and Johnson 1988, 14-15). For example, to describe fabric-structure attributes pertaining to fibre-/fleece-type, spin-/ply-direction and fibre density, which includes thread-count and yarn diameter, have to be included. The identification of weave-type and the presence or absence of dyes and natural pigment is also required. A characterisation scheme is devised for each element involved in the characterisation of fabric structure, thus ensuring complete information

In most published material, attributes fall into four categories: aesthetic, function, fabric-structure and production technology. Where possible, each group of attributes should be included in analysis to ensure complete or near complete description. In addition, each group must be used in conjunction to ensure maximum cultural information (Nelson and Johnson 1988, 15).

Aesthetic aspects include design, which is normally difficult to define due to the fragmentary nature of the material (Nelson and Johnson 1988, 15). The tapestry from the ninth-century female boat-burial from Oseberg, Norway (Ingstad, 1982) and the embroideries from the late tenth-/early eleventh-century burial mound at Mammen, Denmark (Bender Jørgensen 1992c; Hald 1980; Walton 1991) are two examples where the size of the textiles allows for the examination of aesthetic attributes. Careful description of these attributes, enables an investigation of cultural contact through the subject and design of the decorative motifs used.

As with aesthetic attributes, attributes relating to function facilitate cultural examination. The identification and function of the silk head-dresses from York: 5 Coppergate (651) and 16-22 Coppergate (1372) (plate IX & X; Appendix 1: table 7) , and their similarity to those found at Lincoln (Muthesius 1982, 132-136; Walton 1989, 371-375; Walton Rogers, forthcoming) and Dublin (Hecket 1990, 85-96), not only furnished information on the silk trade but also determined the cultural contacts that took place between the three settlements. The nålebinding sock (1309) from 16-22 Coppergate (plate XI & XII; Appendix 1: table 11) (Walton 1989, 343-345) also allowed for detailed examination of function and cultural affinities; nålebinding being a favoured Scandinavian technique. Attributes relating to investigation of the re-use of textiles, as well as their intended and actual use should also be included. Although difficult to identify accurately, investigation of the re-use of textiles has in recent years formed a new and important area of textile research as Cooke and Lomas' work on the Vindolanda textiles demonstrates (Cooke and Lomas 1990, 215-227) (see 3.2.2 above).

For the most part, attributes relating to fabric structure are not too difficult to analyse (Nelson & Johnson 1988, 16). The necessary attributes required for informed assessments of textiles include those relating to the examination of: fibre-type, yarn, the structure of the fabric and the presence or absence of dyes. Where it is not possible to assess all the attributes, the omissions should be clearly stated with the reasons for their omission noted. Mineralised textile evidence for instance, regularly negates the identification of dyes, complex weave-structures and fibre-type, as demonstrated in the majority of the Scottish material. The information obtainable from examined fabrics, not only facilitates cultural investigation but also enables hypotheses to be made regarding textile production technology.

To make accurate assessments about the technology of textile production, it is preferable to make reference to textile manufacturing equipment contemporary with the textiles in question (Nelson & Johnson 1988, 15). Spindle-whorls and loom-weights are commonly excavated but other indicators of textile production technology are less likely to be found. Nevertheless, in the Scottish graves enough equipment has been excavated to allow for interpretations, especially when used in conjunction with comparable material from Scandinavia and the attributes relating to fabric-structure. An understanding of the technology employed in textile production can be applied to trace technological innovation and change, in addition to explorations into the techniques necessary to the production of differing fabric-types.

The selection of indispensable attributes is intrinsically linked to the level of analysis that is necessary and relevant for accurate description and comparability. They are both therefore essential analytical components of a characterisation scheme. A scheme can range from complex, requiring sophisticated equipment and many processes, to very basic, relying on few tests that may not always result in rigorous analysis. Ideally, a scheme should involve analysis at as low a level as is possible to accurately characterise textiles and allow for comparisons appropriate to the acquisition of cultural information (Nelson & Johnson 1988, 16-17).

In addition to designing appropriate characterisation schemes, analysts should have an understanding of methodological limitations, and terminology. It is also necessary to be able to apply the analytical technique most suitable for the accurate description of an attribute. Such an understanding is indeed a vital aspect of the design of a characterisation scheme and will lessen the possibility of spurious results due to the use of inappropriate analytical techniques or the lack of specificity in an analytical technique (Nelson & Johnson 1988, 16-17). For example, to identify fibre-type in mineralised textiles, SEM is more appropriate than low-powered light microscopy. In contrast, where the identification of weave-type in well preserved textiles is required, low-powered light microscopy is applicable.

Other essential elements of any characterisation scheme is the use of a reference set of comparative material, as well as ethnographic material and experimentation where appropriate (King 1978, 94; Nelson & Johnson 1988, 24). Reference sets are particularly important in the analysis of dyes, where it is necessary to compare results with known dye-classes. To ascertain modes of textile production and to test hypotheses relating to excavated textile technology equipment, experimental work can be employed. For instance, the work at the Experimental Textile Workshop at Lejre, Denmark and the Textile Research Centre at Leiden, The Netherlands have been instrumental in solving some of the problems relating to the production of complex twills on the warp-weighted loom. Ethnographic parallels can also be utilised to test hypotheses and to gain a greater understanding of the form of textile technology favoured in antiquity. Hoffman (1964) in her seminal work on the warp-weighted loom, based much of her research on ethnographic evidence from the rural communities in Lapland, Iceland, and the Faeroes who still used warp-weighted looms at the time of her research.

3.5.2 DESIGNING CHARACTERISATION SCHEMES

3.5.2.1 Fibres

To characterise fibres, physical, chemical and mechanical properties can be examined. The most usual properties to be examined are physical and chemical. Both are however, subject to degradation and contamination which can result in spurious results. If a particular attribute overlaps several fibre-types, positive identification, even in a well preserved fibre, can be difficult, for instance, the cellular and nodal components of bast fibres are not easily differentiated between fibre-types, such as hemp and flax (Nelson and Johnson 1988, 17-18). These problems can be overcome with high-level analysis; cross-section examination of bast fibres, using SEM, is for instance, employed to differentiate between various bast fibres, including flax, nettle and hemp.

Often, it is sufficient to identify the fibre-type only, for example, hair, wool, bast or silk. For this, light microscopy of surface morphology is adequate necessitating a characterisation scheme at the primary-level of analysis. If however, identification of a specific type of wool fibre is required, detailed examination of the surface morphology is necessary, as well as fibre diameter, birefringence and pigmentation, demanding more sophisticated techniques (Nelson and Johnson 1988, 17-18). For identification of this sort, the characterisation scheme would include higher level analysis, encompassing the use of SEM and projection microscopes.

The differentiation of bast fibres is normally desirable as, where positively identified, they are found to be used for differing purposes. Flax for instance, has most commonly been utilised for clothing and bed-coverings. Hemp, on the other hand is more suitable as sailcloth. Again SEM is appropriate for this level of analysis. Where textiles produced from bast fibre are heavily degraded, it is not easy to assess physical and chemical properties. To overcome this problem, fibre-type can be assessed by examining mechanical properties, such as the natural rotation direction on drying. Flax for instance rotates in a clockwise direction and hemp in a counter-clockwise one (Nelson and Johnson 1988, 17-18). The effect of fibre degradation does however, have to be considered when employing this form of analysis, degradation can interfere with the fibres natural tendency to rotate on drying, thus leading to spurious results.

3.5.2.2 Dyes and Mordants

Designing a characterisation scheme for the identification of dyes and mordants has its problems as well. The same mordant and dye can produce different colours between fibre-types. Similarly, different mordants and the same dye results in a variety of colours in the same fibre-type. It is therefore essential to ascertain not only dye and mordant class but fibre-type as well. In addition, to assess if a mordant was a necessary aspect of the dying process, it is necessary to distinguish between vat, direct and mordant dye-classes (see 4.5.2 below) (Nelson & Johnson 1988, 23-24). To characterise dyes and mordants, characterisation schemes at a higher level of analysis are always necessary. Such processes often necessitate the design of more than one characterisation scheme, as demonstrated by Green and Daniels (1990, 10-14) (see 3.2 above). Using more than one scheme ensures that complete information is obtained.

The two examples, fibre, and dye and mordant characterisation, clearly illustrates the need for the selection of indispensable attributes, the design of an appropriate characterisation scheme and the availability of a reference set of comparable material. If textiles are to be analysed sufficiently accurately for meaningful comparisons to be made, such factors must be applied.

3.6 SUMMARY

Analysis of archaeological textiles is dependent on both the nature of the evidence and the methodologies employed to facilitate accurate description. The variability in the preservation of textiles inevitably yields a biased dataset; analysis of actual textiles and their mineralised counterparts for instance, require different analytical methods. The size of the sample, impressions of and mineralised textiles, and structural distortion, as well as the presence or absence of technical details such as stitch-holes, selvedges and starting-borders, all affect accurate description. Analysts have to be aware of these limitations and adjust the form of analysis accordingly.

The problems of the perishability of the evidence are not easily solved. The application of the correct analytical method however, can alleviate many of the problems caused by the differing modes of preservation. It is therefore vital to select the correct level of analysis, primary- or high-level, to gain the information necessary for the accurate description of textiles. Primary-level analysis examines macro-structures: fibre-, yarn- and fabric-structure. Light microscopy using low powered binocular microscopes is normally sufficient for this level of examination, which is not generally destructive. To investigate micro-structures however, high-level analysis is necessary utilising sophisticated techniques. Such procedures, which are usually destructive, employ SEM, TLC, X-ray fluorescence and absorption spectrometry, thus facilitating the analysis of fibre-type, wear and use, and dye analysis. This high-level analysis is especially relevant for the examination of mineralised textiles. The higher the level of analysis, the more costly it becomes however. It is therefore essential to assess the cost involved in a procedure and weigh this against the degree of information necessary to make informed assessments about past cultures.

In addition to the nature of the evidence, accurate description and interpretation is confused by the terminology used by many textile specialists. Subjective descriptions of fabric quality - fine, medium and coarse - are ambiguous; the quantification of all technical details - thread count and yarn diameter - is therefore essential for accurate classification. Correct portrayal of yarn morphology and spin-direction is also important if textiles are to be of any value to the pursuit of cultural information and comparability. Furthermore, standardised terminology is desirable in textile reports and publications if they are to be accessible to both specialist and non-specialist. If such publications are to make a valued contribution to archaeological enquiry, they must be seen to be accurately compiled with a readily understandable terminology.

Nelson and Johnson (1988) consider that the use of a sound methodology and the design of characterisation schemes will improve textile analysis considerably, thereby providing the means for accurate analysis and comparison. Attribute selection is seen as the first stage of this procedure, encompassing the aesthetics, function, structure and production technology of textiles. The selected attributes, when linked to the appropriate level of analysis, form the basis for accurate description. It is therefore essential to apply the appropriate analytical technique to accurately characterise an attribute. To describe fabric-structure in well preserved textiles, for instance, light microscopy is sufficient, on mineralised or badly degraded samples however, SEM may be required. Characterisation schemes can consequently be at a primary-level to ascertain macro-structures in well preserved material, or at a high-level to investigate micro-structures and macro-structures in poorly preserved or structurally altered textiles.

By being aware of the levels and problems of analysis, it is possible to investigate and develop ways of resolving them, which in turn allows for accurate descriptions. From such description, it then becomes possible to investigate the social and cultural aspects of textiles from past societies.

CHAPTER 4

TECHNIQUES OF ANALYSIS AND THEIR APPLICATION: A CRITIQUE AND COMMENTARY

CHAPTER 4

TECHNIQUES OF ANALYSIS AND THEIR APPLICATION: A CRITIQUE AND COMMENTARY

4.1 INTRODUCTION

It is the purpose of this chapter to present a critique of and commentary on the techniques of textile analysis and the appropriate application of these techniques. Scandinavian period textiles are used throughout to illustrate how accurate description can facilitate meaningful cultural investigation.

Bender Jørgensen and Walton have been instrumental in enlarging our knowledge of Scandinavian period textiles from all areas of northern Europe. In particular, to Bender Jørgensen (1986; 1992a; 1987 with Walton) can be credited the systematic examination and appraisal of the development and specificity of weave-types across the whole area. Walton (1982b; 1988; 1989; 1990; 1991) has brought Britain to the forefront of north European textile studies with her pioneering research and her subsequent detailed work on Anglo-Scandinavian textiles and their place in the wider world.

In addition to the work of Bender Jørgensen and Walton, the recent research of other specialists has contributed to the improved status of textile studies in general. Janaway's study (1983; 1985; 1989) of mineral preserved and replaced organics has resulted in a more rigorous approach to the analysis of mineralised textile evidence. The work of Ryder (1964a; 1969; 1983; 1987b) has greatly enhanced our understanding of the fleece-types exploited in the past and Taylor and Walton's research into dye-classes (Taylor 1983; 1990; Walton 1988; 1990; 1991; Walton & Taylor 1991) has enabled complete textile characterisation to take place. Finally, a new area of textile studies, the analysis of wear and re-use of fabrics, has been initiated by Cooke (1990; Cooke & Lomas 1990). This chapter is therefore largely based on the recent pioneering work of these researchers.

In general, fabric-types can be defined by weave, spin and cloth quality. Bender Jørgensen & Walton suggest that centres of manufacture can be determined when certain cloth-types are plotted on distribution maps, many of which exhibit a predominance in particular geographical areas, for instance the *Birka-* and *Veka-type* twills in Norway (see 3.3.6.2 above) (plates XIII and XIV; maps 3.1 and 3.2). Bender Jørgensen and Walton also suggest that in some cases, it is possible to distinguish between locally produced and imported materials. In addition, the comparatively new studies of fleece-type and dye-class identification, enable further verification of cloth-types, along with their possible areas of origin (Bender Jørgensen & Walton 1987, 177 & 187; Walton 1991, 139).

Bender Jørgensen (1986, 287) does however, advise extreme caution in the interpretation of distribution maps. The perishability of textiles and the varying conditions under which they survive result in areas devoid of evidence. Moreover, excavations and other find spots are not evenly distributed over a whole region. This is not therefore a true reflection of the original distribution. It is due, in part, to the location of urban excavations and access to funding and also where accidental finds have added to the data; discoveries in peat bogs and grave finds for instance. To solve, at least in part, the problem of perishability and find-spot disparity, maps could also be used to display the distribution of other elements of cloth. In addition to weave-type, elements should include: spin-direction, degree of twist and yarn diameter; thread count and cover factor; fleece- and fibre-type; and finally, dye-class. A clearer picture of the cultural contacts and possible production centres should then emerge, particularly if comparative distribution maps are used in conjunction.

To assess the validity of distribution maps and cultural investigations in general, it is essential to accurately characterise textiles. To achieve this, complete analysis is desirable. This section therefore considers the five interrelated components necessary to achieve complete characterisation: fibre, yarn, fabric, colour and wear. Such divisions are required to emphasise the importance of each component and how each contributes to textile studies in specific and unique ways. A detailed examination of the processes of manufacture of ancient textiles and their distribution is thus made possible.

4.2 FIBRES

Fibres fall into two main categories: animal and vegetable. Within each category there is a great deal of variety, with many of the fibre-types displaying unique properties. Wool and silk, for instance, are both animal fibres but are very different in feel and appearance.

A knowledge and understanding of fibres is fundamental to textile studies as the basic attributes of differing fibre-types have a direct affect on the form and quality of fabric produced. Flax, for instance, produces a crisp, stiff, cool cloth which is enhanced by plain tabby weave (fig. 4.1; plate XVII). Wool, on the other hand, gives a soft, wavy, warm material, augmented by twill weave (fig. 4.2; plate XVIII). Silk also produces a soft fabric, but with its smooth, supple attributes has a luxurious feel, heightened by satin weave (fig. 4.3; plate XVIX) (see 4.4.1 below) (Bender Jørgensen 1992a, 117 & 120; January 1993, pers. comm.). The skill employed to exploit the unique properties of the various fibre-types, has resulted in the utilisation of particular fibres to specific items. For instance, flax has traditionally been used for under-garments and bed-linen, wool for outer-garments, blankets and wall-hangings, and silk where high status, luxury garments and

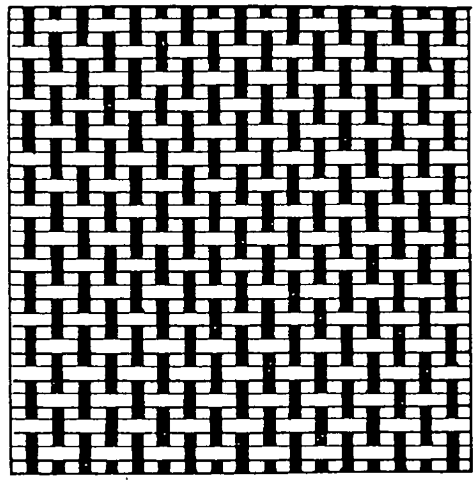


Fig. 4.1. Plain tabby-weave.

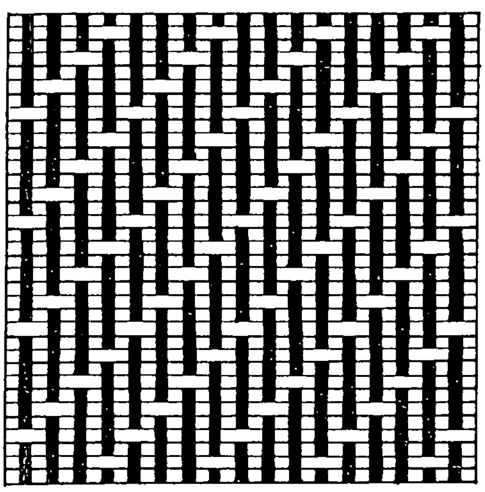


Fig. 4.2. Plain twill-weave.

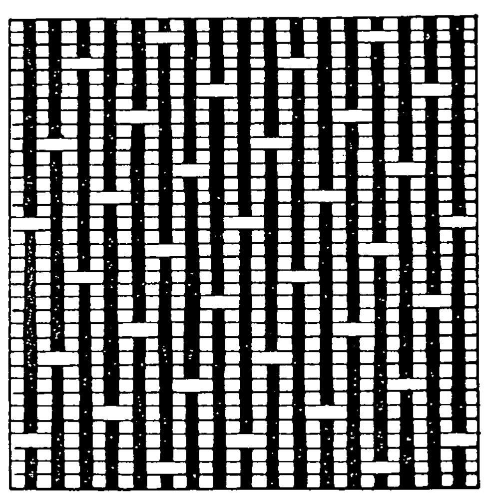


Fig. 4.3. Satin-weave.

hangings are required. It can be said therefore that weave-types and textile products reflect the fibre from which they are produced. An understanding of the products and weave-types most suited to particular fibres-types can thus be utilised to suggest the possible original function of a textile. For example, the reconstruction of undershirts has been undertaken based on the linen textile remains found on oval brooches excavated from the ninth-/tenth-century cemetery at Birka, Sweden (map 3.1) (Hägg 1983).

The main fibre classes in the material from Scandinavian period Britain are wool and flax, with silk and hemp evident but to a lesser degree. Although nettle fibre has not yet been positively recognised in the British archaeological record of this period, it has been identified in Scandinavia and was commonly used in textile production during the Scandinavian period. For this reason it is included in the following discussion.

4.2.1 Wool

The slightly acid waterlogged burial environments of northern Europe are more suited to the survival of textiles produced from animal fibres than those of vegetable fibres (see 2.2.1.1 and 2.2.3.1 above). As a result, there is a bias in the textile evidence from this region, in favour especially of wool products. This is reflected in the emphasis placed on wool in the following discussion.

The main purpose of analysing wool fibres is to ascertain which fleece-type was used in the production of a particular textile. From such investigation, it is possible to suggest areas of origin of cloth and thereby cultural contacts (Bender Jørgensen & Walton 1987, 177). It also makes feasible observations regarding fabric quality and the skills necessary to obtain differing fabric qualities. In addition, fleece-typing is useful for making comparisons where fragments are similar but not identical and thus can help to confirm the number of different cloth-types represented in a given context, of which the Mammen textiles are a good example (see 3.3.5 above).

4.2.1.1 Morphology of Wool

Wool fibres consist of a cortex, comprising approximately spindle-shaped cells, which is surrounded by a cuticle of overlapping scales (fig. 4.4). The upper part of the scale is attached to the fibre, with the lower portion protruding out slightly. It is this arrangement, in conjunction with the friction caused when the scales rub together, that produces the unique felting properties of wool. Wool fibres have characteristic scale patterns which differ depending on their type. When examined under light microscopy, and compared with a reference set, these differences aid identification (Appleyard 1970, 6; Ryder & Gabra-Sanders 1985, 128). The fibres are categorised into three groups - kemp, hair and true wool - each having a readily identifiable scale pattern. Medium and fine fibres have well spaced, wavy scales (plate XX), whereas coarse hairy fibres have a closely set, mosaic scale pattern (plate XXI) (Ryder & Gabra-Sanders 1985, 128). In addition to scale patterns, the presence or absence, and type, of medulla is used in fibre identification. The medulla is the inner hollow core surrounded by the cortex, and consists of a series of air-filled, latticed cavities. The form of the medulla varies between species and breeds and between fibres of the same species and breed (Appleyard 1970, 6; Bender Jørgensen & Walton 1987, 178; Ryder, March 1993, pers. comm.).

In cross-section the shape of wool varies from oval to circular (plate XXI). In general, the finer the fibre, the nearer the contour to circular, coarse fibres normally display an irregular outline. These differing shapes are regularly used for fibre identification. Where these structural characteristics have been modified by degradation however, the chemical element of the fibre may have to be used in identification. Wool consists of keratin, a sulphur containing protein, which renders the fibres insoluble in acids in cold conditions but readily dissolvable in heated caustic alkalis (Appleyard 1970, 6-7). It is the reaction to these conditions that helps in the identification of the fibre.

The shape and chemical balance of wool fibres can be modified by various factors: firstly, exposure to heat and light during the growth of the fleece can produce 'tippy' wool (bleached fibre with narrowed tips); secondly, manufacturing and finishing processes, such as the use of alkalis in the cleaning and dyeing of fleece and yarn, and fulling, may alter the structure of fibres; thirdly, everyday wear tends to flatten and smooth fibres; finally, fungal and bacterial attack can alter chemical and physical balance. Bacterial attack, causes longitudinal striations leading to splitting and separation of the cortical cells, resulting in fibres with 'brush-ends' (Appleyard 1970, 6-7 & 9). As such modifications can confuse accurate identification, an understanding of the processes of degradation, manufacturing procedures and the natural alterations that occur in wool fibres, is essential to analysts.

4.2.1.2 Fleece-types

The three fibre-types, kemp, hair and true wool, are very different in both cross-section and whole-mount (fig. 4.5). True wool is a crimpy fibre that rarely has a medulla; kemp is seasonally moulted and has a wide latticed medulla with a narrow cortex, and hair, which grows continuously, has a narrow or interrupted medulla. Fleece-type can therefore be broadly categorised by the general appearance of these fibre-types (Walton 1990, 146). Fleece-type affects the quality of the cloth that can be produced from the different fibre-types, which was well understood by textile producers throughout millennia, including the Scandinavian period, where exploitation of the various fibre qualities is clearly represented in the material from both York and Scotland.

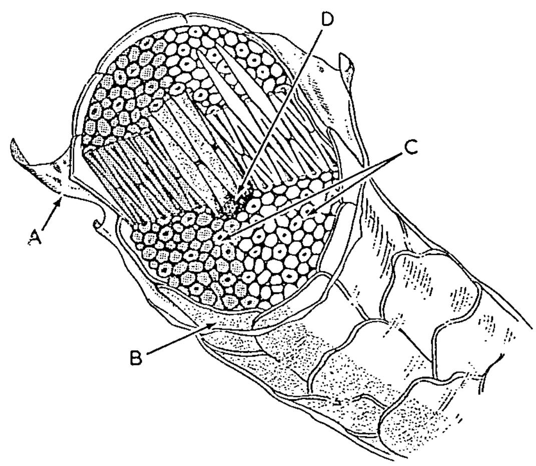


Fig. 4.4. Wool morphology:
a the epicuticle: water repellent membrane.
b scales: the epicuticle and scales form the cuticle of the fibre.
c the cortex: the largest portion of the wool fibre.
d the medulla: hollow space running through the centre of the fibre.

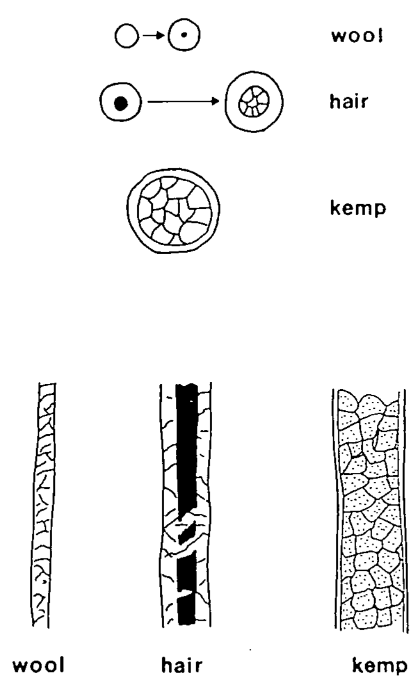


Fig. 4.5. Kemp, hair and wool in cross-section and whole mount.

4.2.1.3 Fleece-Type Categorisation: development

The development of fleece-typing in archaeology was pioneered by Ryder (1964a; 1969; 1983; 1987b) who sought to develop a theory of the evolution of sheep and the subsequent changes in fleece-type. In archaeology, its application has been instrumental in demonstrating that the wools used in textile manufacture have varied considerably in the past and that different fleece-types have predominated at different times and in different areas. From such analysis, Bender Jørgensen and Walton suggest that it is possible broadly to date textiles where little other information is available (Bender Jørgensen and Walton 1987, 178).

Ryder's extensive research enabled him to place fleece-types into seven categories, ranging from long, coarse coats with long, hairy kemps to very fine, soft fleece with short wool (fig. 4.6; table 4.1; Appendix 4). Although the classifications compiled by Ryder are, of necessity, subjective they are nevertheless extremely valuable for textile specialists investigating the possible origin of certain fabric-types.

Category	morphology	mean diam.	mode	diam. range	modern parallel
Ancestral Coat	two distinct coats: outer coarse kemps; very fine underwool	wool 12μ kemp 144μ	wool 14μ kemp 160μ	continuous range from 6μ-190μ	Mouflon
Hairy Medium	narrowing of kemps	36.9μ	30μ	14μ-130μ	Hairy Soay
Generalised Medium	further narrowing of kemps	24.4μ	20μ	12μ-46μ	Woolly Soay
Hairy	kemps transformed into long continuously growing hairs	31μ	22μ	18μ-110μ	Swaledale, Scottish Blackface, Orkney
True Medium	fine fibres become coarser	42.3μ	44μ	22μ-60μ	Cotswold Longwool
Shortwool	further narrowing of outer coat, coarsening of finer fibres	27.5μ	30μ	16μ-40μ	Norfolk Horn, Romney
Fine Wool	further narrowing of outer and medium coat	22.5μ	20μ	12μ-38μ	Merino

Table 4.1: Fleece-type categories
Legend: μ = 1 micron (0.001mm)

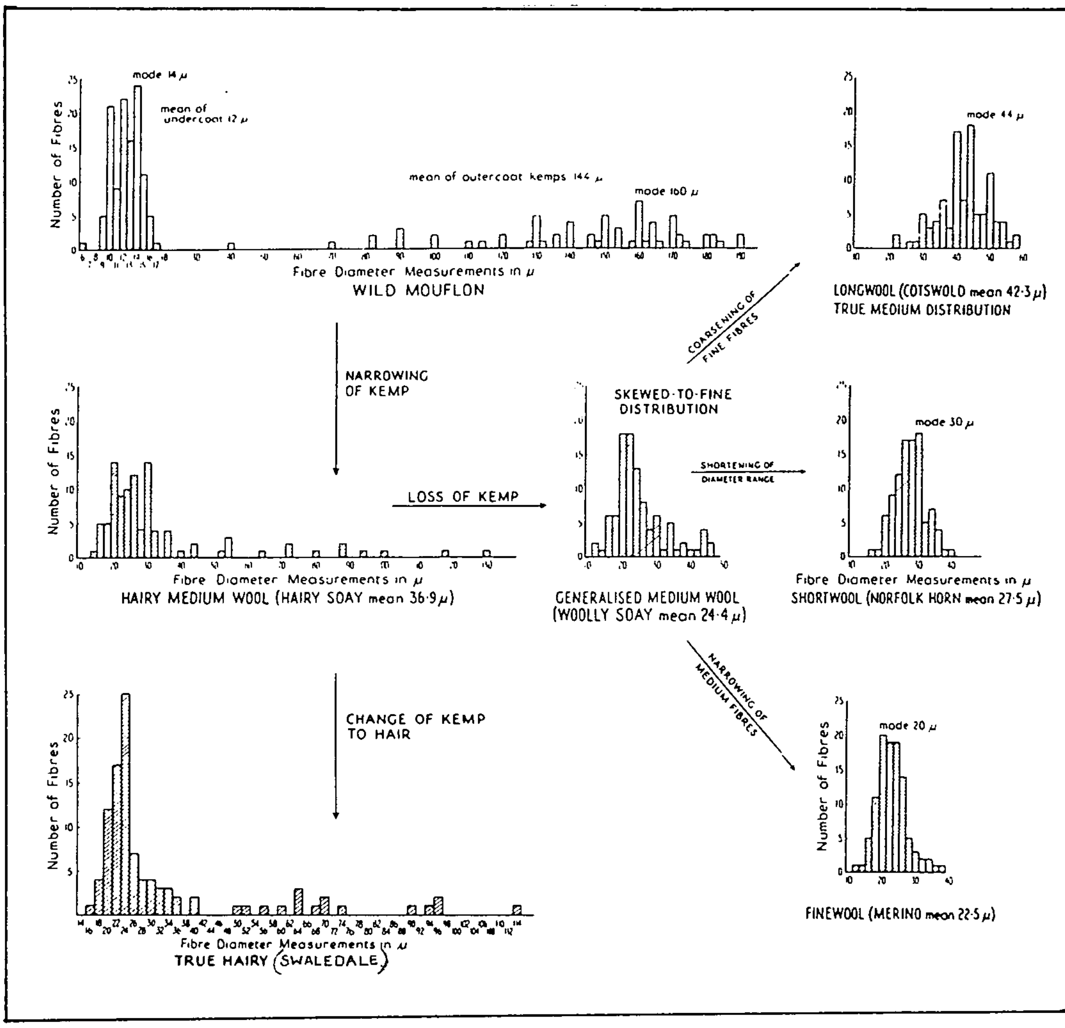


Fig. 4.6. Fleece-type categories.
μ = 1 micron (0.001 mm)

The fleece-types that feature in British Scandinavian period wool are: hairy, hairy medium, generalised medium, true medium, shortwool and fine. Table 4.2 shows the number of samples in each category excavated from 16-22 Coppergate (Appendix 1: table 4, map 1). Complete comparable information is not available for the Scottish material, due in part, to the mineralised nature of the textile evidence. Where actual textile does survive however, hairy wool predominates (Ryder 1964a, 558; 1982, 128) (table 4.3). This evidence is based largely on the analysis of fibres from the Orkney Hood from St Andrew's Parish, Mainland, Orkney (NA 3) (plate XXIII; Appendix 2: table 1, map), the Greenigoe textiles from Orphir, Mainland, Orkney (NA 307) (plate XXIV; Appendix 2: table 1, map 1) and the textiles from Kildonan, Eigg (IL 164) (plate XIV; Appendix 2: table 1, map 1) (Ryder 1964a, 558; 1968a, 137-139; 1983, 193). To this can be added the textile evidence from Cronk Moar, Jurby, Isle of Man. The woollen samples (A4-9) (plate XXV; Appendix 2: table 2; map 1) from Cronk Moar have been likened to the fleece of the Manx Loghtan (Crowfoot 1966, 83), a modern parallel to Ryder's hairy fleece-type (table 4.1). Although such scant evidence must be viewed with caution, when used in conjunction with Ryder's work on the evolution of British sheep breeds (1964a; 1964b; 1969; 1981; 1982; 1983; 1987b), it is probable that his assertion, that hairy wool predominated in Scandinavian period Scotland, is correct. Although there is disparity in the available fleece-type information from York and Scotland, it is evident from Tables 4.2 and 4.3 that the wool exploited for textile production in both locations was of a predominately hairy nature during the Scandinavian period.

	H	HM	GM	TM	S	F	total samples
raw wool	11	7	3	1	-	1	23
textile	18	14	6	10	-	-	48
total fleece-type	29	21	9	11	0	1	

Table 4.2: Anglo-Scandinavian Fleece-types: 16-22 Coppergate (Walton 1989, 301).
Legend: (H) hairy; (HM) hairy medium; (GM) generalised medium; (TM) true medium; (S) shortwool; (F) fine.

	H	HM	GM	TM
NA 3: Orkney Hood - hood	-	2	-	-
hood - tablet-weave: band 1	-	2	-	-
hood - tablet-weave: band 2	-	2	-	-
hood - fringe	-	2	-	-
307: Greenigoe a	2	-	-	-
307b	-	-	2	-
307c/d	1	-	1	-
307e	1	-	1	-
IL 164: Kildonan a	-	2	-	-
IL 164b + pile	-	1	-	1 (pile)
IL 164b	-	-	1	-
Total Fleece-type	4	11	5	1

Table 4.3: Fleece-types: Scandinavian Period Scotland (Ryder 1968a, 137-8). Legend: (H) hairy; (HM) hairy medium; (GM) generalised medium; (TM) true medium.

4.2.1.4 Analysis of Wool

To identify the surface morphology of well-preserved wool fibres, light microscopy is normally sufficient. Scale patterns and medullation can be examined, plus certain structural alterations, such as 'brush ends' and striations (Ryder & Gabra-Sanders 1985, 123-138). Where severe degradation or structural alteration has occurred however, SEM examination may be necessary. This is particularly valuable where fibres are mineralised. Janaway's work (1983; 1989) has illustrated how SEM examination can be used to identify the characteristic scale patterns of particular fibre-types (plate XXVI), thus making it possible to recognise fine, medium and coarse fibres. By using SEM photomicrographs it is also possible to measure diameter range, thereby ascertaining fleece-type categories (Ryder & Gabra-Sanders 1985, 133). A note of caution must be sounded in using such measurements to identify fleece-types however. Little work has been undertaken to quantify the level of shrinkage and expansion, if any, that occurs when fibres are mineralised. Until such research takes place, a healthy scepticism should be applied to measurement of this sort.

SEM investigation can also be applied when examining cross-sections of fibres. The presence or absence of a medulla can be ascertained, in addition to the thickness of the cortex. From this, fibre-type can be identified (Ryder & Gabra-Sanders 1985, 138).

4.2.1.5 Fleece-Type Categorisation: method

To place fibres into one of the seven fleece-type categories (table 4.1), the diameter mode and mean, and the distribution of diameter range of fibres has to be ascertained. When assessing fleece-type, it is the coarsest fibres that define the type not the finest. In addition, the diameter mode and 'tail' of distribution is more important than the mean in determining the category. To categorise fibres, Ryder developed a manual method in which one hundred measurements at x500 magnification are taken of each sample on a centimetre scale. When these measurements are doubled and converted to microns, the appropriate category can be selected (Ryder and Gabra-Sanders 1985, 123-128). The technique, although largely successful is however, necessarily slow and subject to operator errors. To overcome these problems, Hutchings and Ryder (1985, 296-297) have developed a computerised method based on the manual technique. A Bit-pad is used which can also be utilised to identify and measure natural pigment and medullation, an additional asset in fleece-type characterisation.

Using a computer reduces the time it takes to make a hundred measurements of each fibre set. The fleece-type is therefore ascertained at a greater speed, which enables a larger number of samples to be examined. In addition, the method reduces operator and recording errors and requires a lower level of operator-training than is necessary when manual measuring and recording is applied. The data are stored and printed in ranked order of fibre diameter with the mean, standard deviation of diameters, as well as percentage of pigmentation and medullation included (Hutchings & Ryder

1985, 298-299). This form of presentation enables comparisons to be made quickly and accurately, thus enhancing the value of fleece-typing to textile studies.

Whether the manual or computerised technique is employed, to assure optimum results, it is desirable to take fibre samples and measurements from each type of yarn visible in a textile; from warp and weft, as well as from sewing and embroidery thread etc. (Bender Jørgensen & Walton 1987, 178).

Ryder (March 1993, pers. comm.) does acknowledge that fleece-type categorisation is not completely fool-proof as certain structural features of wool fibres alter naturally during the annual growth cycle. Some fibres narrow in the winter and lose medullation and in sheep that moult, kemp, hair and true wool is often shed at different times of the year, or in some fleeces, one type of fibre moults and another does not. The *hairy medium* fleece is a good example of this; the kemps stop growing in the winter for the spring moult whereas the hairs thin during this season, grow continuously and do not moult. The time of year a fleece is rood (plucked) or shorn can therefore effect the categorisation of fleece-types.

4.2.1.6 Raw Wool Staples

Raw wool samples only rarely are recovered from excavations, but where they do, their examination can make a valuable contribution to fleece-type assessment. The morphology of the fibres of raw wool samples is a more accurate indicator of fleece-type category than that of fibres from textiles; nothing has been removed from raw wool staples through processing. The twenty-six raw wool staples excavated from 16-22 Coppergate (Appendix 1: table 9, map 1), gave Ryder a rare opportunity to investigate the natural length of fibres from differing fleece-types. In addition, it made possible the gathering of information on the appearance of the fleece (plate XXIII) and the method of harvesting (Appendix 4) (Ryder 1989, 308).

The dominant fleece-types in the raw wool staples from York, identified by appearance and diameter measurement, are hairy, hairy medium and generalised medium respectively, which correlates with the general pattern evident in the textiles (table 4.2). It would appear therefore, that the predominant fleece-types accessible to the people of Anglo-Scandinavian York were similar to the fleece of today's Soay, Swaledale and Scottish Blackface, as well as Orkney and Manx Loghtan (table 4.1). It is also probable from the methods used to harvest the wool - shorn, and rood (from both living and dead sheep) - that the breeds exploited included sheep that had ceased to moult naturally, as well as those that still moulted seasonally. Information of this sort is an important component of cultural investigations. It allows for investigations into wool harvesting practices, as well as giving information on the sheep exploited for textile production in specific areas.

4.2.2 Silk

Under light microscopy silk is reasonably easy to distinguish from other fibres but high-level analysis is required to characterise cultivated silk (Bombyx mori) and wild silk, the most common of which is *Tussah* silk (Antheraea pernyi), the product of several silkworm species.

4.2.2.1 Morphology of Silk

Silk occurs in the cocoon of the silk moth as two a-cellular filaments or brins produced by twin glands. The brins are extruded through a single spinneret, and consist of the protein fibroin. As the brins extrude they are cemented together by another protein, sericin, thus forming a bave (Appleyard 1970, 13-13; Ryder & Gabra-Sanders 1985, 127).

The properties of cultivated and wild silk are similar, but wild silk is more resistant to strong acids and alkalis (Appleyard 1970, 13). Wild silk is therefore likely to survive to a greater degree in the archaeological record than its cultivated counterpart. There are subtle structural differences between cultivated and wild silk resulting in a slightly different feel and appearance to the finished woven product; wild silk has a coarser feel and less smooth surface. The analysis and understanding of such differences is vital when discussing manufacture, use and trade, and the politics of silk production; cultivated silk production has throughout antiquity been subject to strict political control (Muthesius 1989).

The brins of cultivated silk are uniform, with a smooth rod-like appearance, a lustrous surface and a lack of visible internal structure (plate XXVIII). In cross-section the filaments are equilateral triangles with rounded apices (plate XXIX); the shape of the filaments reflect the light which gives silk cloth its sheen. The diameter range of cultivated silk fibres is from fifteen to twenty-five microns. In contrast, the longitudinal view of wild silk shows a ribbon-like striated filament with a granular structure (plate XXX). The individual filaments are irregular in width, often with flattened areas that have transverse markings. The filaments of wild silk are coarser than those of cultivated silk, with a diameter that can be over sixty microns. In cross-section the equilateral triangle is elongated with a granular interior. Wild silk is often stronger than cultivated silk but is less uniform, and where cultivated silk is white, wild silk has a brownish hue (Appleyard 1970, 13; Cook 1968, 151 & 158; Ryder & Gabra-Sanders 1985, 127).

Although these differences appear to make identification straightforward, severe rubbing and flexing can cause the splitting of the fine fibrils, which under light microscopy show up as internal striations in the filaments (Appleyard 1970, 13). Such structural alteration can therefore confuse the differences in appearance between cultivated and wild silk.

4.2.2.2 Analysis of Silk

Silk is generally easier to analyse than wool or bast fibres, due in part, to the lack of complexity of the morphology of the fibre. High-powered light microscopy is normally sufficient to differentiate between cultivated and wild silk. It is possible through such analysis to recognise the striations and granulation, as well as the cross-sectional shape of the filaments (Ryder & Gabra-Sanders 1985, 127).

From such analysis, it was possible to identify the well-preserved silk textiles from York as cultivated silk (Bombyx mori) (Walton 1989, 313). The silk artefacts are all plain tabby-weave, thus lacking the complexity of fabrics exchanged as political gifts. It would appear therefore that silk of less elaborate type was becoming more readily available to a wider population, possibly due to the opening up of long distance trade routes. It is probable that the silk was imported to York from Byzantine or Islamic workshops, via Scandinavian controlled trade routes through present-day Russia and the Baltic. Silk artefacts with similar technical details were excavated from the ninth-/tenth-century cemetery at Birka, Sweden (map 3.1), which lay on these trade routes, thus supporting this suggestion (Muthesius 1982, 135). A Mediterranean origin is further backed by the kermes dye, extracted from a Mediterranean insect, identified on three of the silk items (see 4.5.2.1 below) (Walton 1989, 396; 1990, 68-69).

Chemical investigation can also be applied to identify silk, particularly where fibres are so badly degraded that they are difficult characterise. Through amino-acid analysis, it is possible to identify silk, which characteristically shows high glycine, serine and alanine peaks. In addition to chemical tests, infrared studies using multiple internal reflection can be used (Lubec 1993, 25).

4.2.3 Bast Fibres

Bast fibres, which include flax, hemp and nettle, are vegetable fibres constructed of elongated cells which overlap one-another. These cells or ultimates are cemented together to form bundles (Appleyard 1970, 15-16; Cook 1968, 4). It is the bundles that form the fibre. To utilise the fibres for textile production, the bundles have to be separated from the woody outer stem of the plant. Several processes, such as retting, scutching and heckling, are employed before the fibre bundles can be spun (Appendix 3: Glossary of Terms). Although the processes required to prepare bast fibres for spinning are time-consuming, the cloth produced is strong and resilient.

The cellulose-base of bast fibres differs slightly between fibre-types, their survival rates are therefore not uniform (Cook 1968, 11). Nettle, for instance, does not survive as well in the archaeological record as flax and hemp. It is more susceptible to chemical and biological attack and less resistant to moisture (Hald 1980, 126).

The susceptibility of nettle fibre to chemical and biological attack is significant in the examination of Scandinavian period textiles. In Scandinavia, nettle fibre was exploited for textile production as early as the Bronze Age (Hald 1980, 127). Textiles produced from nettle fibre were recovered from the ninth-century rich, female boat burial from Oseberg, Norway (Ingstad 1982, 93) and in Scandinavia, the use of nettle fibre for textile production is known to have continued into the Twentieth Century. Not only is nettle more readily prepared for spinning than flax, it is also easier to cultivate. It seems reasonable to suggest therefore, that it was used for linen textile production prior to the use of flax (Hald 1980, 125-6). If this is the case, it is possible that the exploitation of nettle fibre was more prevalent in the production of textiles in the British Scandinavian period than the evidence suggests and has hitherto been thought.

4.2.3.1 Morphology of Bast Fibres

Flax, hemp and nettle have a similar appearance when examined in whole-mount under light microscopy. Longitudinal striations and nodes or cross striations are visible along the length of the fibre (plate XXXI) (Ryder and Gabra-Sanders 1985, 126). To differentiate between the three fibre-types however, it is necessary to employ other analytical techniques; SEM and chemical examination, as well as the general appearance of the woven cloth are utilised for this. Before such investigation can occur though, an understanding of the unique morphology of each fibre-type is necessary.

Flax (Linum usitatissimum)

The ultimates of flax have thick walled cells, which taper towards the end. In cross-section, the cells are polygonal with a very small lumen (plate XXXII). The diameter range of flax is 10 - 20 μ, the fine fibres resulting in a soft fibre with a lustrous feel. The outer fibrillar of flax runs in a clockwise (Z-twist) direction, causing the fibre to rotate in this direction on drying (Appleyard 1970 16; Cook 1968, 9-10; Ryder & Gabra-Sanders 1987, 106). The direction of rotation on drying can thus be used to identify flax fibres.

Hemp (Cannabis Sativa)

Hemp fibres are coarser than those of flax, and have blunt cell ends. In cross-section, the cells, like flax, are polygonal and thick walled. The lumen in hemp is narrower than in flax (plate XXXIII) and is more lignified, which results in a coarser and stiffer feel to the fibre. The fibre diameter, with a range of 15 to 50 μ, also reflects the coarser properties of hemp. Due to the coarse fibres, hemp has traditionally been utilised for the production of sail-cloth and other heavy-duty fabrics. As with flax, the rotational direction on drying can be used as a means of identifying the fibres. Here the outer fibrillar of hemp runs in a counter-clockwise (S-twist) direction, the fibre therefore rotates in a counter-clockwise direction on drying (Appleyard 1970, 18; Cook 1968, 17).

Nettle (Urticaceae)

The cell walls of nettle fibre are extremely thick with a rounded end. In cross-section, the cells are oval and the lumen broader than that of flax and hemp (plate XXXIV). Nettle, like flax, has a soft lustrous feel, and both have a similar fibre diameter (Cook 1968, 25; Ryder & Gabra-Sanders 1987, 95).

4.2.3.5 Analysis of Bast Fibres

Hemp, in its woven form, is normally readily differentiated from flax and nettle fabric; the cloth produced from hemp fibres is generally considerably coarser. The similarities of nettle and flax can however, cause problems for analysts. Both fibres produce linen cloth of a broadly homogenous type. Levels and forms of analysis therefore have to be appropriate to ascertain the unique attributes of each fibre-type. Less than rigorous examination may lead to misidentification. At a level where only technical information is being sought, this may not be crucial, but where detailed cultural examination is required, misrepresentation of this kind, will considerably undermine the validity of such work.

Low-powered light microscopy is normally sufficient to examine well-preserved fibres in whole-mount; the characteristic longitudinal striations and nodes show up clearly (plate XXXI) (Ryder & Gabra-Sanders 1987, 106-7). Where fibres are heavily degraded however, the use of high-powered microscopes (at x400 magnification) with polarising analysers is a more efficient method of identifying bast fibres. This method was applied to three Anglo-Scandinavian textile samples from 16-22 Coppergate that were in a poor state of preservation. The technique enabled the positive identification of bast fibres in one sample (1388) and a tentative verification in the other two (1369) and (1389) (Appendix 1: table 6, map 1) (Walton 1989, 312).

At a higher level of analysis, the use of SEM in bast fibre examination has greatly enhanced the accuracy in differentiating between bast fibre-types. The application of SEM is utilised in both well-preserved and heavily degraded fibres. In well-preserved fibres, cross-section examination reveals the cell-wall thickness and size of lumen (Ryder & Gabra-Sanders 1987, 95). Cross-section examination is particularly important in the examination of flax and nettle where many of the external attributes are homogenous and therefore not appropriate to fibre-typing. The greater depth of field and resolution obtainable with SEM examination also allows for three-dimensional views of the external morphology of the fibres, thus greatly enhancing identification possibilities (Ryder & Gabra-Sanders 1985, 123 & 138; 1987, 92). Where fibres are heavily degraded, structurally altered or mineralised, SEM is especially useful as its application greatly increases the potential of classification. Janaway for instance, pioneered the use of SEM in the identification of mineralised fibres (1982; 1983; 1989). Through his research, the characteristic structure of bast fibres becomes clear (plate XXXV).

Mineralised bast fibres, identified as flax, were recognised in the Scandinavian period burials from Claghbane, Ramsey, Isle of Man (Appendix 2: table 2, map 1) (Janaway 1982, 455) and Scar, Sanday, Orkney (plate XXXV; Appendix 2: table 1, map 1) (Nissan 1992, 8) through the use of SEM examination. To enhance and clarify our knowledge of the type of fibres exploited in Scandinavian period Scotland, the remaining mineralised evidence from this area should be subjected to similar examination. Until such research is carried out, the material evidence we have from this period and region will remain largely under-valued and misrepresented.

Where structural alteration and darkening of fibres has occurred through charring, transmitted light microscopy is not an appropriate technique. Instead chemical analysis is necessary. To identify charred fibres from 16-22 Coppergate (Appendix 1: table 6, map 1), Infra Red ATR (Attenuated Total Reflectance) was applied. The resulting IR patterns were found to be consistent with cellulose, thus identifying them as vegetable fibre. To identify the fibres further TLC (Thin Layer Chromatography) testing was applied. The recognition of linoleic acid indicated the presence of linseed oil, further suggesting vegetable fibres. The identification of vegetable fibres was confirmed through SEM examination where the characteristic external features of bast fibres was substantiated. Of the samples examined, all but one showed a similar morphology. Textiles 1320, 1327-8, 1332-3 & 1336 are thought to have been produced from flax fibre, but sample 1334 is closer in appearance to nettle (plate V; Appendix 1: table 6, map 1) (Evans, Hill & Card 1989, 312).

Diameter measurements can be taken using the manual technique discussed in the section on wool fibre (see 4.2.1.5 above), or by placing a photomicrograph of known magnification on a Bit-pad and applying the computerised technique developed by Hutchings and Ryder (1985). In contrast to fleece-typing however, it is the value of the lowest diameter of the range, followed by the mode and mean respectively, that is significant in identifying bast fibre-types. The method though, is not appropriate for differentiating between nettle and flax fibres, their similarity of diameter negates its use as a means of fibre-type identification (Ryder & Gabra-Sanders 1985, 106). It is particularly valuable where fibre diameter measurements of mineralised samples are required (Ryder & Gabra-Sanders 1985, 133; 1987, 92). The same cautionary note must though, be applied to these measurements as suggested for mineralised wool fibres (see 4.2.1.4 above). Investigation into diameter alterations, if any, of mineralised fibres has not yet been fully researched.

4.3 YARN

Fibres which derive from plants and the majority which are produced from animal coats have to be turned into yarn before they can be utilised in the production of textiles. To render the fibres into a suitable length for textile production, the accepted method is to spin or twist the short strands of prepared fibres into continuous lengths of yarn. Before spinning or twisting can take place however, both wool and bast fibres require processing. The techniques necessary differ slightly between the two fibre-types but the end product is the same, a mass of fibres, aligned or unaligned, that are unusable until spun (Appendix 3: Glossary of Terms).

Unlike wool and bast fibres, silk does not normally require spinning as the filaments of cultivated silk can reach up to 1.6km in length. The only process necessary, takes place during reeling (unwinding the silk from the cocoon), where several baves are very lightly twisted together to form yarn of a suitable thickness for textile production. If however, a thicker yarn is required, multi-filaments of yarn are 'thrown' (lightly spun) (Cook 1968, 152-54). Wild silk is often irregular in length, due to the splitting of the cocoon when the wild silk moth emerges, it therefore, normally requires spinning (plate XXXVI) (Ryder and Gabra-Sanders 1985, 132). With cultivated silk, the cocoon is immersed into hot water to kill the moth before it breaks out, thus preventing breaks in the silk filament. Although there are exceptions to the rule, the differences in the processes to produce silk yarn can be exploited in the identification and differentiation of cultivated and wild silk.

4.3.1 Spin-direction

The terms spin and twist are interchangeable. 'Spin' is normally the favoured term when discussing wool and bast fibres and 'twist' when referring to silk. The basic spin or twist directions are Z-spun, S-spun and I-twistless (fig. 4.7). Z-spun yarn is twisted in a clockwise direction, the central stroke of the 'Z' corresponding with the direction of spin. In contrast, S-spun thread is produced from fibres twisted in a counter-clockwise direction, with in this instance, the central stroke of the 'S' defining the direction of spin. Where fibre has not been spun, it is referred to as I-twistless.

Z- and S-spin and I-twistless refer to single strands of yarn. Where more than one strand is twisted together, a 'plied' thread is produced and if the plied thread is further spun, 'cable' is created. Yarns are normally plied to give the thread added strength, and cabled for decorative effect, as in the fringe of the Orkney Hood (NA 3) (plate XXIV; Appendix 2: table 1, map 1). Whether spinning plied or cabled yarn, the direction of twist, with few exceptions, is always in the opposite direction to the multi-strands from which it is being constructed. As with single strand yarns, plies and cables are notated in specific ways. For example, an Z-plied thread twisted from two strands of S-spun yarn is notated as 'S2Z' in the majority of texts, and where two S2Z-plies form an S-cable, the thread is generally presented as 'S2Z2S' (fig. 4.8). In contrast, S-ply is notated as 'Z2S' and Z-cable as 'Z2S2Z'; the final direction of twist is always placed at the end of the phrase. In view of the influence spin-direction has on the appearance of fabric structure and its subsequent implications for cultural studies, it is essential for analysts and researchers to be aware of the terms used to describe the variety of ways in which fibres can be twisted.

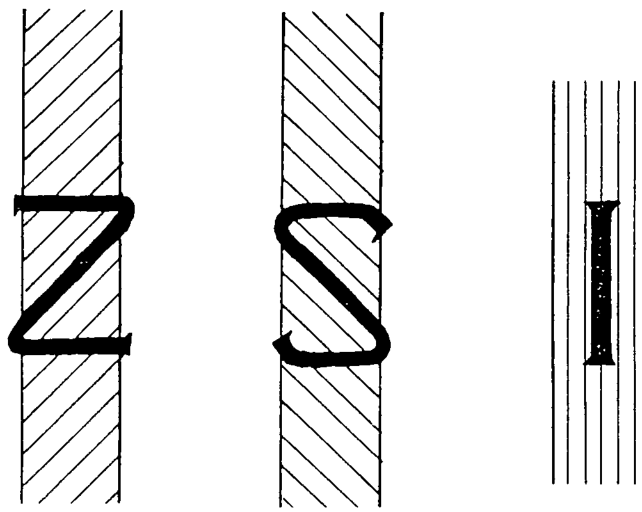


Fig. 4.7. Spin direction:
clockwise - Z-spun.
anti-clockwise - S-spun.
twistless - I-twistless

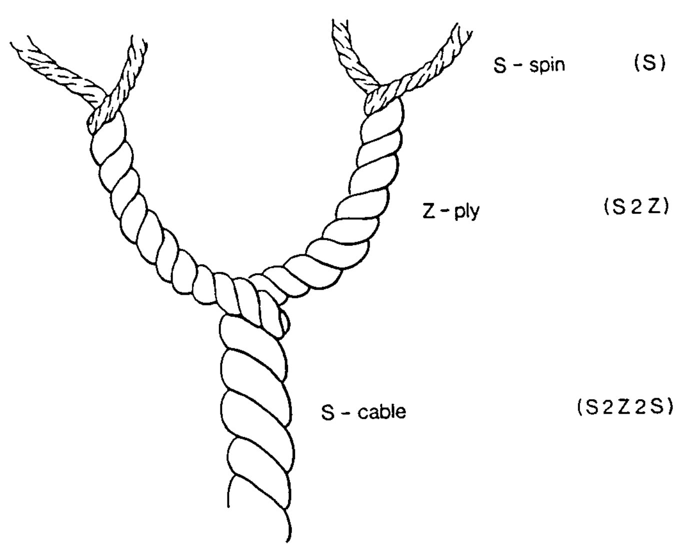


Fig. 4.8. Plying and cabling yarn.

Investigations into yarn is based largely around spin-direction. Bender Jørgensen (1986, 13) suggests that in any culture, one basic spin-direction predominates and often changes over time. She maintains that spin-direction is therefore the pivotal feature that characterises textiles of a given culture, not fibre- and weave-type.

Certainly the direction of spin in the wool textiles from York and Scotland are at variance and appear to have differing affinities. The predominant spin-directions in both sets of material are Z/Z and Z/S but the percentage of each is different. The York wool textiles are 19.5% Z/Z and 72.4% Z/S, with S/S and ply making up the remaining 8.1%. On the other hand, the Scottish wool textiles where both fibre-type and spin direction is identifiable are 52.4% Z/Z and 38.6% Z/S, with 19% S/S, ply or not identified. It has to be taken into account however, that there is a discrepancy in the data, the textiles come from differing burial environments, with in general, divergent modes of preservation. The York material is exclusively from a settlement site with actual textile surviving. In contrast, the Scottish material comes from graves, and much of the textile evidence is mineralised or preserved in the form of impressions. These differences result in a higher percentage of woven textile samples with positively identified fibre-types and spin-direction from York with 98.2% (54.1% wool) than from Scotland with 39.4% (26.4% wool). Such discrepancies have to be considered when looking for cultural affinities and data differences but the evidence, as presented, points to a Scandinavian similarity in the Scottish material, and an Anglo-Saxon and north-west European one in the textile evidence from York.

In addition to the predominant spin-direction of a given culture, spin-direction is also used for specific purposes, for instance, in spin-patterned weaves. The use of spin-direction affects the overall appearance of fabric, illustrating the conscious decisions made by weavers to produce differing effects. Even with plain tabby weave, by varying spin-direction thus: Z/Z, Z/S, S/Z and S/S, four fabric types of very different appearance can be produced (Bender Jørgensen January 1993, pers. comm.; Hald 1980, 136; Nockert 1991, 67)). The diversity of spin-patterned weaves can be increased by alternating either the warp ends or weft picks between Z- and S-spun yarn, thereby producing stripes. Spin-direction can also be used to emphasise features of twill weaves. For instance, to obtain a well defined twill diagonal, the spin direction has to run in the opposite direction to the diagonal; a Z-diagonal would have an S-spun warp and a Z-spun weft. In contrast, for a subtle twill diagonal, the spin direction and diagonal run in the same direction (Bender Jørgensen 1986, 288; Nockert 1991, 67).

The permutations of weave design derived from spin-patterning are endless and were fully exploited by weavers in antiquity. Bender Jørgensen (1986, 288) suggests that as particular spin-patterned weaves predominated at different times and in different regions, their identification is a valuable source of cultural information. In Scandinavian pre-history for instance, the dog's-tooth twill weave was normally achieved through spin-patterning. At a later stage, the weave effect was accomplished through the use of different coloured wool and rarely via spin-patterning. Such changes in method can be used to date textiles.

4.3.2 Analysis of Yarn

The analysis of yarn in well preserved textiles is relatively straightforward. Low-power light microscopy is normally sufficient to ascertain spin-direction and ply (plates XXXVII & XXXVIII). The depth of field obtainable with SEM does allow for more accurate measurements of yarn diameter and variation however (Ryder and Gabra-Sanders 1985, 123 & 130). In addition to spin-direction and yarn diameter, it is also necessary to assess the angle of twist, and the number, length and diameter of fibres, as outlined in Madsen's criteria for objective yarn description (Madsen 1988, 249) (see 3.3.6.3 above) (table 3.2). Ryder and Gabra-Sanders suggest that the application of SEM may make possible, by examining the alignment of the fibres, the differentiation of 'hard', smooth yarn from 'soft', loose yarn (plates XV & XVI) (commonly known as 'worsted' and 'woollen' respectively; see 3.3.6.3 above). The difference between the two yarn-types has implications for the feel and appearance of woven fabric, and as such is a valid area of research.

SEM for yarn examination is most useful when identification cannot be obtained in more straightforward ways, for instance, where textiles are mineralised or heavily degraded (Ryder and Gabra-Sanders 1985, 123-138). Spin-direction of mineralised textiles can often however, be identified using low-power light microscopy at high magnification (plate XXXIX).

4.4 FABRIC STRUCTURE

An examination of fabric structure is an essential element of textile studies and must encompass fibre-type, yarn-type and fabric quality, as well as fabric-type: woven or non-woven. Fabric quality in woven fabric includes assessments of fibre density, evenness and balance of the weave, and quality of the yarn. In non-woven fabrics, the quality of the yarn and execution of the techniques used to produce the item, nålebinding and sprang for instance, are the essential components to examine.

Bender Jørgensen and Walton base weave-type categories on weave, spin and quality. They suggest that by categorising weave-types it is possible to assess chronological change and specificity of weave-types in specific geographical areas (Bender Jørgensen 1987, 177 and 187; Walton 1991, 139). Certainly fabrics from various periods appear to demonstrate this, including the Scandinavian period. With the exception of isolated examples, from Scotland for instance, *Veka-type* cloth has, to date, only been excavated from sites in Norway (map 3.2). The Scottish textiles, from Greenigoe, Orphir, Orkney (NA 307a,c,d) and Kildonan, Eigg (IL 164a,d) (plate XIV; Appendix 2: table 1, map 1), were possibly either imports or brought over with the Norwegian raider or settler with whom they were buried. In addition, the *Birka-type* twill, although excavated from the cemeteries of trading centres throughout Scandinavia, features to a greater extent in western Norway than in any other region (map 3.1). York has two examples of the *Birka-type* twill, one from Lloyds Bank (669) (Appendix 1: table 1, map 1) and one from 16-22 Coppergate (1382) (plate XIII; Appendix 1: table 4, map 1), and Scotland two, from Greenigoe (NA 307e) and Kneep, Lewis, Western Isles (IL 853) (plate VIII; Appendix 2: table 1, map 1). Based on this evidence, Bender Jørgensen (1986, 358-359 & 361; 1992a, 138-140) considers that both the *Veka-* and *Birka-type* twills were manufactured in Norway. Their occurrence outside this area indicating trade and cultural contact.

4.4.1 Weave-types

There are three fundamental weaves: tabby, twill and satin, with colour- and spin-pattern weaves enlarging the repertoire. Each of the three principal weaves has a unique structure which is easily identified. Tabby weave is the simplest and oldest weave-type, where the weft thread passes over and under alternate warps in a regular order (fig. 4.1; plate XVII). Twills, which first appeared in the Bronze Age, predominately in wool textiles, are produced by stepping the weft to one side of the row above, thus achieving a diagonal effect (fig. 4.2; plate XVIII). Twill weaves require a more complex system of knitting the warp threads to the heddle, thereby increasing production time. Finally satin weave, which increases the sheen of silk yarn, is created by passing a weft pick over one and under several warp ends alternately (fig. 4.3; plate XVIX). Within each category of weave-type, there are numerous permutations, each of which produces differing effects (Appendix 3: Glossary of Terms) (Bender Jørgensen 1986, 288).

The main weaves from the British Scandinavian period material are plain tabby and twill (2/2 and 2/1), and diamond and chevron twills (2/2 and 2/1). Also evident are tabby and twill repps, brocade weaves, and tablet-woven bands, as well as non-woven techniques and piled fabrics (Appendix 3: Glossary of Terms).

Although tablet-woven bands are regularly excavated from Scandinavian period sites, only one was excavated from York and two from Scotland. The York sample (1340) from 16-22 Coppergate was produced on four-holed tablets (fig. 4.9), with one linen and three silk threads making up the warp. The band is only five millimetres wide and was dyed with indigotin and madder (Appendix 1: table 11, map 1) (Walton 1989, 381-382). The Scottish finds are both an integral part of the hood (NA 3) from St Andrew's Parish, Mainland, Orkney (plate XXIV, Appendix 2: table 1, map 1). Both were produced using two- and four-holed tablets, with twenty-three warp threads in the upper band and 150 in the lower one. The bands are woven from hairy medium wool which contain natural pigment (Henshall 1951-2, 10-13).

The brocade weaves, one from 16-22 Coppergate (1336) (plate XL; Appendix 1: table 6, map 1) and one from Scar, Sanday, Orkney (Appendix 2: table 1, map 1) are unusual in the contexts in which they were found. The sample from York is carbonised linen and the one from Scar is mineralised, the fibre of which has yet to be identified. The textile from York is a 'honeycomb' pattern weave on a Z/Z-spun 2/1 twill base. To date, no tenth-century parallel has been excavated although a small number of earlier date are known from Valsgärde, Sweden and from Germany. This weave-type is of particular interest to researchers investigating production technology. The shedding required to produce a 'honeycomb' pattern weave is complex and not easily executed on a warp-weighted loom. Although not impossible, it is more probable that another loom-type was used. The obvious contender is the treadle-operated horizontal loom, but there is no evidence of its use in north-west Europe prior to the eleventh-century. It is possible however, that a

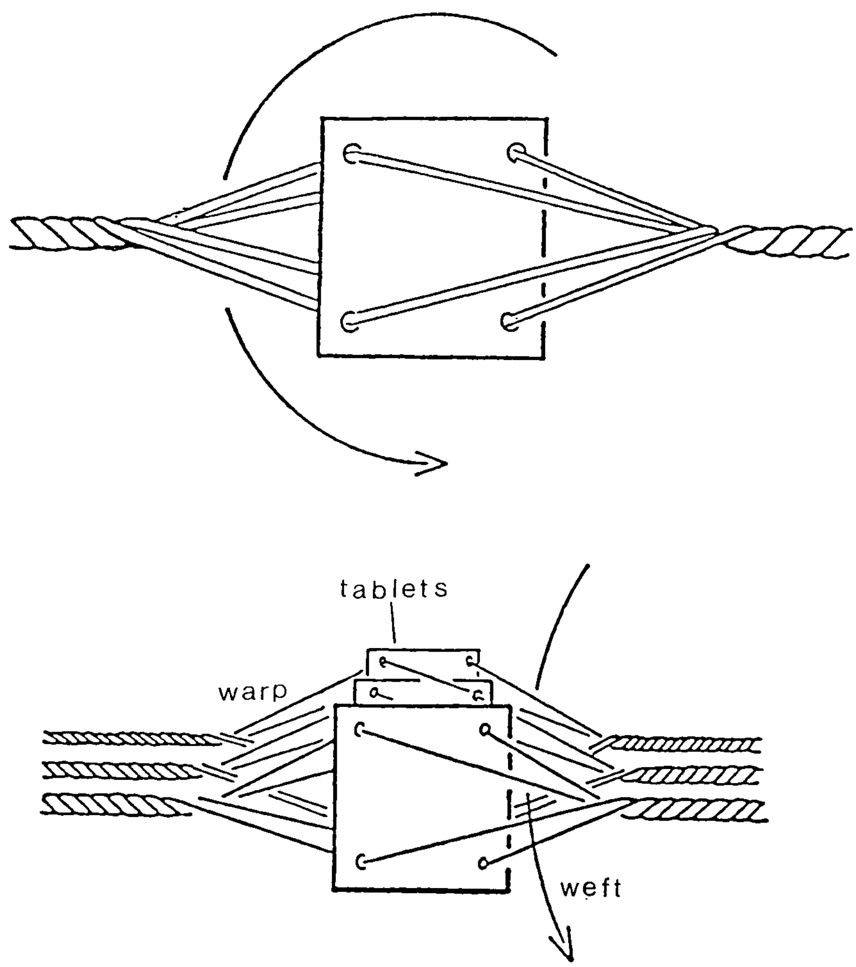


Fig. 4.9. Tablet-weaving using 3 4-hole square tablets and 12 warp-threads.

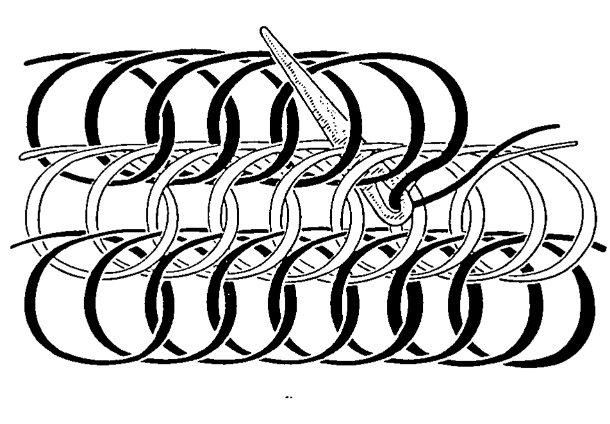


Fig. 4.10. Nålebinding.

less elaborate horizontal loom was in use during the tenth-century, and that 'honeycomb' and other similar patterned weaves were woven on these looms (Walton 1989, 353 & 356-357). The brocade from Scar is based on a Z/Z tabby-repp with a count of 18-20/10 threads per centimetre. The brocading threads are S-plied and float over five warp ends to produce a probable diamond shape. It is not clear if the sample shows the obverse or reverse of the fabric so positive characterisation is not possible. Parallels are known from Birka, Sweden and Hedeby, Schleswig, but to date, it is unique in the Scandinavian material from Scotland (Gabra-Sanders, forthcoming).

There are only two examples of non-woven techniques in the British Scandinavian period material under discussion: the nålebinding sock [1309] from 16-22 Coppergate (plate XI; Appendix 1: table 11, map 1), which was produced by a form of knotless knitting (fig. 4.10); and the sprang impression on an oval brooch [IL 223] from Clibberswick, Unst, Shetland (plate VI; Appendix 2: table 1, map 1), produced by twisting adjacent warp threads, without the use of weft threads (fig. 4.11) (Appendix 3: Glossary of Terms).

Piled fabrics (Appendix 3: Glossary of terms) are evident in both the Scottish and York material. The way the pile tufts are incorporated into the background weave differs however. There are four samples from York: 579 (plate XLI) and 581 from Lloyds Bank (Appendix 1: table 1, map 1), and 1295 and 1460a from 16-22 Coppergate (Appendix 1: table 4, map 1). The pile in these textiles has been darned in after the cloth has been woven, a technique unparalleled in the production of piled fabrics in the Scandinavian period. The pile tufts in the sample from Kildonan, Eigg (Appendix 2: table 1, map 1) and Cronk Moar, Jurby, Isle of Man (plate XXVI; Appendix 2: table 2, map 1) were woven in as the fabric was being produced, which appears to have been the accepted method during the ninth to eleventh centuries. The textiles from Kildonan and Cronk Moar have parallels in

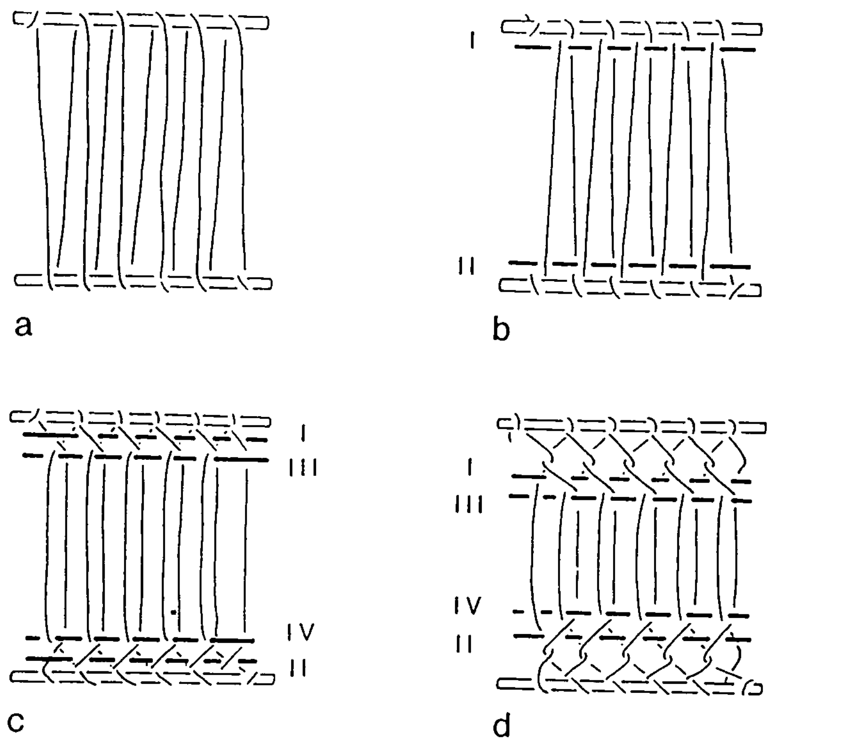


Fig. 4.11. Sprang 'plaiting':
<u>a.</u> warp set up.
<u>b.</u> rear warp brought forward and held by rods I & II.
<u>c.</u> rods III & IV inserted to hold the first cross in warp at top and bottom.
<u>d.</u> position of rods after two further moves.

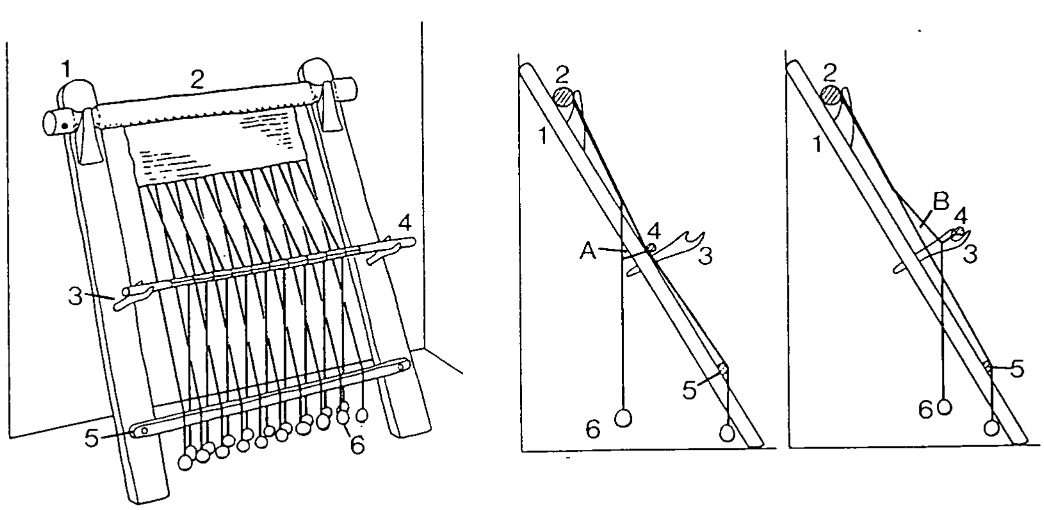


Fig. 4.12. Warp-weighted loom:
<u>1.</u> uprights; <u>2.</u> cloth-beam; <u>3.</u> heddle-rod bracket;
<u>4.</u> heddle-rod; <u>5.</u> fixed shed-rod; <u>6.</u> loom-weights.
<u>A.</u> natural shed; <u>B.</u> countershed.

most areas of Scandinavian settlement, suggesting that the unusual production technique displayed in the York textiles was a local preference (Walton 19899, 335-336). Whatever the method of production, the result is the same, a warm semi-waterproof, lightweight fabric, almost certainly used for cloaks, rugs and blankets.

Where there are starting-borders and selvedges weave-types are more readily identified; a knowledge of the direction of the warp and weft aids the accurate assessment of complex weaves and also ensures the correct identification of warp or weft faced weaves. In addition, starting-borders furnish valuable information on loom-types and thus enable hypotheses to be made relating to the type of weave that can be produced on a given loom-type. Selvedges were identified in twenty-six textiles, from York (four wool tabbies, four wool twills, seven vegetable fibre tabbies and eleven silk tabbies; Appendix 1), and one twill from Scotland (IL 164) from Kildonan, Eigg (Appendix 2: table 1, map 1). No starting-borders feature in the Scottish or York material. The excavation of loom-weights from York does however, suggest the use of the warp-weighted loom (fig. 4.12) (MacGregor 1982, 100-102; Walton 1989, 414).

4.4.2 Analysis of Weave-type

Light microscopy is normally sufficient to identify fabric structure, in both woven and non-woven fabric, mineralised and actual. Thread counts in woven textiles are better counted by eye, although a low magnification can be used. Low-power light microscopy is necessary to ascertain weave-type however (Ryder and Gabra-Sanders 1985, 132). When assessing fabric quality and thread count, it is essential to be aware of any lack of balance in warp and weft, and unevenness in the overall cover of threads per centimetre. Variety in diameter measurement, as well as balance and evenness, is an important consideration when examining fibre density. In general, light microscopy is also sufficient for the assessment of non-woven techniques. Even where textile evidence is mineralised, light microscopy is normally adequate to identify weave-type (plate XLII).

4.5 NATURAL PIGMENT AND DYES

Identification of the type and level of natural pigments in wool textiles has been researched mainly by Ryder (1968a; 1974, 1981; 1990). Such research not only makes possible the identification of colour, but also enables investigations into differing breeds of sheep; different breeds have different coloured fleece. From such investigation, it becomes possible to suggest the provenance of the fibres used in the production of particular textiles.

The analysis of dyes in ancient textiles is a comparatively new area of textile research. Walton and Taylor have been instrumental in increasing our knowledge of the dyes used to colour Scandinavian period textiles (Taylor 1983; 1990; Walton 1988; 1990; 1991; February 1993, pers. comm.; Walton & Taylor 1991; Walton & Bender Jørgensen 1987). Through their work it has become possible to investigate the exploitation of dye-plants from both local environments and imported dye-stuffs, both plant and insect.

The next section considers how identification of both natural pigment in wool and the dyes used in textile production may yield cultural information. The identification of natural pigments in textiles enhances our knowledge of how the natural colours of wool were exploited to produce patterns in woven cloth. Identification of specific dyes highlights the use of local and imported dye-stuffs, as well as colour preference in particular cultures.

4.5.1 NATURAL PIGMENT

The colour naturally contained in wool comes from granules produced by pigment cells in the wool follicle bulb, the pigment granules contain melanin which helps to determine fibre colour. The natural colours of wool are brown, black, grey and white, depending on the level of pigment granules in each fibre and throughout the fleece in general. A whole range of shades exists and are dependent on the differences in size and density of the pigment granules, as well as the level of melanin in each granule. For instance, black wool has a greater density of pigment granules than brown wool. Grey fleece, which can be true-grey or brown-grey, is evident where a fleece has a mixture of pigmented and non-pigmented (white) fibres. The more common true-grey comprises a mixture of black and white, with brown-grey, having a combination of brown and white (Ryder 1990, 137-138). Care has to be taken with interpretation however, as the fleece from a piebald (black and white) or skewbald (brown and white) sheep can be combed or carded to give a grey fleece, or conversely a black, brown or white fleece.

Coarse fibres are normally more densely pigmented than fine ones. Pigmentation does however, change along the length of a fibre. The tip of a re-growing fibre normally has the densest pigmentation and colour, whereas at the base the fibre is often paler and regularly loses pigmentation before growth stops. Although pigmentation is more dense at the tips of the fibre, wool staples in black sheep can appear dark brown at the time of harvesting; a year's exposure to sunlight during growth can fade them (Ryder 1990, 136-137). Such changes should be borne in mind when assessing wool colour.

4.5.1.1 Analysis of Natural Pigmentation

Although it is possible to detect pigment granules in whole mount under light microscopy, it is not possible to ascertain their distribution. Light microscopy, coupled with Hutchings and Ryder's computer technique (1985) (see 4.2.15 above) is normally sufficient to assess the level of pigmentation and examination in cross-section its distribution. A more sophisticated technique is available however. Electron Spin Resonance (ESR) measures the level of melanin in the pigment granules, thus identifying the level of colour, each colour having a unique spectra peak (Ryder 1990, 146-147). ESR is extremely expensive to implement and rarely feasible or necessary for archaeological use. The technique does however, give more accurate readings than examination under light microscopy and ESR is especially useful where work on fleece- and sheep evolution forms part of a textile project (appendix 4).

4.5.1.2 Natural Pigment in the Textiles and Fibre from York and Scotland

Of the wool textiles from York five contained fibres with more than ten percent natural pigmentation (fibres with pigmentation below this level are classed as white), with one sample of yarn and two of cord also displaying naturally pigmented fibres. A plain tabby weave textile from Lloyds Bank, Pavement (666) shows a combination of heavily pigmented and non-pigmented wool, resulting in a random pattern effect (Appendix 1: table 1, map 1). Textile 1259 from 16-22 Coppergate is a plain tabby weave with both warp and weft heavily pigmented, giving an overall dark brown hue (Appendix 1: table 4, map 1). A mixture of pigmented and non-pigmented wool is used in both the warp and weft of the twill weave textile 1264 from 16-22 Coppergate, which produces a mottled effect (Appendix 1: table 4, map 1). Sample 1303, also from 16-22 Coppergate, has a very dark pigmented warp and a non-pigmented weft, the result is a twill weave with dark brown and white diagonals (Appendix 1: table 4, map 1). Finally, sample 663 from Lloyds Bank, a chevron twill weave, contains natural pigment, as well as showing evidence of nonspecific dye residues (Appendix 1: table 1, map 1) (Walton 1989, 403-404). It is evident, even from this small sample, that the Anglo-Scandinavian textile producers from York were well versed in the variety of effects that could be produced from the imaginative use of pigmented wools. From the Scottish material examined by Ryder (1968a), natural pigment was evident in all of the textiles.

In both the samples from York and Scotland, the fleece-types containing natural pigment are hairy, hairy medium and generalised medium. From the literature pertaining to natural pigment in textiles from York, it is not clear how many samples were tested. It is therefore not possible to assess what percentage of the textiles were produced from naturally coloured fibres. In the Scottish material however, of the twelve tested by Ryder, 100% contained natural pigment. It is highly probable therefore that the producers of the Scottish material relied more heavily on naturally pigmented wool for colour than those who produced the textiles from York. The lack of natural pigment in the evidence from York also suggests that non-pigmented wool was more readily available to the Anglo-Scandinavians in England, than to the Norse in Scotland. This hypothesis is further supported by the twenty-six raw wool staples excavated from York. Here twelve samples (48%) showed no evidence of natural pigment. It has to be remembered however, that of the twenty-three wool samples suitable for testing from Scotland, only twelve (52%) were examined for natural pigment. The data are thus biased and the results possibly spurious. Ryder's research (1968a; 1974) into the evolution of Scottish sheep breeds, does however, point to the use of hairy wools, which are normally pigmented, in Scandinavian period Scotland. It is equally possible therefore, that the results are representative, and that the use of pigmented wool was the normal practice in ninth- to eleventh-century Scotland, as indeed it continues to be in Orkney and Shetland.

4.5.2 DYES

Dyes fall into three categories: direct, vat and mordant dyes. Direct dyes, of which saffron is an example, are applied in solution directly to the yarn or cloth. Vat dyes are insoluble until reduced in alkaline, such as stale urine or lime which renders the dye substances into a soluble form for dyeing. Indigotin (indigo and woad) and lichen purple are both vat dyes and based on the evidence available, appear to be the most commonly used vat dyes in Scandinavian period northern Europe; the indigotin was almost certainly obtained from woad. Dyes such as madder, kermes and cochineal require the use of a metallic compound, the mordant which bonds with the fibre, to which the dye then bonds (Taylor 1983, 153; Walton 1993, pers. comm.; Walton & Taylor 1991, 5).

To ascertain to which of the three categories a plant or insect dye belongs, it is necessary to test for the presence of both the dye substance and any mordant (Taylor 1983, 153). The identification of the mordanting metal is not always straightforward however. Alum and iron salts are found naturally in soils and are therefore likely to be absorbed by textiles during prolonged burial. As a result, it is easy to misread the results recorded during testing, either by not recognising the presence of mordanting metals, or by identifying the wrong one. It is advantageous to identify the presence of the correct mordanting metal though, as with mordant dyes, the colour is dependent on both the dye and type of mordant used (Taylor 1983, 153-154; 1990, 40).

In antiquity, the most common mordant, alum salt was obtained from aluminium, which produced bright shades. Iron salts were also used, and although the colours were duller, the range of shades available was wider (Taylor 1983, 153-154; 1990, 40). Iron salts were readily available during the Scandinavian period, but access to alum salt was more complex. The salt from aluminium was not commercially exploited in Britain as a mordant until the sixteenth century. Alum salt was therefore most likely imported, probably from the coasts of Scandinavia (Taylor 1983, 153). It is probable that clubmoss was exploited as an alum salt substitute by dyers, the plant accumulates aluminium from the soil, making it a suitable mordanting medium (Taylor, 1990, 40). Clubmoss (Diphasium complantum (L) Rothm.) plants were excavated from the Anglo-Scandinavian levels at York, adding credence to the supposition that the plant was utilised as a mordant (Hall & Tomlinson 1990, 19). In addition, recent experiments using clubmoss as a mordant for madder dye-plants has shown that it bonds the dye successfully to the fibre and gives a rich colour (Taylor 1990, 40).

4.5.2.1 Analysis of Dyes

Assessing the dyes used on north European archaeological textiles is fraught with problems due to the nature of the material and the environment in which textiles survive. Heavy staining occurs in the slightly acid, waterlogged soils of the region, thus masking any surviving colour. In addition, certain dyes will have leached out or decayed to such an extent that even under analysis they are not detectable (Taylor 1983, 154; Taylor & Walton 1991, 5).

To analyse as many samples as possible for dye, it is necessary to devise a relatively fast method. For this reason, Walton and Taylor (1991) rely on absorption spectrometry to assess the presence of dye and its colour, and Thin Layer Chromatography (TLC) to distinguish between closely related dyes. Both techniques, which were applied to the York material, are relatively quick to implement and are therefore cost effective. In addition, the procedures are not complex and give accurate results when compared to a known reference set.

The aim of dye analysis is not to quantify the level of dye. It is sufficient simply to ascertain whether or not dye has been used to colour a textile or yarn and what, if any, that colour is. To achieve this, it is necessary to devise a sequence of tests to enable the separation of the dye from the textile or yarn, while leaving the burial staining on the textile. In addition, with mordanted dyes, it is essential to separate and identify the mordant as well as the dye if the original colour is to be accurately described (Taylor 1983, 153-154).

To assess the presence of dye using absorption spectrometry, the absorption spectra is recorded and compared with the spectra of known dye solutions. The spectra recorded is representative of what was taken up by the fibre during dyeing, with different dyes having differing spectra (fig. 4.13) (Taylor 1983, 154-157; Walton 1988, 14-17; February 1993, pers. comm.; Walton & Taylor 1991, 5).

Fig. 4.13 The Maximum Absorption Spectra of Scandinavian Period Dyes

weld	400nm	yellow X	420-445nm
madder/ bedstraw	520-525nm	kermes/cochineal	530-535nm
lichen purple	585nm	indigotin	604-610nm

Although it is feasible to identify the colour of the dye using absorption spectrometry, it is not always possible to determine the actual dye-stuff. If positive identification is required, TLC is employed after absorption spectrometry. The technique makes possible the identification of the individual chemical elements of each dye-stuff, in particular the dyes that produce reds and purples. The plant dyes that produce red, comprise: dyer's madder (Rubia tinctorum L.), wild madder (Rubia peregrina L.) and lady's bedstraw (Galium verum L.). Of the purple/red insect dyes, kermes (kermes vermilio [Planch.] targ.) and Polish cochineal (Porphyrophora polonica L.) were exploited during the Scandinavian period (Taylor 1983, 159; Walton 1991, 139-140; February 1993 pers. comm.; Walton & Taylor 1991, 5-6). Distinguishing the dye-plant or insect has important implications for cultural studies. By ascertaining specific dye products, it becomes possible to investigate trade and the exploitation of the local environment. At York, the positive identification of kermes and dyer's madder confirms trade contacts with the Mediterranean region and possibly the Frankish area of Continental Europe.

The main chemical components of dyer's madder are alizarin and purpurin, which is detectable through TLC testing. When wild madder and lady's bedstraw is tested however, it becomes clear that both lack alizarin. All three dye-stuffs have the same spectra with absorption spectrometry so the additional TLC test is essential when assessing the cultural aspects of dye-stuffs (Taylor 1983, 158-159; 1990, 39; Walton 1991, 139-140; Walton & Taylor 1991, 5-6). Although the chemical component of wild madder and lady's bedstraw is very similar, wild madder was confined largely to south and west English coastal areas, whereas lady's bedstraw was widely available throughout Britain. (Taylor 1983, 153 & 159). It is probable therefore that lady's bedstraw was readily available near York. Dyer's madder was not native to Britain during the Scandinavian period suggesting imports from north-west Europe. It is equally feasible however, that is was being cultivated in or near York. Analysis of the York textiles reveals that dyer's madder was used to dye good quality as well as everyday textiles, which does suggest an easily accessible source (Taylor 1983, 153; Walton & Taylor 1991, 7). In addition, residues of dyer's madder were found to be contemporary with the Anglo-Scandinavian madder-dyed textiles from York (Walton & Taylor 1991, 7).

When TLC testing is employed to differentiate insect dyes, it becomes clear that kermes and cochineal have very different chemical components, although their absorption spectra is the same. Cochineal contains carminic acid, whereas the main chemical in kermes is kermesic acid (Walton & Taylor 1991, 6). A knowledge of these chemical differences led to the identification of the use of kermes to dye silk artefacts excavated at York. By analysing both the silk and the dye-stuff, it became possible to assess the use, and provenance of imported silk materials in Scandinavian period Britain (see 3.5.1 and 4.2.2.2 above).

In addition to TLC testing for red and purple dyes, the process is also employed for the detection of yellow and brown dyes. Of all the colours obtainable, yellows and browns are the most difficult to detect, due largely to the take up of organic materials from the burial environment and the subsequent staining and contamination of the textile and dye residue. The organic material taken up has the same absorption spectra as the dye-stuffs (Walton & Taylor 1991, 6). Although the absorption wavelength can be widened, TLC testing is advisable for more accurate results (Taylor 1983, 155). The fugitive nature of many the dyes that produce yellows and browns also causes problems. The dyes are fugitive to light and washing, or leach out during burial to such a degree that they are rendered virtually undetectable (Taylor 1983, 153). A wide range of plants produce yellow dyes, for instance weld (Reseda luteola L.) and dyer's greenweed (Genista tinctoria L.), as well as saffron, although they are notoriously difficult to detect. Saffron and weld can be identified by their absorption spectra but TLC is desirable for more accurate results. Evidence from York, suggests the probable use of both weld and dyer's greenweed (Taylor 1983, 153). Hanks of greenweed stems, tied in bundles, do imply the regular use of this particular dye-stuff to produce yellow (Hall & Tomlinson 1990, 19). Only one yellow dye has however been positively identified at York, but its source remains unknown, it is consequently known simply as 'yellow X' (Hall 1983, 25; Walton 1988, 17; February 1993, pers. comm.).

Apart from absorption spectrometry and TLC, a technique that is gaining popularity in dye analysis is High Performance liquid Chromatography (HPLC). To date the process has been used mainly to identify dyes from historic textiles and not those from burial environments. Although more sophisticated than absorption spectrometry and TLC, HPLC at present remains a slow and expensive technique.

It does however, have potential for identifying poorly preserved dyes in ancient textiles, in particular those that produce brown and yellow hues (Walton 1993, pers. comm.; Walton & Taylor 1991, 7).

4.5.2.2 Dyes from York

Sixty textiles, yarns and raw wool staples were tested for dye from York, in thirty-six dye was identified to varying degrees. Analysis revealed that dyer's madder/lady's bedstraw was the most common dye-stuff evident in the Anglo-Scandinavian levels, thus red appears to have been the preferred colour. Dyer's madder/lady's bedstraw makes up 67.5% of the dyes, with indigotin (probably from woad), lichen purple and kermes also apparent but to a lesser degree, making up 15%, 10% and 7.5% of the total dye-stuffs (table 4.4) (Taylor 1983, 153; 1990, 43; Walton 1989, 396; 1988, 17; 1993, pers. comm.). If the sample is representative, it indicates that dyeing was a routine method of colouring cloth in Anglo-Scandinavian York. It is also probable that a vast range of colours and dye-stuffs were used; the absence of these in the data being due to the fugitive nature of some of the dye-stuffs available to the Anglo-Scandinavian dyers in York (Taylor 1983, 157-158).

Site	Madder - 67.5%	Indigotin - 15%	Lichen Purple - 10%	Kermes - 7.5%
16-22 Coppergate	1256 raw wool	1258 wool tabby	1306 wool twill	(1342) silk tabby
9th-11th C	1283 raw wool	1302 wool twill	1407 silk thread	1355 silk ribbon
	(1260) wool tabby	1343 silk tabby		1408a silk reliquary
	(1301) wool twill	1347 silk tabby		
	1379 wool twill			
	1308 wool twill			
	1381 wool twill			
	1309 sock			

	1270 wool cord			
	1312 wool cord			
	1315 wool yarn			
	1281 silk tab.			
	1345 silk tab.			
	1349 silk <----	------------------	---------> tabby	
	1350 silk tab.			
	1352 silk <----	------------------	---------> tabby	
	(1371) silk tab.			
	1407 silk ribbon			
	1340 silk <----	> tablet-weave		
Lloyds Bank	(584) wool tabby			
10th-11th C	591 wool tabby			
	592 wool tabby			
	589 wool twill			
	593 wool twill			
	576 wool twill			
	566 wool twill			
	567 wool <----	----------> twill		

Table 4.4: Dyes from York. Brackets = uncertain result. Arrows = textile with two dyes (After Walton 1989, 396).

4.5.2.3 Colour Preference and Indicators of Status

Through the analysis of dyes from both settlement and burial sites, it has been possible to identify the dye-stuffs exploited during the Scandinavian period. This allows for investigations into how colour was used to make statements pertaining to status and possibly, the preferred colours of life and death. The analysis of dyes on textiles from the ninth- to eleventh-century levels at York, Lincoln, London and Dublin, and from graves throughout Scandinavia can be used to examine this aspect of textile studies (Bender Jørgensen & Walton 1987; Taylor 1983, 1990; Walton 1988; 1990; Walton & Taylor 1991).

Of the dyes detected on textiles and yarns from the urban sites, reds and purples predominate. In York, Lincoln and London, red is the favoured colour and in Dublin, purple. These differences may be due to preference or simply the ready availability of particular dye-stuffs (Taylor 1990, 42-43; Walton 1988, 18). The predominance of reds and purples could also be recovery bias; dye-stuffs that produce yellows and browns are fugitive and therefore rarely survive at a level sufficient for detection (see 4.4.2.2 above). In contrast, the predominant colour detected on the textiles from Scandinavian graves is blue (Walton 1988, 18-19). Blue is also apparent in one of the linen textiles (C) from the grave at Camp Keeil Vael, Balladoole, Isle of Man (Appendix 2: table 2, map 1) (Crowfoot 1966, 44). It is possible that the silver buckle to which the textile adhered was the source of the colour, where silver compounds impregnated the material. It is equally possible however, that the material was dyed with woad and produced specifically for burial.

Comparing dyes from settlement sites in Britain and Ireland with those from burial environments in Scandinavia however, is problematic. The two areas may have had different colour preference as displayed in the evidence. Equally, blue may have been the preferred colour for burial garments in all areas under Scandinavian influence and not as commonly used for garments for the living. In the sagas, blue is associated with death (Pálsonn 1971, 25) and although written in the thirteenth-century, the literature could be an indicator of the custom of burying the dead in specially prepared blue clothes or wrappings.

Until full analysis is published on the textiles from Scandinavian urban sites and, where possible, material from British graves is analysed, these questions must remain unanswered. Although the mode of preservation of the majority of the textiles from British graves does largely negate dye analysis, twenty-seven of the ninety-one textiles from the Scottish graves are suitable for dye analysis.

The work carried out on the textiles from the rich late tenth-/early eleventh-century grave from Mammen, Denmark can be utilised to illustrate how colour may reflect status. Reconstruction of garments has been enhanced by the detailed analysis of dye residues. Dye-stuffs of the same type were used to reproduce the cloth and embroidery threads in their original colours. The predominant colours are red and blue, with purple and red silks and red and blue embroidery embellishing the garments (Bender Jørgensen 1992c; Walton 1991, 141-142). The colours are extremely bright and when compared with the evidence from other Scandinavian graves, appear to be exceptional.

In particular dyer's madder and lichen purple were identified, both of which are good indicators of status. Evidence of the cultivation of dyer's madder has not yet been recognised in Scandinavia during the Scandinavian period, although it was grown in France, and probably England. In the majority of Scandinavian graves, where madder has been identified, the lack of alizarin indicates that it was wild madder or lady's bedstraw and not dyer's madder. The presence of a non-indigenous dye-plant to dye the Mammen textiles suggests the ability to procure imported dyes and thus probably status. In addition, lichens which produce purple dye, although readily available, do not appear to have been exploited in Scandinavia until the fourteenth-century. Lichen purple was recognised only on the silk textiles and yarns, thus indicating that the dye-stuff was an import from the Mediterranean, or that the silk was dyed at source (Walton 1991, 140-141). Either way, long distance trade or contact to acquire such luxury items indicates status.

4.6 WEAR AND RE-USE OF TEXTILES

Analysis of wear and re-use of ancient textiles is the newest area of archaeological textile research. Although research of this nature has not been carried out on either the textiles from York or Scotland, it is included here as investigations into wear should increasingly become a routine aspect of textile research. The current work has been instigated by Cooke at UMIST (University of Manchester Institute of science and Technology), and although in its infancy, it is already making a valuable contribution to textile research. The work at UMIST will lead to an atlas of the morphology of long-term fibre degradation and the processes that cause the destruction of textiles. In addition, an extensive archive is being compiled of photomicrographs to aid researchers carrying out comparative work. As such, it will make the investigation of the causes and sequence of wear and damage easier (Cooke 1990, 5; Cooke & Lomas 1990, 226).

Compiling an atlas and archive of the morphology of wear is not the only element of Cooke's research. Careful analysis of wear and use can give information of the possible occupation of the wearer or user of the textile sample. For instance metal splashes from smelting and metal swarf may indicate metal working. In the same way, wood dust can suggest carpentry, and grass-pollen, hay-making. Obviously such research necessitates the use of samples that have not been conserved or treated in any way, and a knowledge of the exact context in which the material was found is desirable (Cooke & Lomas 1990, 222). To date, most of this research has been carried out on historical textiles. Its usefulness with archaeological textiles has therefore yet to be assessed.

Investigation has been undertaken to ascertain if evidence of wear survives burial. The examination of soldiers' leg bindings and the sole of a child's shoe from the vicus attached to the Roman fort at Vindolanda, Northumberland (see 3.2.2 above), clearly illustrates that evidence of wear can survive burial if the conditions (in this instance an anaerobic, waterlogged environment) are favourable (Cooke & Lomas 1990, 224-226).

When analysing textiles from archaeological contexts it is easy to forget that the majority of fabrics were subjected to hard and continuous wear. Many items would have been handed down, and modified, patched or repaired. In some instances, such treatment would have continued until the damage caused by continual use reduced articles to rags (Cooke 1990, 5). Many of these rags survive further degradation during burial, and become the samples textile specialist work with.

Textile fibres are subject to damage at all stages; during growth, manufacture and use, as well as during burial, conservation, storage and display. The result of much of this damage is an easily recognisable change in morphology. Through the identification of the changes in morphology, an understanding of the manufacture and use of archaeological textiles becomes possible (Cooke 1990, 13).

4.6.1 Analysis of Wear

To identify wear, use and re-use of archaeological textiles, optical light microscopy and SEM are both employed depending on the nature of the damage or wear and the level of information required.

At fibre level, damage due to wear is dependent on fibre-type and the differing mechanisms of wear. Wool, silk and bast fibres have very distinct micro-structures, resulting in diverse wear morphology. For instance, in fracture analysis, the difference in the morphology of the fracture in each fibre-type can be utilised in the identification of fibres where other means are not possible; for example, where the fibre surface is badly eroded, or is carbonised or mineralised. In addition, different mechanisms of wear produce diverse forms of damage on both fibres and fabric surface. These distinct forms of damage are used to identify the various forms of wear that ancient textiles and fibres are subjected (Cooke & Lomas 1990, 215).

Ageing of fibres occurs due to oxidation and hydrolysis, exposure to light and chemicals, and from fungal and bacterial attack. All these forms of wear break down the long chain molecules of the fibre, reducing its strength. The result is a brittle break, which has a characteristic shape depending on the fibre (plates XLIII & XLIV). In addition, the differences in the morphology of shear damage from cutting with knife, scissors or razor is easily distinguishable. Such damage has a distinct morphology, depending on the fibre-type, which can be utilised to aid fibre identification. Tensile fractures caused by projectile points, needles for instance, are also recognisable (plates XLV, XLVI & XLVII) (Cooke & Lomas 1990, 215 & 218). Tensile fractures of this kind are useful for identifying stitch-holes where textiles have been distorted, thus obscuring the evidence of sewing.

Fabric-structure is damaged through mechanical abrasion brought about by both washing and use. The combination of mechanical and chemical attack due to the washing of fabrics alters the structure considerably. In cellulose fibres for instance, the chemicals in alkaline soaps or soda ash, destroy the molecular links of the fibres, causing fibrillation. The mechanical action of rubbing, tangles these fibres and smears them on the surface of the textile (plate XLVIII). In wool fibres, the result of mechanical and chemical damage through washing is also smearing and tangling of fibres, but the end result here is a shrunken, matted fabric (plate XLIX). Wool cloth is often felted deliberately as part of the manufacturing process however, so unless the sample is large enough, it is often difficult to ascertain if felting is due to washing and wear or manufacture (Cooke 1990, 8; Cooke & Lomas 1990, 215).

Fibres can also be smeared when fabric is smoothed or polished, for example with a linen smoother. The structural changes that occur in textiles due to rubbing and polishing cannot sustain extensive use and washing, the level of damage to fabric-structure is therefore a good indicator of the extent to which an item has been used (Cooke 1990, 5). It would be a useful exercise to examine the non-carbonised or mineralised linen fabrics from York and Scotland to ascertain if any show signs of smearing due to 'ironing'. Glass linen smoothers have been excavated in both York

(MacGregor 1982, 102; Walton 1989, 413) and Scotland (Henry 1992, 41 & 106; Scott 1956, 266-7), indicating their use in Scandinavian period Britain. In addition, a whale-bone plaque excavated from the boat burial at Scar, Sanday, Orkney, has been tentatively identified as a linen smoothing board (Nissan July 1993, pers. comm.). Similar samples identified as smoothing boards and linen smoothers have been excavated from female graves in western Norway (Roesdahl & Wilson 1992, 242). It appears probable therefore, that the British finds represent the continuation of a custom practised in the homelands.

Damage to woven fabric-structure resulting from wear, shows a unique form of degradation and is easy to recognise. Wear starts on the exposed crowns of the cloth. The sequence is readily detectable, with flattening occurring first, followed by fibrillation (plate L), cracking and breaking, which shows in the fibres as characteristic brush ends. The final process of the sequence is the rounding off of the fibres (plate LI) (Cooke 1990, 5; Cooke & Lomas 1990, 220). Obviously such damage weakens the fabric considerably and speeds its degradation.

4.7 SUMMARY

The differing attributes of fibres have a direct affect on the form and quality of the fabric produced. Linen, normally of plain tabby weave, creates a crisp cool material, suitable for under-garments and bed-linen. Wool, which can be either tabby or twill weave, or produced from non-woven techniques, produces warm, soft, water-resistant textiles, utilised for outer-garments, cloaks and blankets. From silk, comes a soft, smooth fabric, enhanced by satin weave, best suited to luxury items. The weave-types and textiles produced, thus reflect the fibre from which they are made.

The analysis of fibres also gives information about trade and cultural contacts. The study of fleece-type for example, can furnish information on the area of origin of the cloth and cultural contacts. Silk highlights long distance trade networks.

Bender Jørgensen (1986, 13) maintains that spin-direction is an essential element in characterising the textiles of any given culture, with a single spin-direction predominating in specific areas at a particular time. Certainly, this appears to be the case with the textiles from York and Scotland. The spin-direction in the York wool textiles is similar to that of Anglo-Saxon and north-west European material with more Z/S spun yarns than Z/Z. The Scottish material, in contrast, parallels Scandinavian textiles where Z/Z spun yarns predominate

Fabric-structure is fundamental to accurate textile description. By assessing fibre-, yarn- and fabric-type, and fabric quality, it is possible to assess chronological change in specific geographical areas and the specificity of weave-types to particular cultures, for instance the *Birka*- and *Veka-type* twills. Probable areas of manufacture can thus be identified.

Investigation of naturally pigmented wool reveals particular colour patterned weave-effects, as well as furnishing information on the evolution of colour in the fleece of sheep. Dye analysis shows how dye-plants from local environments were exploited and the importation of dyes. It can also be used to assess possible colour preferences, for example, the apparent preference for red fabric in York, Lincoln and London and purple in Dublin. In addition, status may be detectable through dye analysis, for instance, the brightly dyed garments from Mammen, Denmark which were produced through the use of imported dye-stuffs from the Mediterranean.

The analysis of textile wear and use, although a new area of research, has already confirmed the value of such investigations. Work on textiles from Vindolanda has shown that it is possible to assess the extent and type of wear textiles undergo during their active use and it has also been possible to recognise the use and re-use of textiles in antiquity. In addition, the research has shown that wear survives further degradation on burial, allowing for analysis of function.

Rigorous analysis of fabric-structure is essential to an understanding of the technology available to textile producers in past cultures. The examination of fabric-structure also highlights technological developments over time. The presence of starting-borders on woven textiles allows for assessments of loom-type for instance. Where non-woven textiles survive in the archaeological record, it becomes possible to examine the various methods used to produce them and possible cultural contacts. Nålebinding for instance, is a specifically Scandinavian technique which suggests that the nålebinding sock (1309) from York (plate XI; Appendix 1: table 11) may have been an import.

If analysis is carried out rigorously, a great deal of cultural and technological information is obtainable. The work of Bender Jørgensen, Walton, Taylor, Janaway and Ryder for instance, has greatly enhanced our knowledge of Scandinavian period textiles, and clarified the cultural affinities and technologies of those who lived and settled in areas under Scandinavian influence. Their work has revealed for example that the textiles from Scotland show continued affinities and contact with the Norwegian homelands and that the textiles from York have closer affinities with the Anglo-Saxon areas of England and north-west Europe.

CHAPTER 5

CONCLUSIONS

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CONCLUSIONS

The main purpose of this study has been to review critically current techniques of ancient textile analysis. The guiding issue as put forward in Chapter 1 was: what information do we hope to gain from examining archaeological textiles and how can we use such information? The answers are dependent on the special interests and pre-suppositions of the specialist. My main area of interest is the use of ancient textiles to address cultural-historical issues. To obtain such information, three questions were posed in the opening chapter. (i) How should we view textiles from the past - what are we looking for and why do we need to ascertain certain things? (ii) What are the problems preventing us gaining the information we require? (iii) What is the present state of textile research and analysis and how should the discipline develop in the future?

To examine the cultural aspects of ancient textile studies, and to answer the questions posed, it is first necessary to understand the processes of preservation and the techniques of conservation, as well as the levels and appropriate application of analytical techniques. In addition, an awareness of the problems of analysis presented by the nature of the material and the methodologies employed is advantageous. This thesis has therefore concentrated on these issues to form a base for future research. To conclude, I shall re-examine the three questions from which it becomes possible to address the central issue pertaining to the examination of ancient textiles, as stated above.

The first question considers how we should view textiles from the past; what we are looking for and why it is necessary to ascertain certain things. The fundamental reason for the analysis of ancient textiles is to further an understanding of technological and culture history. This is achieved by considering specific technical details, for instance, fibre- and yarn-type, fabric-structure, colour and the use and re-use of textiles. Each makes a unique contribution to a greater understanding of the production technologies available to and exploited by textile producers from past cultures. They may also reflect how our ancestors exploited their environment to obtain the raw material - fibre and dyes - necessary to textile production.

The second question concerns the obstacles which may prevent us gaining the information we require. Chapter 3, examines in detail the problems relating to both the nature of the material under examination and the methods employed in their analysis. The numerous modes of preservation to which ancient textiles are subject affects the level of information that can be obtained through analysis. For instance, the level of information obtainable from textiles preserved in waterlogged conditions is far greater than the detail gained from mineralised textiles (3.3.1 to 3.3.5).

Problems of methodology include imprecise terminology, lack of an explicitly stated approach and the use of inappropriate analytical techniques. There is little standardisation of terminology which affects description and interpretation. Specialists regularly use different terms to describe the same concept, or use the same term but interpret it in different ways. For example, several terms are used to describe fabric quality, yarn-type and spin-direction (3.3.6). Lack of an explicitly stated approach and the use of inappropriate analytical techniques also results in inaccurate description. It is therefore necessary to employ the correct level of analysis specific to the type of preservation of the textile and the level of technical detail required. For instance, for exact bast fibre identification cross-section examination is necessary and to ascertain fleece-type, diameter measurements of wool fibres has to be undertaken. In contrast, simply to identify a fibre as bast or wool, low-power light microscopy of the fibre in whole mount is sufficient (4.2.1 and 4.2.3).

Resolving the problems arising from the nature of the material under examination is not easy. Problems brought about by methodology can however, be addressed and alleviated if detailed guidelines for recording and research are followed. Nelson and Johnson stress the necessity of a sound methodology and the design of characterisation schemes to facilitate the application of the correct analytical process to characterise a textile. This can be achieved by the selection of indispensable attributes, the use of comparative material and reference sets, and experimental archaeology where appropriate, thereby enabling accurate description at a level appropriate to the information required (3.5).

The final question relates to the present state of textile research and analysis, and how the discipline should develop in the future. In the last two decades, unprecedented advances have been made in the study of ancient textiles, in particular in northern Europe and Scandinavia. This is due in part to the rise in the number of urban excavations undertaken; previously textiles came mainly from graves or chance finds. The data examined in this thesis illustrate this clearly. The early date of the discovery of the majority of the Scottish material and the nature of its preservation is in marked contrast to the textiles recently excavated from York. The Scottish material is made up of largely nineteenth- and early twentieth-century finds and is preserved in mineralised form, whereas the York material has been preserved due to waterlogged conditions and has been excavated within the last twenty years. The techniques available to specialists are now considerably more sophisticated, thus facilitating detailed analysis and more informed interpretation, as evidenced in the York material.

As well as improved analytical techniques, the way archaeological textiles are viewed within the discipline of archaeology has altered. Prior to the advent of urban excavations, textile specialists regularly worked in isolation with little back-up from archaeological institutions with the resulting lack of access to the technology necessary for accurate description. Textile reports, where they appeared, were often not seen as an integral part of the interpretation of a site or period; they tended to contain technical details only.

The work of textile specialists is now considered, by the majority working in archaeology, to be an integral aspect of excavation strategies and reports. It has been recognised that the evidence obtainable from textiles contributes to the study of past cultures to the same degree as other aspects of material culture. This recognition has led to a greater number of textile specialists involved, at a higher level, in excavation and post-excavation procedures than has hitherto been evident. The work of the York Archaeological Trust is a good example of the value accorded to textile studies. The textiles from each site excavated in York are rigorously analysed and interpreted, the results of which form an integral part of the final site report; the Anglo-Scandinavian textiles from Lloyds Bank, Pavement, 5 Coppergate (AY 17/3: Hedges; Muthesius; Ryder; Walton 1982), Parliament Street (AY 17/4: Walton 1986) and 16-22 Coppergate (AY 17/5: Ryder; Walton 1989) illustrate this clearly.

An area of textile research which is gaining attention is experimental work designed to test theories relating to textile production technology. The Archaeological Textile Workshop at Lejre, Denmark is at the forefront of such work, in particular research into the production of complex twill weaves using the warp-weighted loom. The waterlogged environments from which textiles are now regularly excavated has widened the repertoire of textile production equipment available to researchers to carry out this type of research. Experimental work greatly enhances our knowledge of textile production technology, innovation and change and thus makes a valuable contribution to technological history.

Although great advances have been achieved in textile studies, there are still problems to be addressed. Standardisation of terminology and definitions is of paramount importance if textile reports are to be readily accessible to specialists and non-specialists alike. One reason for the lack of standardisation is that in general, textile specialists are self-taught, and normally work alone. A degree of individualism remains in the techniques of analysis and the terms used to describe technical details, due in part to the relatively small number of people working with archaeological textiles. This situation is being addressed in northern Europe through the formation in 1981 of NESAT (North European Symposium for Archaeological Textiles). For the first time textile specialists from very different backgrounds and with varying degrees of experience have been brought together to share their experience and research, and to form a more coherent base for textile studies in general. In addition, the twice yearly publication of the Archaeological Textile Newsletter, produced in Leiden, the Netherlands enables those working with archaeological textiles to keep up to date with current trends, as well as recent textile finds and analysis. More importantly perhaps is the opportunity it gives textile specialists to communicate through an easily accessible channel.

The three questions posed in the introduction to this thesis have thus been addressed. First, the analysis of ancient textiles furthers an understanding of technological and culture history. Second, the obstacles to gaining the information we require derive from the nature of the material under examination and the methodologies employed. The nature of the material is difficult to resolve, but sound methodologies and the design of characterisation schemes can overcome the problems of methodological approach. Finally, there have been unprecedented advances in textile studies over the last two decades which is evidenced in the level of technical and interpretative information now available to specialist and non-specialist alike. By exploring the three questions, it has thus been possible to investigate the overriding issue of textile studies, namely the information we hope to gain from examining ancient textiles and how such information can be used to address culture-historical issues.

The way forward for textile studies is clear. An internationally agreed terminology to describe textiles and textile terms is essential. It is also of paramount importance that when terms and notations have been approved, they are adopted by all specialists working with textiles. The use of inappropriate terms should be avoided, for example 'woollen' and 'worsted', to ensure accurate description. Accurate and detailed characterisation is essential to meaningful interpretation, and to ensure accessibility for future researchers. To achieve this it is vital to employ sound methodologies and to design characterisation schemes suitable to the material being examined. All textile reports should clearly indicate which technical details have been recorded and some form of interpretation should be included. Finally the study of ancient textiles needs to be given higher profile in archaeology departments in institutions of higher education; having to justify an interest in ancient textile studies is still too much the norm.

In conclusion, it is evident from the research undertaken here that a knowledge of the modes of preservation and techniques of conservation coupled with the levels and appropriate application of analytical techniques, make possible the accurate and detailed characterisation of archaeological textiles. The analysis of ancient textiles has significant implications for the technological, cultural and social development and diversity of our ancestors. I have thus developed a sound platform from which to launch my future research.

PLATES

PLATES

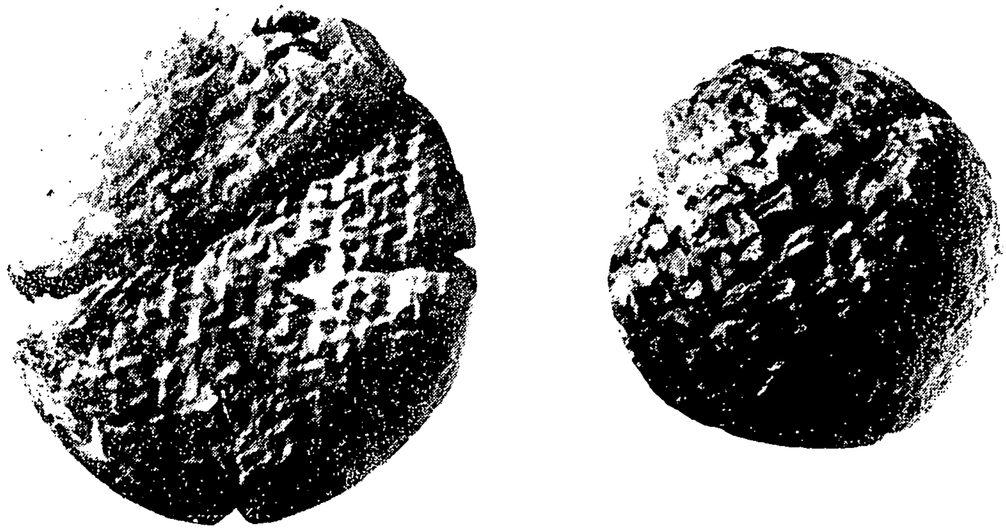


plate I. Plain tabby- and basket-weave impressions from Jarmo, Iraq.

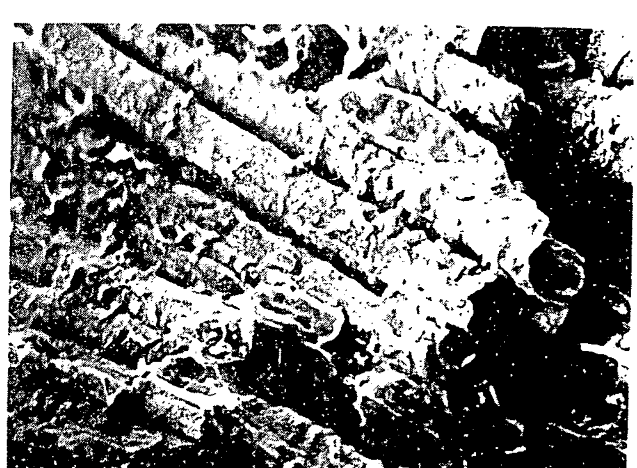


plate II. Scanning electron micrograph of negative cast mineralised flax from a Scandinavian period sword from Claghbane, Ramsey, Isle of Man .

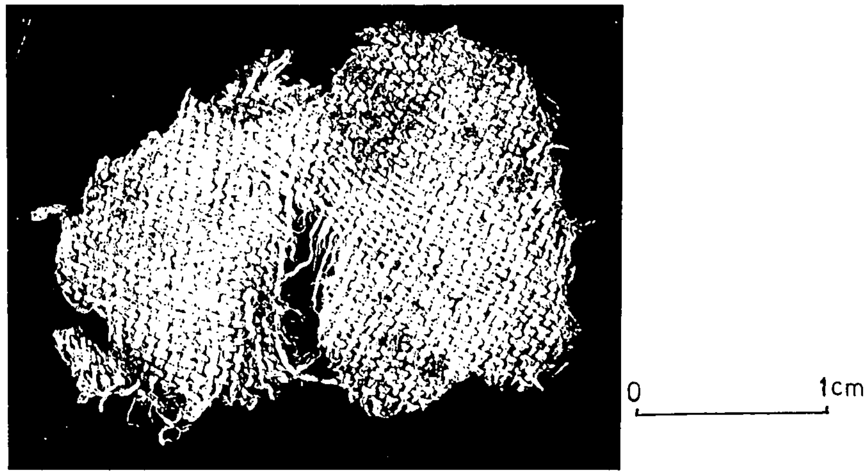


plate III. IL 856 - Copper alloy preserved linen from oval brooch 2 from Kneep, Lewis, Western Isles.

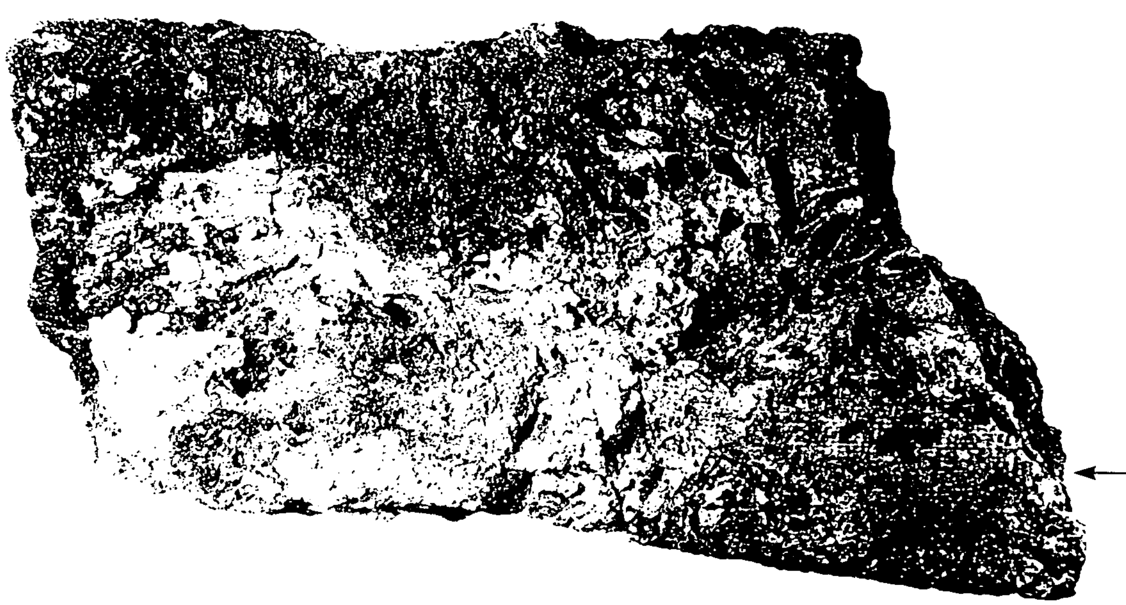


plate IV. Mineralised tabby-weave textile on section B of a Scandinavian period sword from Scar, Sanday, Orkney.

plate V. Charred vegetable fibre textiles from 16-22 Coppergate York.
(1317, 1319-21, 1324-5, 1327-8, 1331-6 and 1338-9)

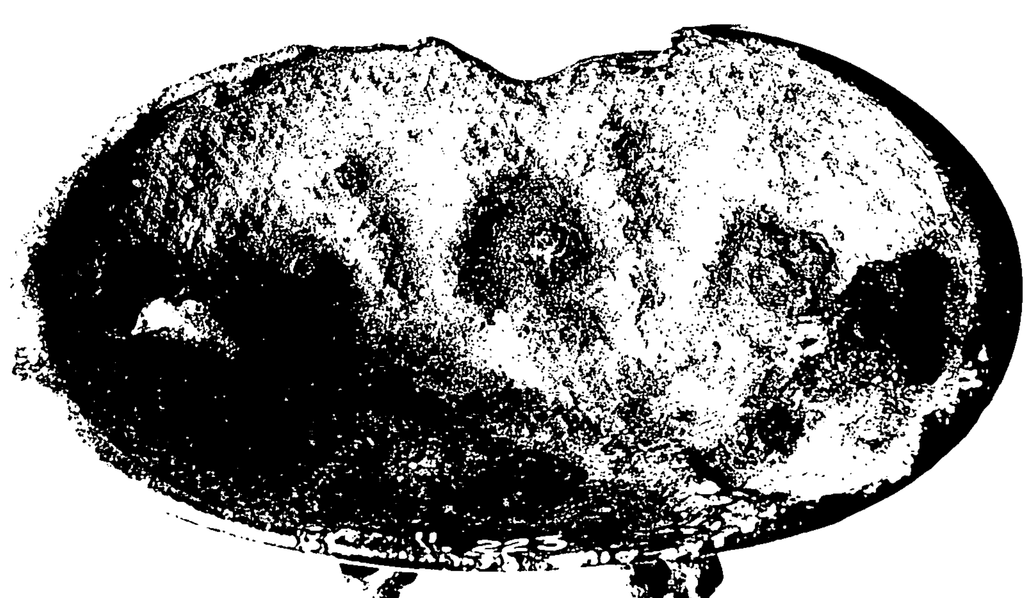


plate VI. IL 223 - Impression of sprang 'plaiting' on oval brooch from Clibberswick, Unst, Shetland.

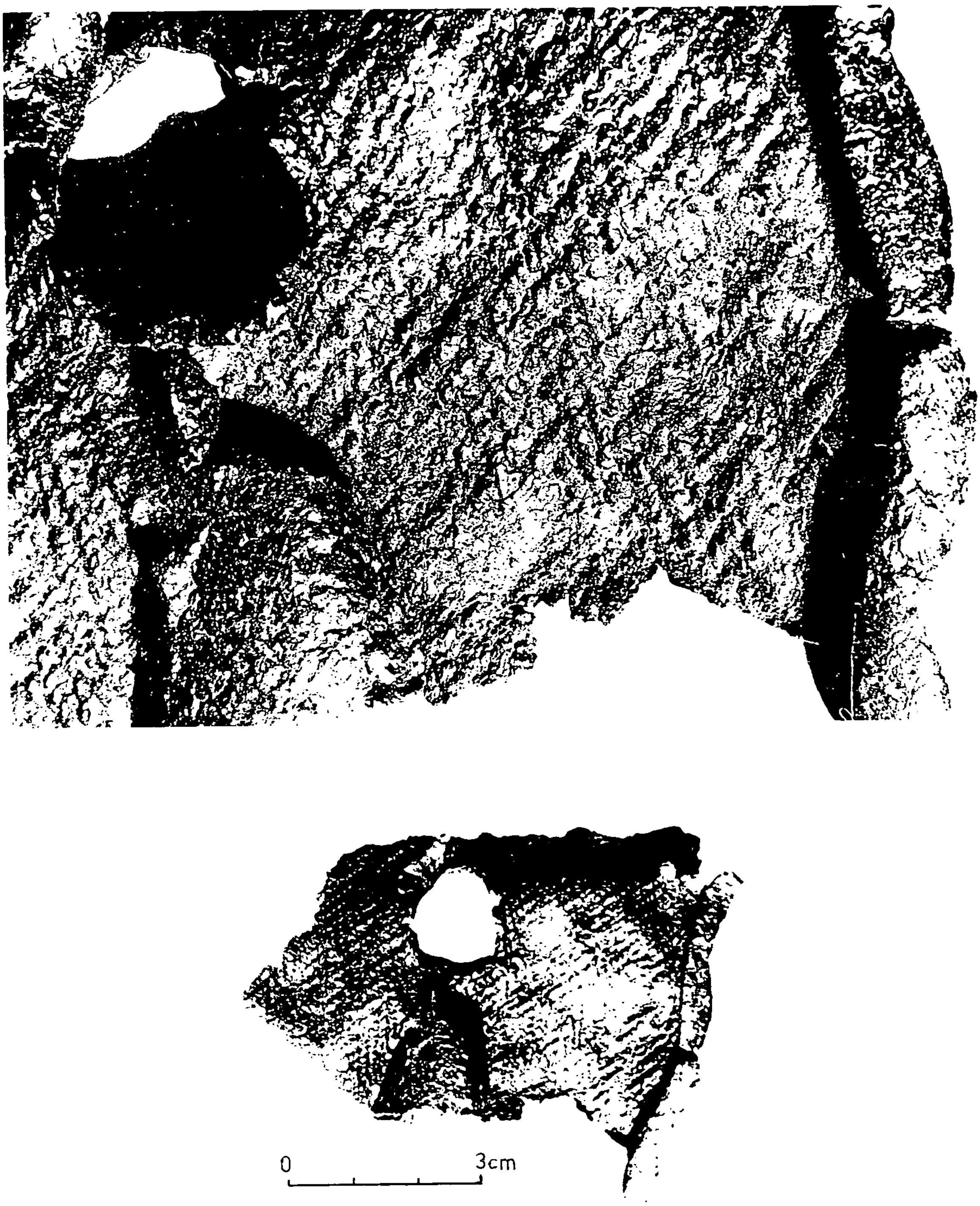


plate VII. IL 750 - 2/2 herringbone twill on a brooch fragment from Chaipaval, Northton, Harris.

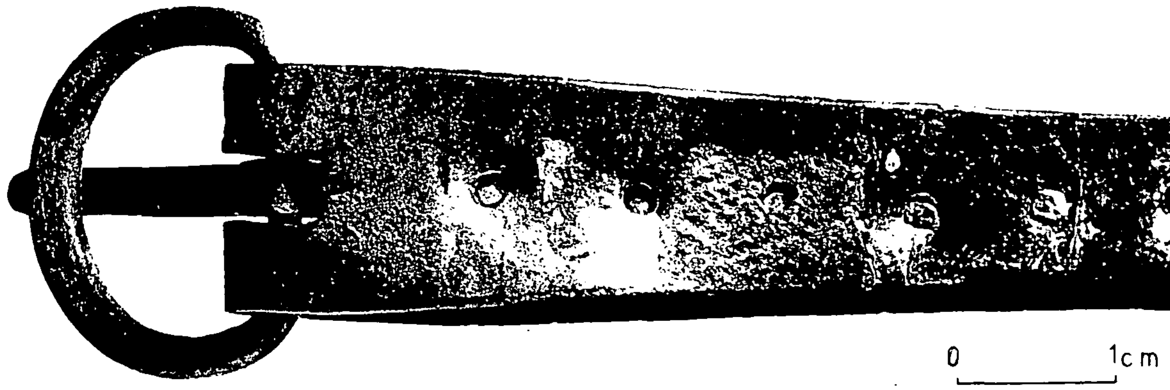


plate VIII. IL 853 - Impression of 2/2 *Birka-type* diamond twill on strap end from Kneep, Lewis, Western Isles.

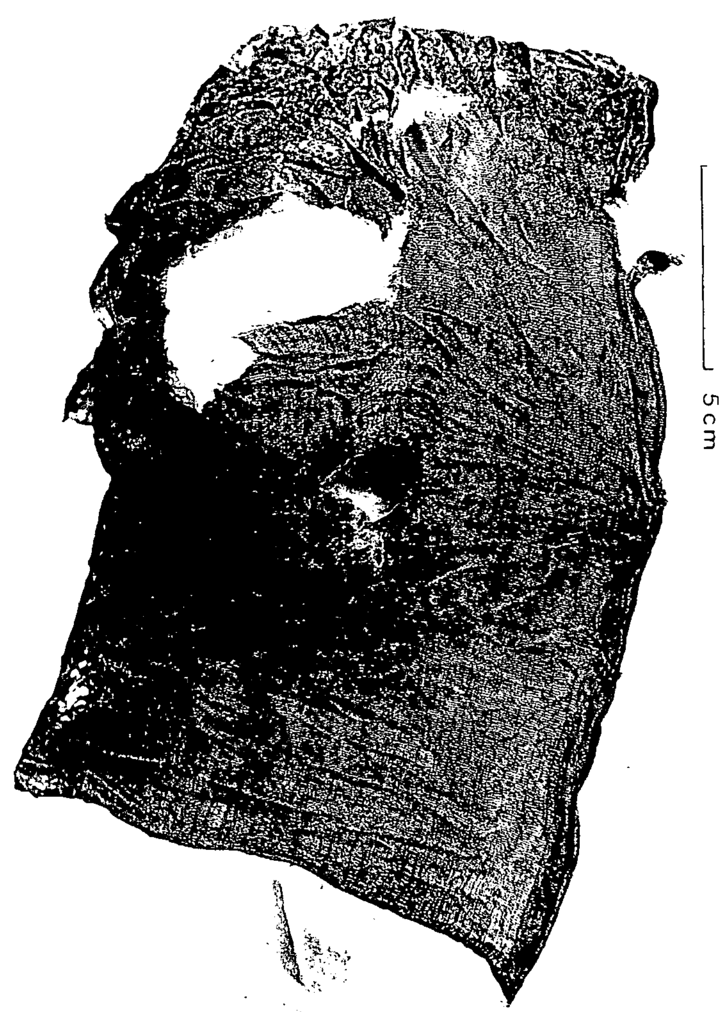


plate IX. 1372 - Silk head-dress from 16-22 Coppergate, York: before conservation (length opened out 0.59m).

plate X. 1372 - Silk head-dress from 16-22 Coppergate York:
after conservation.

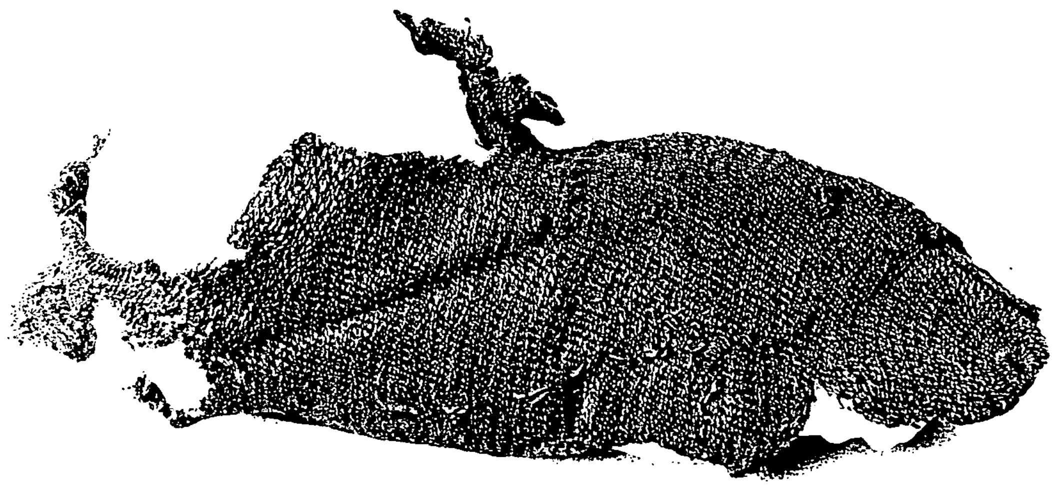


plate XI. 1309 - Nålebinding sock from 16-22 Coppergate, York: before conservation (length from heel to toe 0.26m).

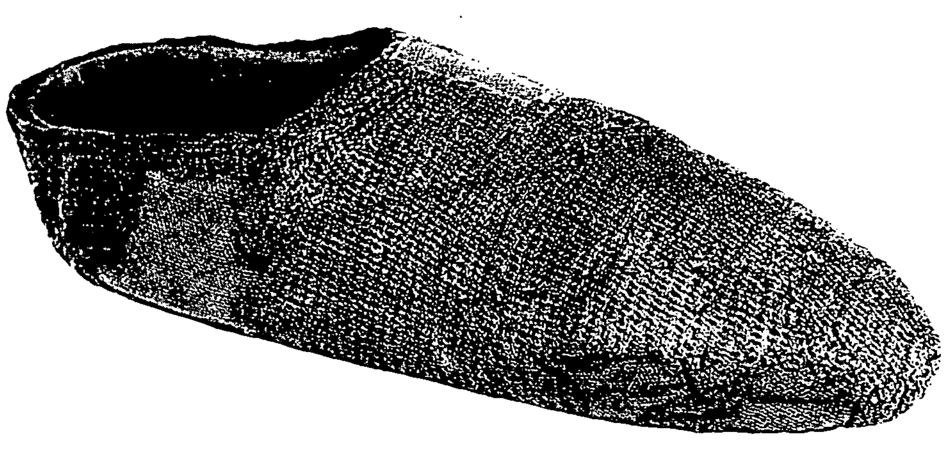


plate XII. 1309 - Nålebinding sock from 16-22 Coppergate, York: after conservation (length 0.26m).

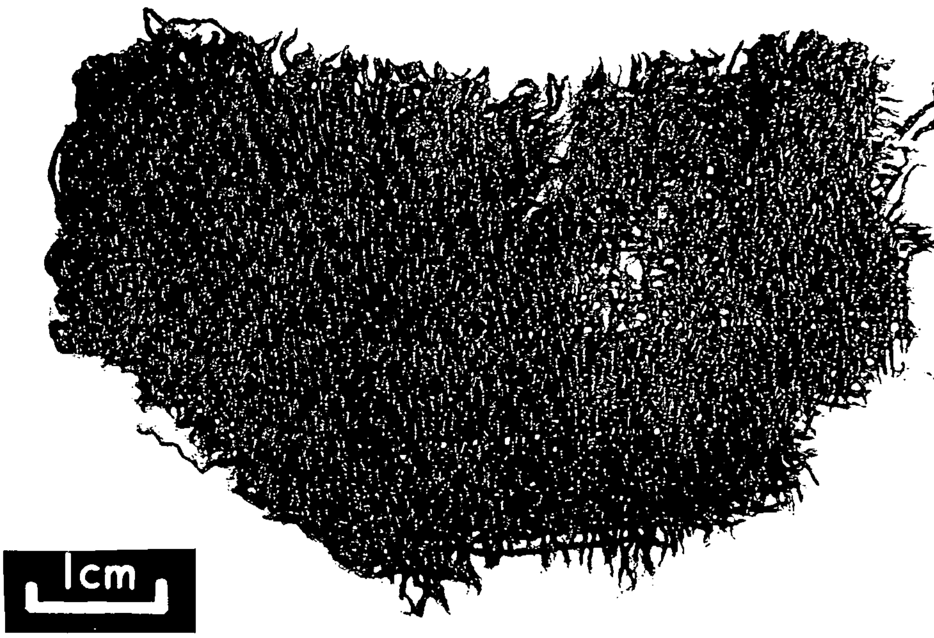


plate XIII. 1382 - 2/2 *Birka-type* twill with selvedge from 16-22 Coppergate, York (length 65mm).

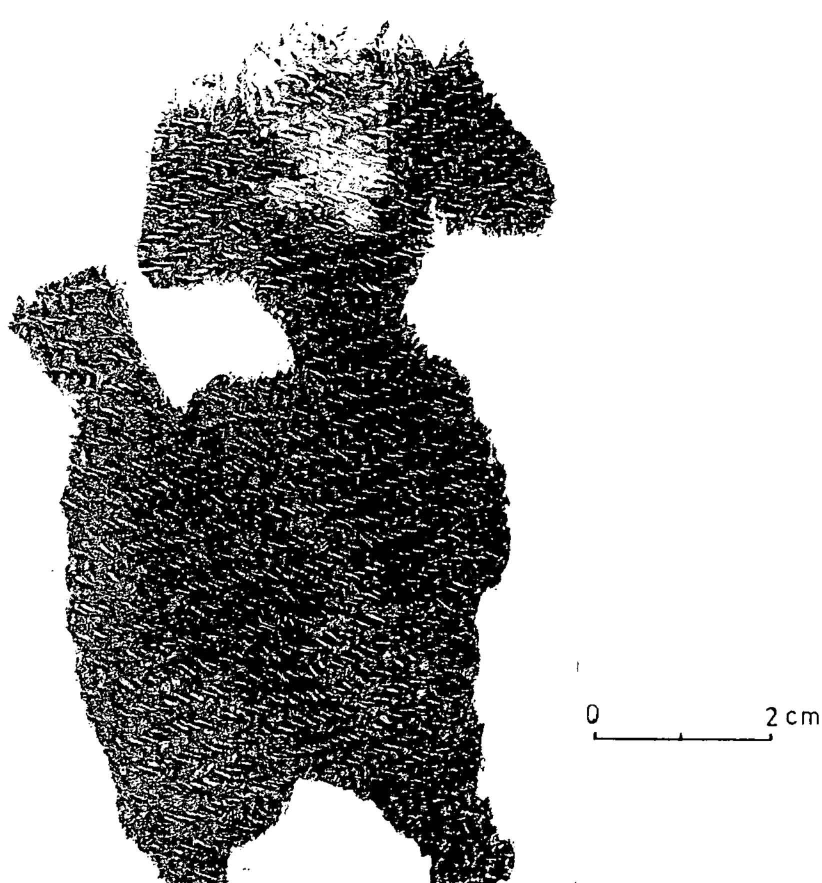


plate XIV. IL 164a - 2/2 *Veka-type* twill from Kildonan, Eigg.

plate XV. 'Woollen' Z-spun yarn (x60).

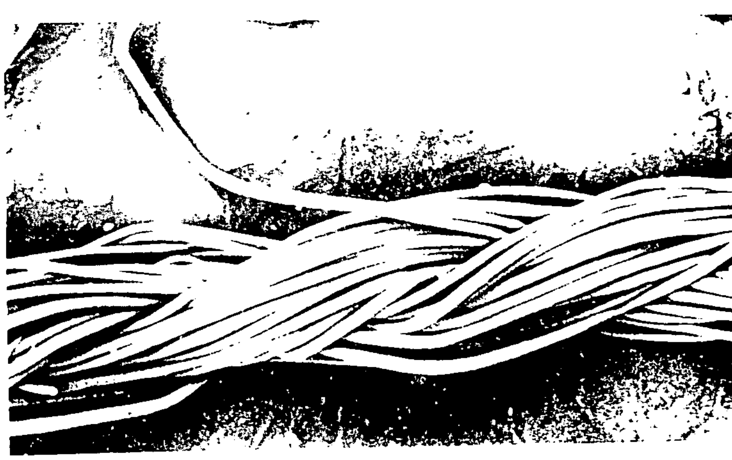


plate XVI. 'Worsted' S-ply yarn (x60).

plate XVII. Plain tabby-weave:
linen.

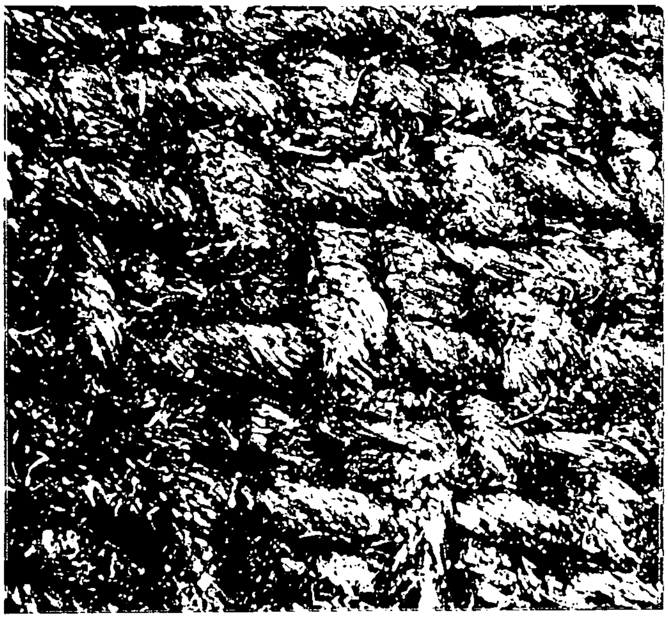
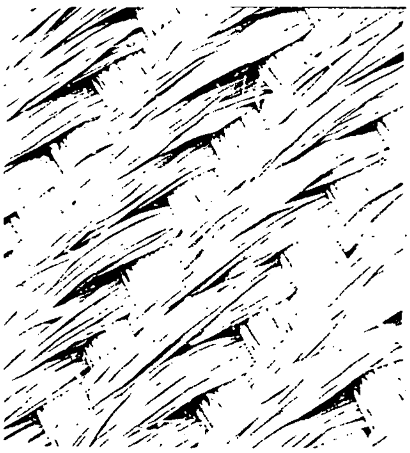


plate XVIII. Plain 2/2 twill-weave:
wool (x6).

plate XVIX. Satin-weave:
silk.



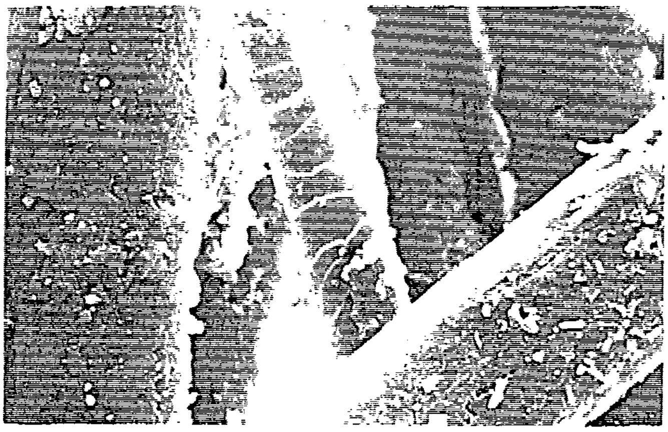


plate XX. Waved scale patterns of wool fibre from hairy medium fleece (x200).

plate XXI. Mosaic scale patterns of wool fibre from hairy fleece (x200).

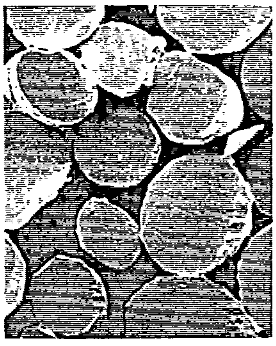


plate XXII. Cross-section of fine wool fibres.

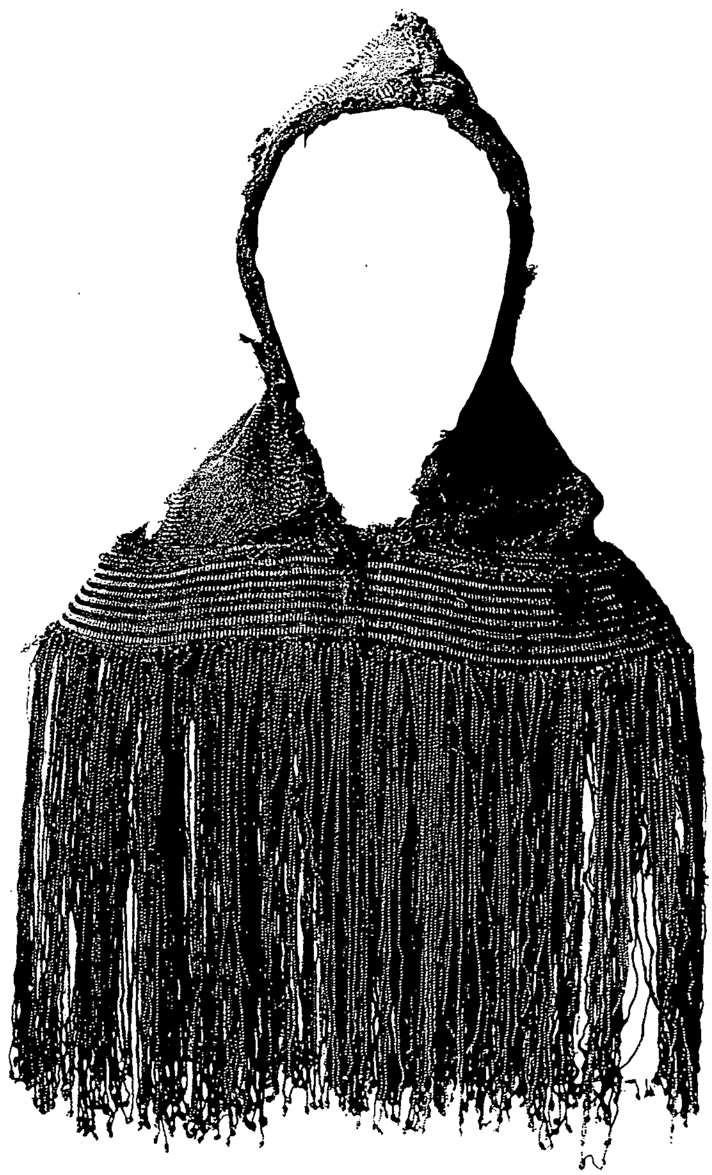


plate XXIII. NA 3 - The Orkney Hood from
St. Andrew's Parish, Mainland.

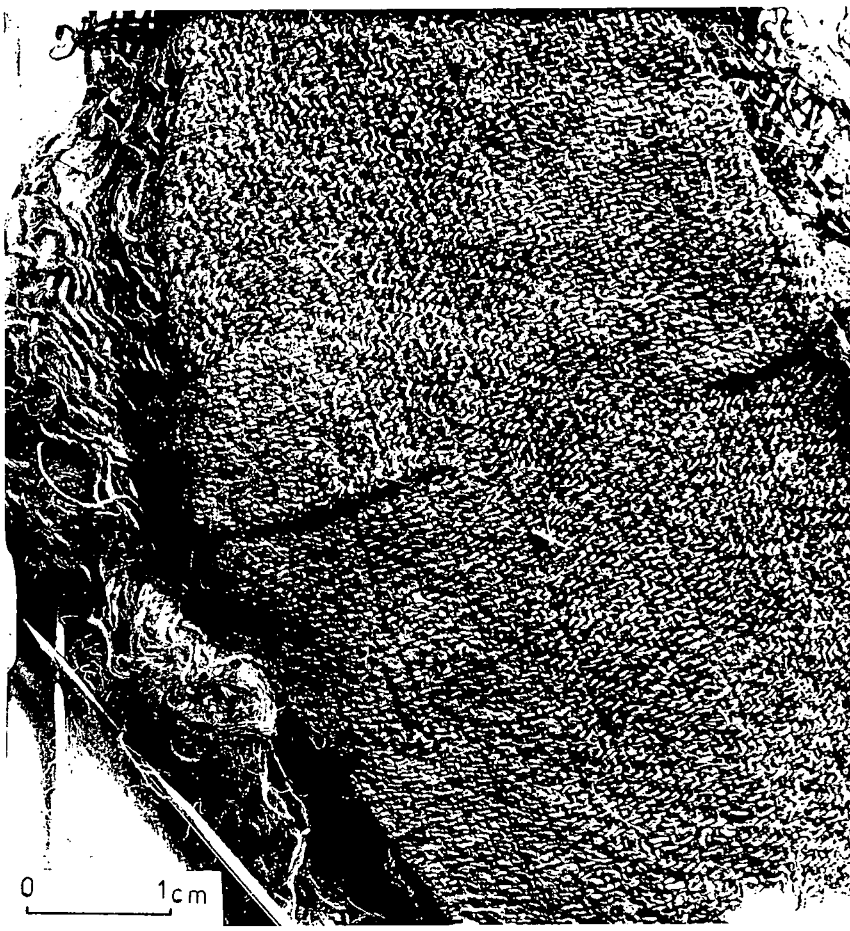


plate XXIV. NA 307 - 2/2 *Birka-type* twill from Greenigoe, Orphir, Mainland, Orkney.

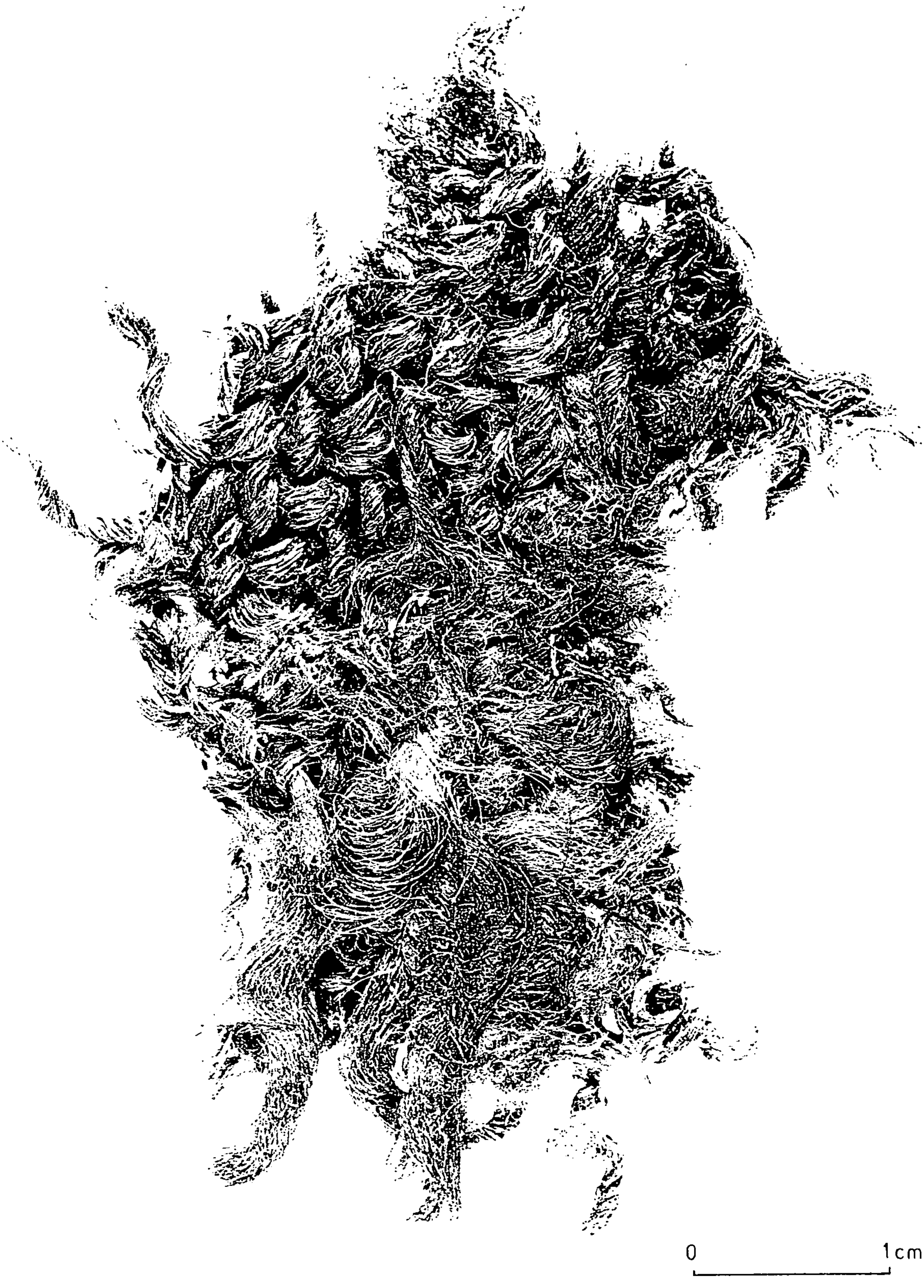


plate XXV. A1 - Piled fabric from Cronk Moar,
Jurby, Isle of Man.

plate XXVI. Scanning electron micrograph of mineralised wool showing scales.

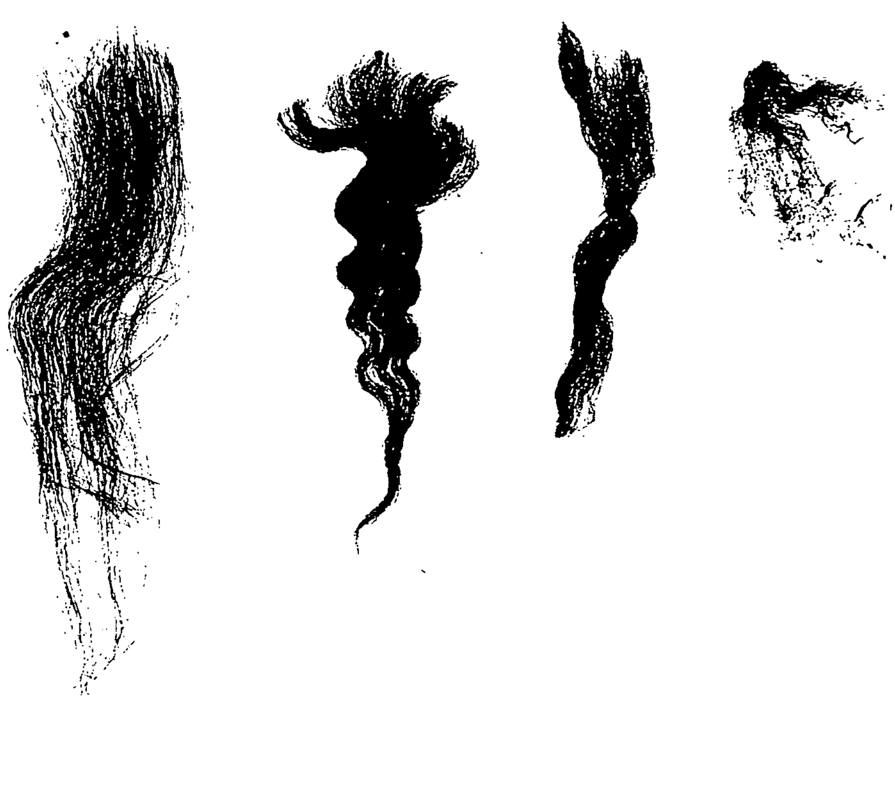


plate XXVII. Raw wool staples from 16-22 Coppergate, York:
1374 - hairy fleece (90mm); 1376 - hairy medium;
1378 - ?medium; 1377 - generalised medium.

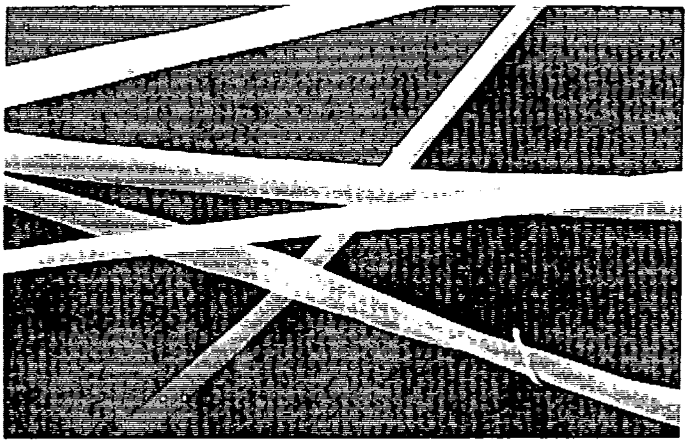


plate XXVIII. Cultivated silk in whole-mount (x800).

plate XXIX. Cross-section of cultivated silk.

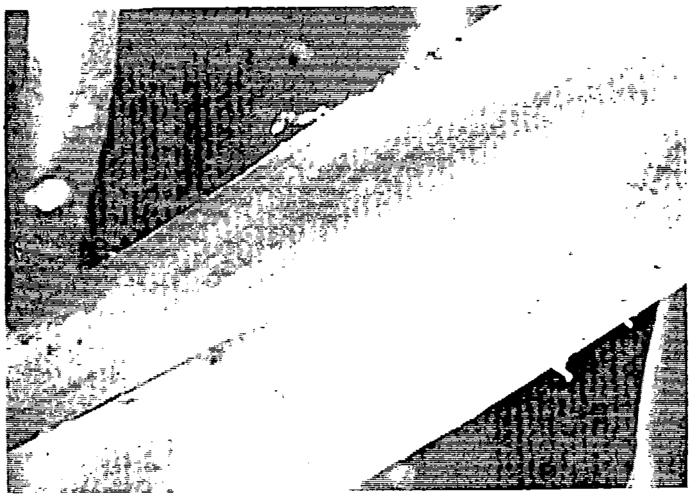


plate XXX. Wild silk in whole-mount (x1700).

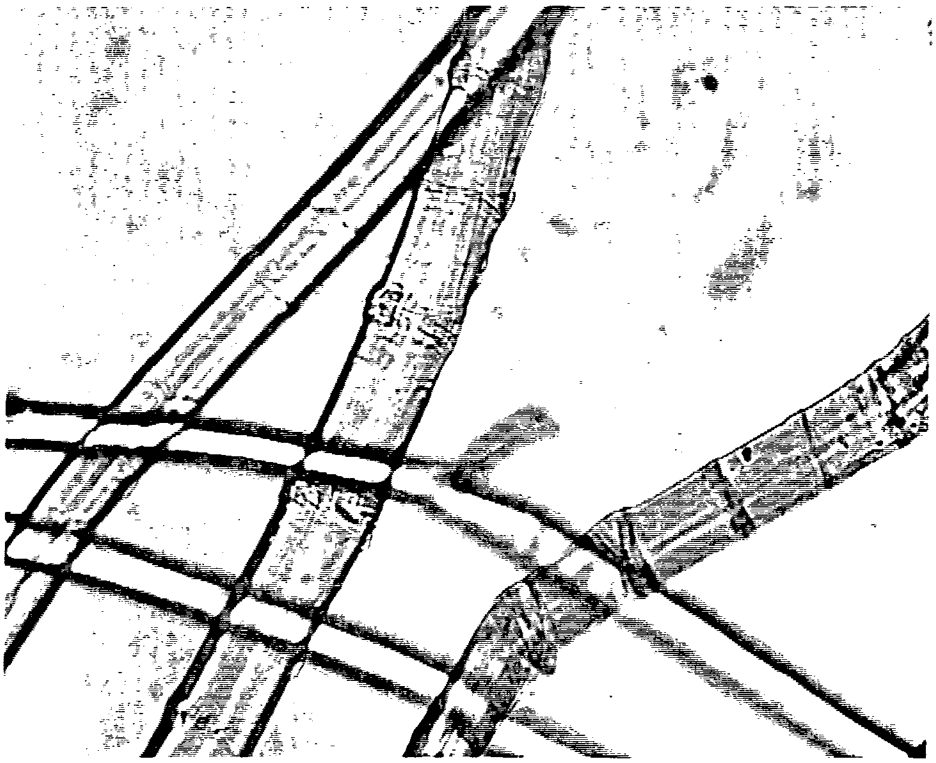


plate XXXI. Bast fibres showing nodes and striations (x200).

plate XXXII. Cross-section of flax fibres (x2625).

plate XXXIII. Cross-section of hemp fibres (x1125).

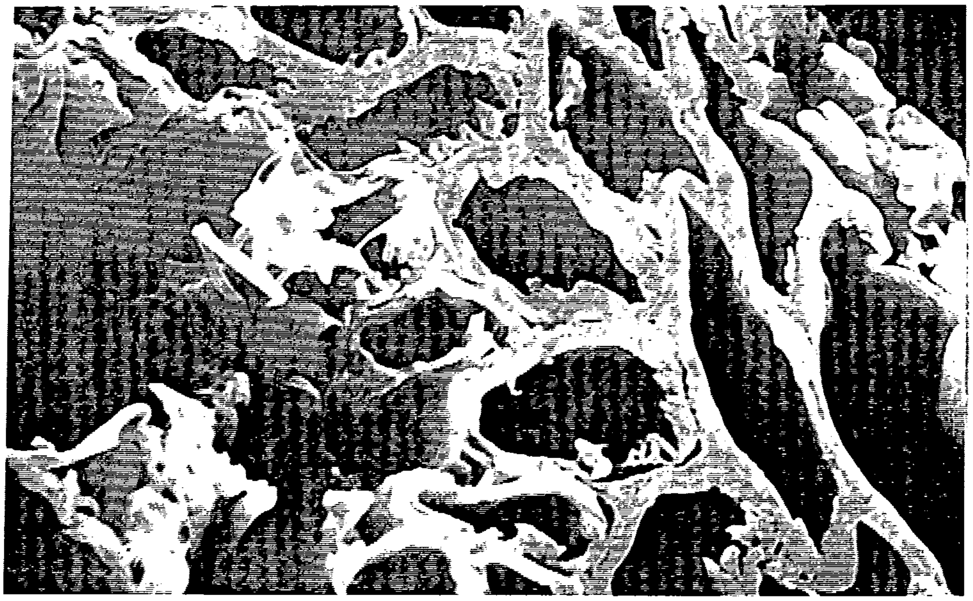


plate XXXIV. Cross-section of nettle fibres (x2625).

plate XXXV. Scanning electron micrograph of flax ultimates from section B of the sword from Scar, Sanday, Isle of Man.

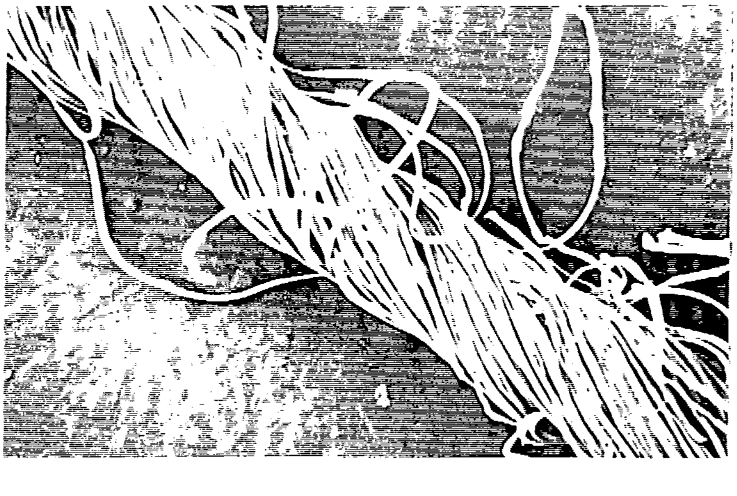


plate XXXVI. Z-twist wild silk yarn (x60).

plate XXXVII. Z-spun wool yarn (x25)

plate XXXVIII. Z2S-spun wool plied yarn (x6).

plate XXXIX. S-spun mineralised yarn (x12).

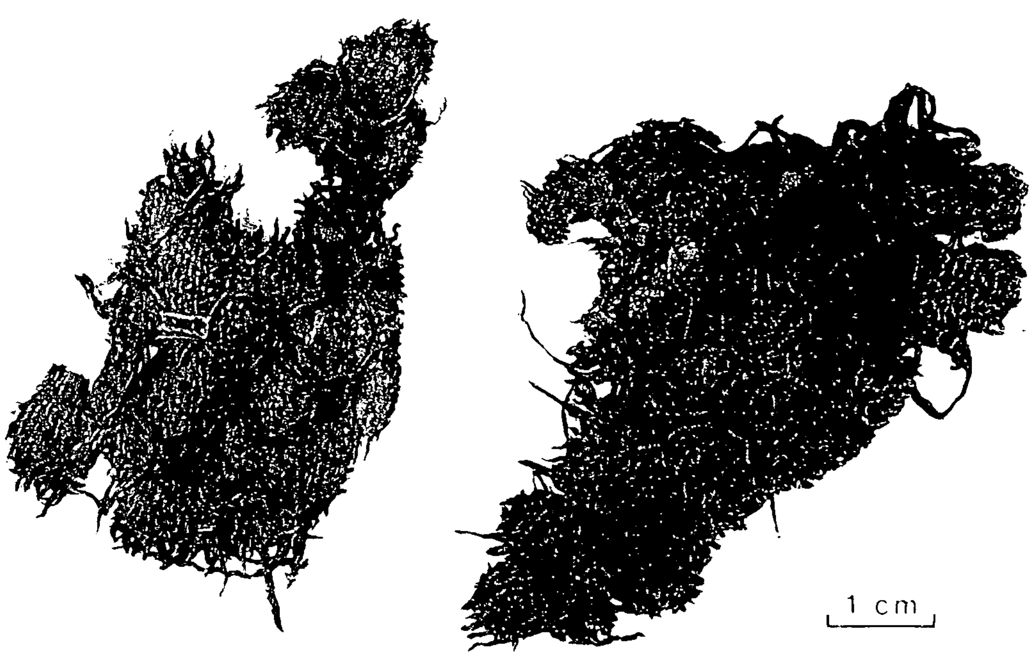


plate XL. 1336 - carbonised linen honeycomb-weave from 16-22 Coppergate, York (left piece 55mm long).

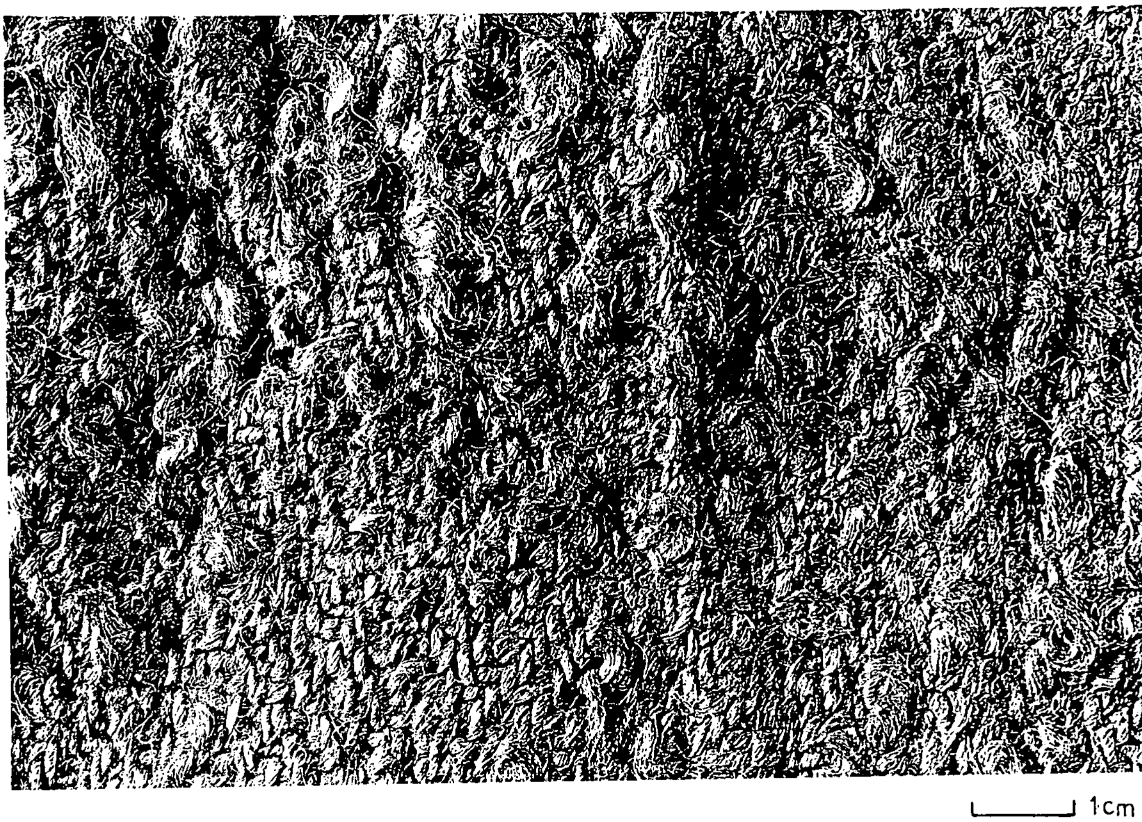


plate XLI. 579 - piled fabric on 2/2 diamond twill base from Lloyds Bank, Pavement, York.

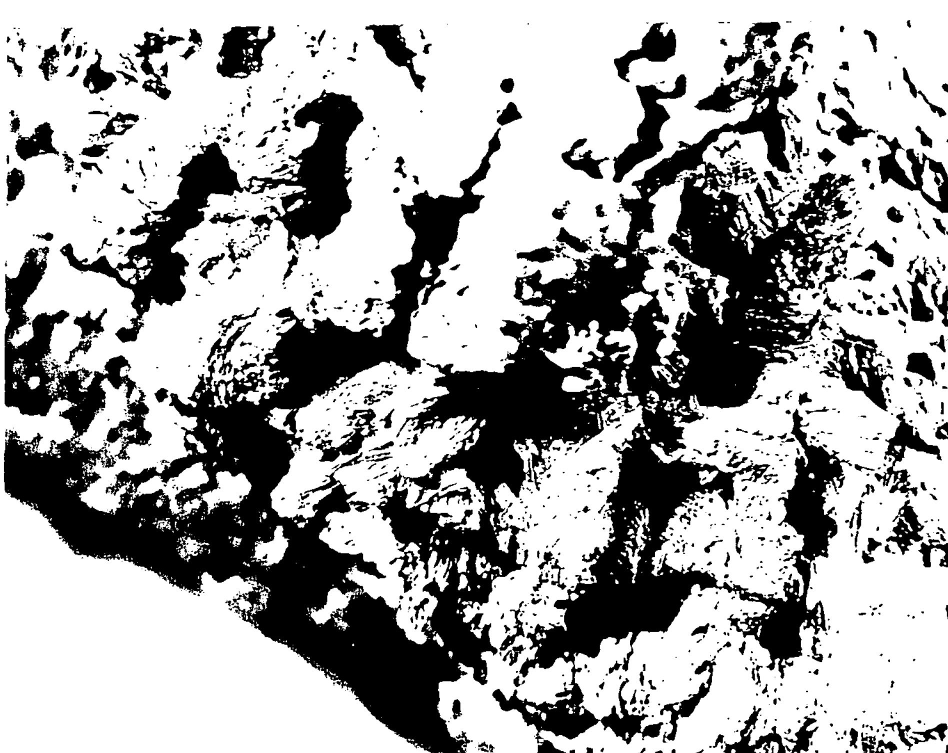


plate XLII. Mineralised tabby-weave with S-spun yarn (x6).

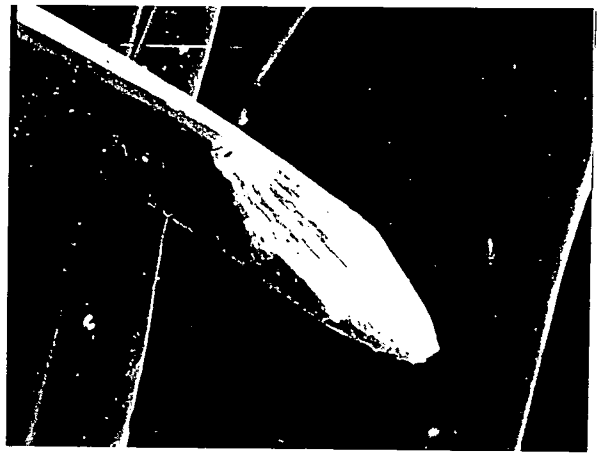


plate XLIII. Brittle break - silk (x2000).

plate XLIV. Brittle break - flax (x2000).

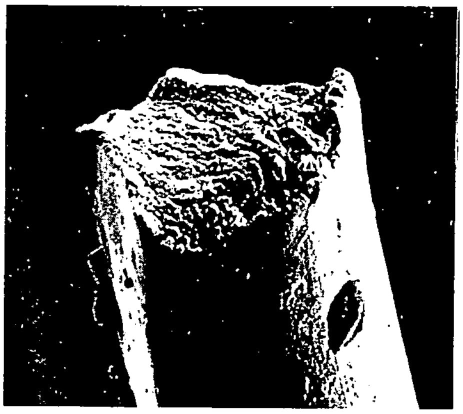


plate XLV. Tensile break - silk (x3000).

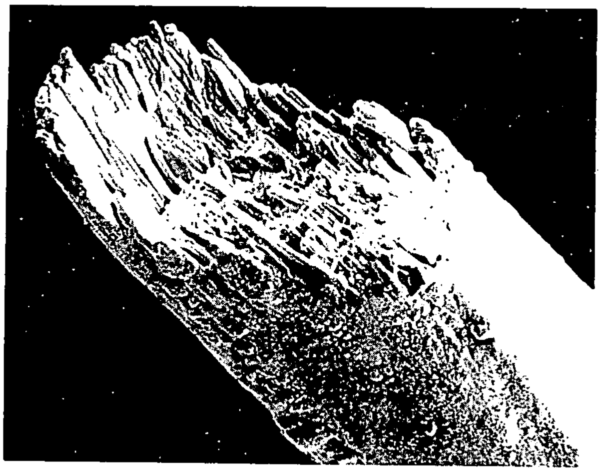


plate XLVI. Tensile break - flax (x3500).

plate XLVII. Tensile break - wool (x2000).

plate XLVIII. Polished linen textile (x900).

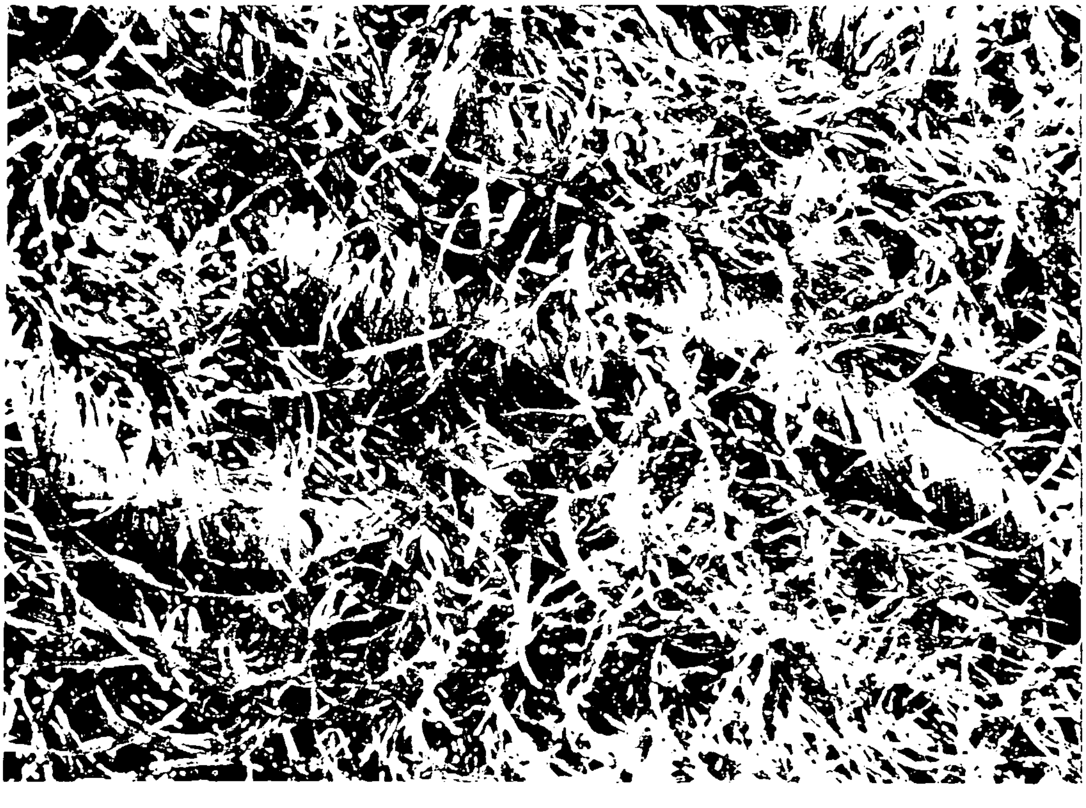


plate XLIX. Felted wool textile (x12).

plate L.   Crown damage (x900).

plate LI.   Rounded ends (x900).

APPENDIX 1

TABULATED SYNOPSIS OF THE SCANDINAVIAN PERIOD TEXTILE EVIDENCE FROM YORK

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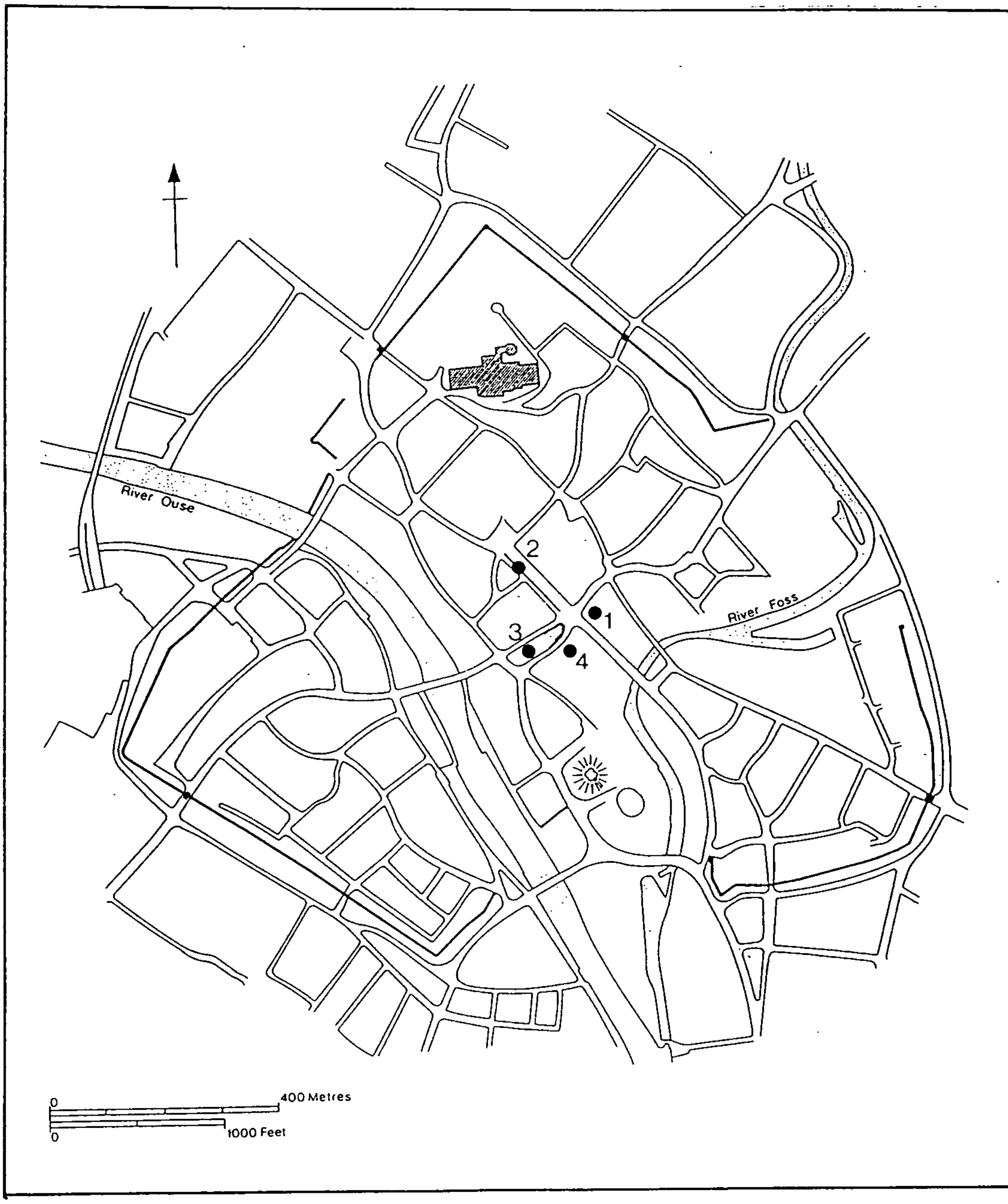
TABULATED SYNOPSIS OF THE SCANDINAVIAN PERIOD TEXTILE EVIDENCE FROM YORK.

The technical details of the Scandinavian period textile evidence from York has been presented here in tabulated form only as catalogues detailing the material are well represented in the Archaeology of York fascicules 17/3 (Hedges, Muthesius, Ryder and Walton 1982), 17/4 (Walton 1986) and 17/5 (Ryder and Walton 1989). The inclusion in the tables of cover factor is based on a formula currently being worked on by the author. Where further clarification is required, comments compliment the technical details.

The legend applied to the following tables is detailed below for clarity and ease of use.

*	-	before thread count details = direction of warp and weft not known.
n.d.d.	-	no dye detected.
nat. pig.	-	natural pigment.
*	-	before raw wool staple fleece-types (table 9) = wool plucked from the sheep after death.
H	-	hairy fleece-type.
HM	-	hairy medium fleece-type.
GM	-	generalised medium fleece-type.
TM	-	true medium fleece-type.
Sh	-	shortwool fleece-type.
F	-	fine fleece-type



Map 1. Sites from York with Anglo-Scandinavian textiles:
1 Lloyds Bank, Pavement. 2 Parliament Street.
3 5 Coppergate. 4 16-22 Coppergate.

TABULATED SYNOPSIS OF TEXTILES, THREADS, CORDS AND WOOL STAPLES FROM YORK

ANGLO-SCANDINAVIAN WOOL TEXTILES FROM YORK

Table 1: Wool Textiles from Lloyds Bank, Pavement - (Hedges 1982)

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam. (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
Group I - 'worsted' twills, hard to feel									
564	25 x 10	2/1 diamond	* 22/16	0.5/0.4	104	?	Z/Z	light brown	twill - accurate m'tings
565	50 x 40	2/1 diamond	* 22/11	0.7/0.7	112	?	Z/Z	med.-brown	twill - accurate m'tings
566	100 x 70	2/1 diamond	* 26/14	0.4/0.5	101	?	Z/Z	light brown	twill - accurate m'tings
567	120 x 60	2/1 diamond	* 18/11	0.4/0.5	87	?	Z/Z	light brown	twill - error in heddle lifting
568	c180 x 40	2/1 diamond	* 22/14	0.5/0.5	103	?	Z/Z	mid-brown	twill - accurate m'tings
569	30 x 20	2/1 diamond	* 20/11	0.7/0.7	109	?	Z/Z	light brown	full pattern not clear
570	c150 x 150	2/1 diamond	* 16/10	0.6/0.7	99	?	Z/Z tight/loose	light brown	twill - accurate m'tings
Group II - similar to group I									
571	160 x 50	2/2 chevron	* 18/15	0.7/0.6	103	?	Z/S	light brown	inaccurate m'tings/ irregular repeat
572	frags. 20cm^2	2/2 diamond	* 14/18	0.75/0.75	99	?	Z/S	light brown	inaccurate m'tings. Sewn hems on 2 frags. - Z-spun thr'd
573	frags. 65cm^2	2/2 diamond	18/12	0.8/0.8	109	?	Z/S	light brown	inaccurate m'tings. Patt. not symmetrical = error in heddle knitting. Selvedge in 1 frag.

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam. (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
Group III - 'woollen' twills, soft to feel									
574	90 x 2.5	2/1 chevron	* 20/14	0.5/0.5	100	?	Z/S	red-brown	accurate m'tings. Braid and sewing thr'd , both Z2S-ply
575	frags. 1.5 m^2	2/1 diamond	* 27/16	0.3/0.5	96	?	Z/S	red-brown	accurate m'tings, error in heddle lifting. sewn to 590 with S2Z thr'd
Group IV - 'woollen' twills, soft to feel									
576	250 m^2	2/2 diamond	* 20/10	0.6/1.0	110	?	Z/S	red	inaccurate m'tings. Sewn hem Z2S- thr'd
577	110 x 50	2/2 diamond	* 14/9	0.7/0.7	99	?	Z/Z+S	mid-brown	inaccurate m'tings. S2 = alternate Z- & S- yarn. Yarn & thr'd = Z- & S2Z-
578	90 x 80	2/2 diamond	* 8/7	1.2/0.8	98	?	Z/S loose/tight	mid-brown	
579	200 x 120	2/2 diamond pile	* 12/7	0.9/1.2	101	?	Z/S pile - S	mid-brown	inaccurate m'tings. Pile - loose S-spun, darned in, line every 5mm
Group V - 'woollen' plain tabby and twills, soft to feel									
580	100 x 10	?plain tabby	4/3	2.5/2.5	100	?	Z/S	light brown	selvedge, heavily matted or fulled
581	200 x 80	plain tabby pile	4/2.5	2.0/4.0	100	?	S/S pile - S	dark brown	Pile - darned loose S-spun. Selvedge. Z2S- yarn to sew on frag. of S/Z textile
582	370 x 160	plain tabby	5/3.5	2.0/2.2	100	?	S/S	light brown	errors in weave define Wa & We. Wa darker, spin tighter than We
583	90 x 50	?2/2 twill	* 4/3	1.0-4.0/ 1.5-5.0	100	?	Z/Z	light brown	crudely spun yarns. Lot of errors in weave
584	110 x 50	plain tabby	* 3.5/3.5	1.5-2.5/ 1.5-2.5	97	?	S/S	S1 - red-brown S2 - l't brown	loosely spun yarns

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam. (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
585	20 x 20	plain tabby	* 5/5	1.0-2.5/ 1.0-2.5	99	?	Z/S	light brown	
586	35 x 15	?	c3.5/3.5	2.5/2.5	98	?	Z/S	light brown	Z2S- yarn, 1.9mm diam. sewing thread
587	20 x 30	2/2 twill	6/5	1.8/1.5-2.0	104	?	Z/Z	light brown	folded fabric
588	35 x 15	?2/1 twill	4.5/5	1.0-2.2/ 0.5-2.3	92	?	Z/Z	light brown	
589	90 x 30	2/2 twill	4.5/4	1.2-1.7/ 1.2-1.7	85	?	S/S	mid-brown	Z2S-, 1mm diam. sewing thr'd, golden colour
590	500 x 600 & 220 x 170	plain tabby	* 4/3	2.5/3.0	100	?	S/S	dull brown	stained red in parts - from contact with 575

Group VI - plain 'worsteds', hard to feel

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam. (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
591	160 x 15	plain tabby repp	* 22/12	0.5/0.2	98	?	Z/Z	mid-brown	
592	150 x 20	plain tabby repp	* 19/12	0.7/0.4	117	?	Z/Z	med.-brown	

Group VII - 'worsted', hard to feel

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam. (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
593	100 x 80	2/1 twill repp	* 17/7	0.8/0.8-1.5	108	?	Z/Z	mid-brown	Z-spun sewing thr'd on one edge

Additional Wool Textiles from Lloyds Bank, Pavement - (Hedges 1982)

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam. (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
662	230 x 60	2/2 chevron twill	10/7	0.9-1.0/ 1.0-1.3	99	H-HM/HM	Z/S	mid-brown	gores in We. Z2S-ply sewing thr'd
663	280 x 30	2/2 chevron twill	* 9/6-7	1.0/1.3	99	H/HM thr'd - TM	Z/Z+S	dark brown dye/nat. pig.	S1 - alternate Z-+S-spun yarn. Z2S- sewing thr'd
664	110 x 50	2/2 diamond twill	* 15/12	0.4-0.7/0.7	96	?	Z/S	red-brown	
665	190 x 80 90 x 60	plain tabby	* 7/6	1.5/1.5	100	GM/HM	S/S	yellow-brown	two fragments
666	25 x 10 12 x 10	plain tabby	* 16/7	0.6/0.75	98	H/TM	Z/S	dark brown nat. pig.	'worsted'

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam. (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
669	45 x 15	2/2 diamond Birka-type twill	* 30/20	0.3/0.3-0.4	97	?	Z/Z	mid-brown	'worsted'. Z2S ply, 1.3mm diam. sewing thr'd
670	25 x 20	2/1 diamond twill	28-30/18	0.3/0.4	97	TM/HM	Z/Z	mid-brown	selvedge
671	10 x 10	twill - ?2/2	* c12/c10	0.6/1.0	100	?	Z/S	light brown	
672	40 x 30	plain tabby	* 3-4/3-4	c2.0/1.5-2.0	87	?	S/S	mid-brown	
673	8 x 7	plain tabby	* c8/c8	0.8/0.9	89	?	Z/S	light brown	'woollen'
674	7 x 85	braid	10 Wa thr'ds used/3-4 thr'ds per cm	1.0/1.0	-	H-HM/ H-HM	Z2S	mid-brown/red - Wa - ?madder We - n.d.d.	55mm frayed out Wa thr'ds

Table 2: Wool Textiles from Parliament Street - (Walton 1986)

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread diam. (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
948	125 x 70	2/1 twill	15/?	0.5/0.75-1.0	-	?	Z/S	dark brown	'woollen'. Selvedge
949	370 x 30	2/1 twill	* 12/4	0.75/2.0	98	?	Z/S tight/tight	chestnut	'woollen'
950	140 x 20	2/1 twill	* 13/9	0.75/2.0	102	?	Z/S v tight/v tight	mid-brown	'woollen'
951	220 x 15	2/1 twill	* 17/14	0.5/0.75	100	?	Z/S	mid-brown	'woollen'
952	140 x 40	2/1 twill	* 17/15	0.5/0.6-0.75	100	?	Z/S	mid-brown	'woollen'
953	85 x 15	twill	* 14/10	0.5-0.6/ 0.5-0.75	78		Z/S	mid-brown	'woollen'
954	55 x 45	2/1 twill	* 14/7	0.75/1.0	101	?	Zt/S very tight/?	mid-brown	errors in heddle lifting
955	160 x 8	plain tabby	* 8/5	1.0/1.5	95	?	Z/S	mid-brown	'woollen', poss. fulled
956	200 x 90	2/2 diamond twill	* 12-14/10	0.75/0.75	99	?	Z/S	mid-brown	'woollen'. poss. Seam on one edge

Table 3: Wool Textiles from 5 Coppergate - (Walton 1982) (groups as for Lloyds bank)

Catalogue No	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
Group III - 'woollen' twills, soft to feel									
643	2 frags. - 1cm^2	2/1 diamond 6-shaft	* 16/9	0.5/0.7	93	?	Z/S	mid/dark brown	unusual diamond twill
Group IV - 'woollen' twills, soft to feel									
644	25 x 25 50 x 20	non-reversed 2/2 twill	* 10/7	1.0/1.1	100	?	Z/S	mid-brown	two fragments
645	90 x 30	non-reversed 2/2 twill	* 11/7	0.8/1.4	100	?	Z/S	dark brown	
646	30 x 15	non-reversed 2/2 twill	* 9/9	1.0/1.0	99	?	Z/S	mid-brown	S2 - double thr'ds occur
647	80 x 100	2/2 diamond twill	* 12/8	0.8/1.0	99	?	Z/Z+S	mid-brown	inaccurate m'tings. S2 - irregular use of Z- & S-yarn. Z2S sewing thr'd
648	60 x 30 & 15 x 15	non-reversed 2/2 twill	* 10/9	0.8/1.0	98	?	Z/S	mid-brown	
649	25 x 20	non-reversed 2/2 twill	* 10/9	0.1/0.1	99	?	Z/S	mid-brown	
Group V - 'woollens', soft to feel									
650	20 x 20	non-reversed 2/2 twill	* 8/8	1.0/2.0	112	?	Z/S	mid-brown	
Group IX - 'worsted', hard to feel									
652	35 x 35	2/2 twill repp	* 15-20/5-8	0.6/0.9	102	?	Z/S	mid/dark brown	'worsted'. S2 - few floating thr'ds

Table 4: Wool Textiles from 16-22 Coppergate - (Walton 1989)

Catalogue No	Dimensions (mm)	Period	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
Plain Tabby									
1257	25 x 20 & 20 x 20	c850-c900	4/2-3	1.5-2.0/2.0	83	H/H	Z/S	mid-brown	warp fringe
1258	170 x 140	c850-c900	* 6/5	1.0/1.5	90	H/GM	Z/S	dark brown indigotin	loosely woven. Hem
1259	3 frags. - l'gest 140 x 90	c850-c900	* 12/8	0.5/0.9	89	H/HM	Z/S	black n.d.d. - (nat. pig.)	Z2S-, 1.8mm diam. Combed sewing thr'd
1260	22 x 10 70 x 50 45 x 30	c850-c900	12-16/6	0.8/1.0	105	M/?	Z/S	dark brown ?madder	selvedge. Wa almost covers We = repp
1261	25 x 20	c850-c900	* 15/9-10	0.4/0.6	83	?	Z/S	Fawn	calcified; prob. wool
1262	50 x 50	c850-c900	* 18-22/11	0.6/0.8	103	M/M	Z/S	dark brown n.d.d.	S1 - almost covers S2. yarn poss. combed
1295	65 x 30	c930/5-c975	* 5/4	1.0/2.0 2.0 - pile	90	H/H H - pile	Z/S S-sp.- pile	dark brown n.d.d.	pile thr'ds 90mm long, darned in
1296	200 x 100	c930/5-c975	* 3-4/3	0.8-2.0/ 1.5-3.0	87	?	S/S	grey-brown n.d.d.	
1297	65 x 60	c930/5-c975	* 4/3-4	1.5/0.8-1.5	92	M/HM	Z/S	n.d.d.	loosely woven
1298	40 x 10	c930/5-c975	* 6/4-5	1.0/1.0	78	?	Z/S	?	badly decayed, prob. tabby
1299	12 x 8	c930/5-975	* 14/8	0.4/0.7	81	?	Z/S	dark brown	
1411	75 x 45	Scan. Period	* 12/8	0.8/0.8	99	?	Z/S	gery	partially calcified
1460a	230 x 60 part of b	Scan. Period	* 5/5 pile	1.0-1.5/1.5	81	H/H H - pile	Z/S	mid-brown madder	pile loosely twisted, darned in. Pile 25-30mm deep
1460b	binding of 1460a	Scan. Period	24/16	0.4/0.4	98	?	Z/Z	dark brown	selvedge, combed wool. Z2S combed sewing thr'd
Non-reversed 2/2 Twills									
1263	180 x 150	c850-c900	11/11	0.7/1.0	102	M/M	Z/S	mid-brown n.d.d.	We gore. hem - Z2S-, 0.7mm diam. sewing thr'd
1265	5 x 5	c850-c900	* 12/10	0.6/0.5	86	?	Z/S	?	weave not clear

Catalogue No	Dimensions (mm)	Period	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
1266	15 x 10 7.5 x 5	c850-c900	* 14/12	0.6/0.7	97	?	Z/S	mid-brown n.d.d.	?part of 1268
1300	260 x 80 190 x 80	c930/5-c975	* 14/7	0.3-0.7/ 1.0-1.5	96	GM/H	Z/S	light brown n.d.d.	
1301	20 x 15	c930/5-c975	* 14/12	0.5/0.7	95	?	Z/S	red madder	?part of diamond twill 1308
1379	40 x 40	c975- ear./mid.11C	*7/5	1.0/1.8-2.0	98	?	Z/S	red madder	

2/2 Chevron twills

Catalogue No	Dimensions (mm)	Period	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
1264	210 x 150, 120 x 120, 130 x 190 & 17 x 70	c850-c900	* 9/7	0.7/1.2	94	HM/H	Z/S	mott. brown n.d.d. (nat. pig.)	
1267	60 x 20	c850-c900	* 14/10	0.6-0.8/1.0	100	?	Z/S	?	S-spin - reverses every 12 thr'ds. Part of 1268
1302	140 x 100	c900-c930/5	* 8/5-6	0.9/1.2	91	M/H	Z/S	mid-brown indigotin	
1303	140 x 60	c900-c930/5	10-11/6-7	0.7/1.1	93	H/HM	Z/S	Wa dark - (nat. pig.). We lighter - no nat. pig. n.d.d.	Wa - combed. We uncombed. Selvedge. S2Z, 1.8mm diam. Sewing thr'd
1304	110 x 35	c900-c930/5	* 10/8	0.8/0.8	93	H/HM	Z/S	dark brown n.d.d.	*Kreuzköper* twill.
1305	45 x 20	c900-c930/5	* 16/12	0.5/0.7-1.0	100	GM/HM	Z/S	light brown n.d.d.	rolled up with 1306
1306	79 x 70	c900-c930/5	18/16	0.5-0.6/ 0.5-0.6	100	HM/M	Z/S	dull red lichen purple	selvedge.

Catalogue No	Dimensions (mm)	Period	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
2/2 Diamond Twills									
1268	50 x 40	c850-c900	* 12-14/10-14	0.6-0.8/ 0.8-1.0	101	?	Z/S	mid-brown	?part of 1266-7. Z-spin - reverses every 14 thr'ds. Stitch holes
1307	70 x 35	c930/5-c975	* 11/7	0.4/1.2	91	HM/HM	Z/S	light brown n.d.d.	
1308	c40 x 30	c930/5-x975	* 14-16/ 11-13	0.4/0.7	94	M/HM	Z/S	reddish madder	
1380	75 x 25	c975- ear./mid. 11C	* 15/11	0.5/0.7	94	?	Z/S	grey-brown	calcified. ?wool
1381	30 x 25	c975- ear./mid. 11C	* 14/11	0.5/0.7	93	?	Z/S	reddish-grey madder	
1382	65 x 40	c975- ear./mid. 11C	22/12	0.3-0.4/0.5	91	H/H	Z/Z	dark brown n.d.d.	selvedge. Birka-type

ANGLO-SCANDINAVIAN VEGETABLE AND/OR CARBONISED TEXTILES FROM YORK

Table 5: Vegetable Fibre and Carbonised Textiles from Parliament Street (Walton 1986)

Catalogue No	Period	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fibre	Spin Direction	Comments
957	Scan.	45 x 10	plain tabby	* 8/4-5	0.75/1.0	78	?	Z/Z	carbonised
958	Scan.	85 x 75	crepe	* 18-20/16	0.5/0.5	99	bast	Z/Z	pattern repeat every 12 threads

Table 6: Vegetable Fibre and Carbonised Textiles from 16-22 Coppergate (Walton 1989)

Catalogue No	Period	Dimensions (mm)	Weave	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fibre	Spin Direction	Comments
1272	c850-c900	40 x 30	plain tabby	* 8-9/8	0.5-0.9/0.6	79	?	Z/Z	carbonised
1273	c850-c900	20 x 10 30 x 15 15 x 10	2/2 twill	* 9-10/7-8	0.6-0.9/ 1.0-1.2	55	?	Z/Z	carbonised
1279	c900-c930/5	190 x 165	2/2 chevron twill	* 13-14/ 13-14	0.9/0.9	95	?	Z/Z	carbonised
1317 with next 13	c930/5-c975	30 x 30	plain tabby	* 5/5	1.2/1.2	84	?	Z/S	carbonised. ?Poss. wool
1319	c930/5-c975	45 x 20 25 x 20 20 x 20	plain tabby	* 7/6	0.9/1.2	90	?	Z/Z	carbonised. Yarn rough in appearance
1320	c930/5-c975	30 x 15	plain tabby	8-10/6-8	0.6-0.9/1.2	95	?	Z/Z	carbonised. Selvedge. Sewn to 1328
1321	c930/5-c975	100 x 100	plain tabby	11/7	0.7-1.0/ 1.0-1.2	99	?	Z/Z	carbonised. Selvedge. Hem sewn with ?Z2S-, 1mm diam. thr'd
1324	c930/5-c975	30 x 30	plain tabby	* 12/11	0.7/0.7	96	?	Z/Z	carbonised
1325	c930/5-c975	60 x 55	plain tabby	13/9	0.7/0.7	97	?	Z/Z	carbonised. Selvedge
1327	c930/5-c975	110 x 50	diamond mesh + tabby borders	upper - 18/10 lower - 22/7	0.6/0.6	123 119	flax	Z/Z	carbonised. Seam & hem
1328	c930/5-c975	100 x 50	plain tabby	20-28/ 13-18	0.4/0.4	98	flax	Z/Z	carbonised. Selvedge. Sewn to 1333 & 1320 - Z2S-, 0.5mm diam.yarn
1331	c930/5-c975	30 x 20 25 x 20	non-reversed 2/1 twill	* 11/8	0.6/1.0	93	?	Z/Z	carbonised
1332	c930/5-c975	60 x 50 25 x 20 70 x 50	non-reversed 2/2 twill	* 8/8	1.0/1.0	96	flax	Z/Z	carbonised
1333	c930/5-c975	105 x 65	2/1 chevron twill	* 11-13/9-12	0.6/0.6	90	flax	Z/Z	carbonised. Sewn to 1328 & 1334

Catalogue No	Dimensions (mm)	Period	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
1334	c930/5-c975	125 x 45	2/2 chevron twill	* 10-11/7-8	0.7/1.0	93	?nettle	Z/Z	carbonised. Sewn to 1333 & 1336
1335	c930/5-c975	30 x 30 35 x 10	2/2 chevron twill	* 13-14/9-11	0.8/1.0	96	?	Z/Z	carbonised
1336	c930/5-c975	55 x 45 55 x 35	honeycomb	* 15/15	0.8/0.8	96	flax	Z/Z	carbonised. Sewn to 1334
1318	c930/5-c975	30 x 20	plain tabby	* 5/6	1.0/1.2-1.5	90	?	Z/Z	carbonised
1322	c930/5-c975	40 x 30 20 x 15	plain tabby	* 12/6	0.4-1.0/1.0	94	?	Z/Z	carbonised
1323	c930/5-c975	35 x 15	plain tabby	* 12/10-11	0.8/0.7	99	?	Z/Z	carbonised
1326	c930/5-c975	35 x 30	plain tabby	* 14/12	0.5/0.6	92	?	Z/Z	carbonised
1329	c930/5-c975	12 x 11	plain tabby	* 24/18	0.2/0.2	67	?	Z/Z	carbonised
1330	c930/5-c975	80 x 50	plain tabby	* 20/18	0.5/0.5	100	?	Z/Z	mineralised. With 1301
1363 with 1364-6	c975	not clear	plain tabby	* 5/5	1.0/1.0	75	?	Z/Z	carbonised. Weave loose & open.
1364	c975	7.5 x 5	?plain tabby	* 8/7	0.8/0.8	84	?	Z/Z	carbonised
1365	c975	20 x 20	plain tabby	* 8/6	0.7/0.8	77	?	Z/Z	carbonised
1366	c975	not clear	plain tabby	* 14/7	0.7/0.8	99	?	Z/Z	carbonised.
1367	c975	30 x 15	plain tabby	*14/16	0.4/0.3-0.5	81	?	Z/Z	carbonised
1368	c975	20 x 15	plain tabby	* 16/16	0.3-0.6/0.5	94	?	Z/Z	carbonised
1369	c975	10 x 10	plain tabby	* 14/12	0.5/0.7	95	?flax	Z/Z	grey
1388	c975-ear./mid. 11C	45 x 10	plain tabby	*24/20	0.3-0.5/0.4	99	flax	Z/Z	greyish-white
1389 with 1402	c975-ear./mid. 11C	15 x 10	plain tabby	* 13/11	0.7/0.7	98	?flax	Z/Z	grey-brown
1402	c975-ear./mid. 11C	2x<5 x5	plain tabby	* 13/11	0.7/0.7	98	?	Z/Z	calcified. Grey. Similar to 1389
1390 same context as 1391 & 1396	c975-ear./mid. 11C	160 x 90	plain tabby	22-26/18-20	0.3-0.4/0.4	96	flax	Z/Z	carbonised. Selvedge. Seam - Z2S-, 0.4mm diam. thr'd. ?part of child's shirt.
1391 found with 1396 & 1401	c975-ear./mid. 11C	60 x 35	plain tabby	* 10/6	0.8/0.8-1.3	93	?	Z/Z	carbonised

Catalogue No	Dimensions (mm)	Period	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Fleece-type	Spin Direction	Colour/Dye	Comments
1396	c975-ear./mid. 11C	100 x 60	plain tabby	16/14	0.2-0.3/ 0.3-0.4	69	?	Z/Z	carbonised. Selvedge
1401	c975-ear./mid. 11C	80 x 60	plain tabby	* 22 20	0.4/0.4	98	?	Z/Z	carbonised. Seams - Z2S-, 0.6mm diam. thr'd. Similar to 1390
1392 with 1399/1400	c975-ear./mid. 11C	25 x 20	plain tabby	* 10/8	0.8-1.0/ 0.8-1.2	98	?	Z/Z	carbonised
1399	c975-ear./mid. 11C	not clear	plain tabby	* 20/20	0.4/0.3	92	?	Z/Z	carbonised. Interfolded with 1400
1400	c975 ear./mid. 11C	140 x 60	plain tabby	* 26-30/ 26-28	0.2/0.2	80	?	Z/Z	carbonised. Interfolded with 1399
1393	c975-ear./mid. 11C	60 x 40	plain tabby	* 17/10-16	0.4/0.4	85	?	Z/Z	carbonised
1394 with 1395	c975-ear./mid. 11C	30 x 20	plain tabby	* 14/8	0.4/0.6	77	?	Z/Z	carbonised. Interfolded with 1395
1395	c975-ear./mid. 11C	100 x 70	plain tabby	* 20/16	0.4/0.4	93	?	Z/Z	carbonised. Seams - Z2S-, 0.6mm diam thr'd
1397 with 1403	c975-ear./mid. 11C	100 x 90	plain tabby	8/5	0.8-1.2/1.0	90	?	Z/Z	carbonised. Selvedge
1403	c975-ear./mid. 11C	40 x 25	non-reversed 2/2 twill	* 8/8	0.8-1.2/0.9	94	?	Z/Z	carbonised
1398	c975-ear./mid. 11C	40 x 15	plain tabby	* 20/15	0.5/0.5	100	?	Z/Z	carbonised. Seam - Z2S-, 0.5mm diam. thr'd
1404	c975-ear./mid 11C	30 x 15	2/2 diamond twill	* 15-18/13	0.5/0.5	94	?	Z/Z	carbonised.
1462	Scan. Period	50 x 20	2/2 twill	* 9/7-8	0.8/1.0	93	?	Z/Z	carbonised. Sewn pleats - Z-sp., 1.5mm diam. thr'd

Table 7: Silk Textiles from Lloyds Bank, 5 and 16-22 Coppergate, and Lincoln (Hedges 1982; Walton 1982 & 1989; Muthesius 1982)

Catalogue No	Site/Group	Period	Dimensions (mm)	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Spin Direction	Colour/Dye	Comments
594	Lloyds Bank Group VIII	Scan. Period	1.63m x 15mm	70/12	0.15/0.2	103	Z/Z	light brown	tied in simple knot. Selvedge
651	5 Coppergate Group VIII	Scan. Period	160 x 260	21/20	0.1/0.4	84	Z/-	golden	selvedge. Mend with Z-spun thr'd. head-dress
1281	16-22 Coppergate	c900-c930/5	90 x 15	* 20/20-40	0.1/0.3-0.4	104	Z/I	mid-brown madder	
1282	16-22 Coppergate	c900-c930/5	40 x 20 x 30 x 20	20-26/24-30	0.2/0.3-0.5	104	Z/I	gold-brown n.d.d.	8mm wide selvedge, 26 paired warps
1341	16-22 Coppergate	930/5-c975	25 x 8	*18-24/20	0.1-0.2/ 0.3-0.4	78	Z/I	gold-brown not tested	
1342	16-22 Coppergate	930/5-c975	145 x 30	* 18/23	0.1/0.4	93	Z/I	dark brown ?kermes	hem - I-spun, 0.7mm diam. silk sewing thr'd
1343	16-22 Coppergate	c930/5-c975	165 x 25	20-22/22	0.1/0.3-0.4	75	Z/I	gold-brown indigotin	12mm wide selvedge, 41 paired warps. Hem - S-spun, 0.5mm diam. thr'd
1344	16-22 Coppergate	c930/5-c975	8 x 10	* 20/24	0.1/0.4	97	Z/I	light brown lichen purple	
1345	16-22 Coppergate	c930/5-c975	165 x 95	* 24/20	0.15/0.25	68	Z/I	light brown madder	hem - Z-spun, 0.1-0.2mm diam. thr'd. ?Part of cap
1346	16-22 Coppergate	c930/5-c975	c25 x 30	* 24-28/14	0.1/0.1	36	Z/Z	mid-brown n d d	loosely woven
1347	16-22 Coppergate	c930/5-c975	120 x 50	24/34	0.2/0.4	119	Z/I	brown indigotin	16mm wide selvedge, paired warps - 17/1/21
1348	16-22 Coppergate	c930/5-c975	30 x 15	* 30-40/ 16-20	0.1/0.1-0.2	47	Z/Z	mid-brown not tested	loosely woven.
1349	16-22 Coppergate	c930/5-c975	400 x 145	28/20	0.1/0.1	42	Z/Z	red-brown madder + lichen purple	9mm wide selvedge, 39 paired warps. Hems. ?Child's head -dress

Catalogue No	Site/Group	Period	Dimensions (mm)	Thr'd Count (per cm)	Thread Diam (mm)	Cover Factor	Spin Direction	Colour/Dye	Comments
1350	16-22 Coppergate	c930/5-c975	30 x 5	* 24-32/14	0.1/0.5	78	Z/I	red madder	seam.With 1351
1351a b	16-22 Coppergate	c930/5-c975	35 x 12 with b	*40-48/14 *40/28	0.1/0.3 0.1/0.1	68 57	I/I Z/Z	not tested	sewn together - I-spin, 0.5mm diam. thr'd
1352	16-22 Coppergate	c930/5-c975	4 strips - 270x5,260x510 5x5,120x5	60 pairs/ 10 singles	0.2/0.2	112	Z/Z	red-brown madder + lichen purple	selvedge
1353	16-22 Coppergate	c930/5-c975	17 x 16	56/26	0.3/0.2	133	S/S	light brown not tested	ribbon - c86 warps wide. Selvedges.
1354	16-22 Coppergate	c930/5-c975	20 x 4	56/20	0.15/0.15	89	S/S	not tested	ribbon - 106 warps wide. Selvedges
1355	16-22 Coppergate	c930/5-c975	135 x 19	48-52/30-36	?	-	S/S	mid-brown kermes	ribbon - c90 warps wide. Sewing
1371	16-22 Coppergate	c975	100 x 25	* 16/34-60	0.2/0.2-0.3	112	Z/Z	mid-brown ?madder	loose, open weave
1372	16-22 Coppergate	c975	590 x 180	24-25/19-20	0.1-0.3/0.35	84	Z/I	gold-brown not tested	head-dress. selvedge - 11mm wide, ?40 paired warps. seams - S-spun, 0.4mm diam. thr'd
1407	16-22 Coppergate	c975- ear./mid. 11C	225 x 33	42-50/32	0.2-0.3/0.2	105	S/S	red-brown madder	ribbon. Selvedges. Thr'd in fold - see below
1408a	16-22 Coppergate	c975- ear./mid. 11C	33 x 30	18-20+16-17 (50-4)/ 40+40 (80)	?	-	Z/I	kermes + ?	reliquary - outer pouch. Sewn - I-spin, 0.5 mm diam. thr'd. cross emb.
1408b	16-22 Coppergate	c975- ear./mid. 11C	24 x 20	40/60 & 20(40)/52	?	-	S/I	not tested	reliquary - inner pouch. Sewn - S-spin, 0.5-0.7 & 0.4mm diam. thr'd
?	Lincoln	L 9/E 10 C	c 0.51m L x c 0.165m W	22/20-24	?	-	Z/I	gold-yellow	very like 651. ?From same cloth. head-dress

ANGLO-SCANDINAVIAN CORD AND YARN FROM YORK

Table 8: Cord and Yarn from Lloyds Bank and 16-22 Coppergate (Hedges 1982; Walton 1989)

Catalogue No	Site	Period	Cord/Yarn & Length (mm)	Fibre	Diameter	Spin/Ply Direction	Colur/Dye	Comment
595	Lloyds Bank	Scan.	yarn - 0.13	wool	3.0-11.0	S	light brown	very coarse
596	Lloyds Bank	Scan.	yarn - 0.14 x 2	wool	c7.0	S2Z	light brown	
597	Lloyds Bank	Scan.	cord - 0.11	wool	c7.0	Z3S	mid-brown	
598	Lloyds Bank	Scan.	cord - 0.13	wool	c4.0	Z2S	black	
599	Lloyds Bank	Scan.	cord - 0.13	wool	c3.5	Z3S	mid-brown	
600	Lloyds Bank	Scan.	cord - 0.13	wool	c3.0	Z2S	mid-brown	
601	Lloyds Bank	Scan.	yarn - 0.39	wool	2.0-7.0	S	mid-brown	very coarse. ?Poss. from textile
602	Lloyds Bank	Scan.	cord - 0.16	wool	c5.0	Z3S	mid-brown	?unwound
603	Lloyds Bank	Scan.	cord - 0.13	wool	c3.5	Z4S	light brown	
667a	Lloyds Bank	Scan.	cord - 0.19	wool	3.0	Z2S	mid-brown	with yarn 667b
667b	Lloyds Bank	Scan.	yarn - 240 & 130	wool	0.3-0.4	Z	mid-brown	soft 'woollen'. With cord 667a
668	Lloyds Bank	Scan.	yarn - short l'gths, max 80	wool S - HM/ Z - HM	1.4-<	S & Z	light brown nat. pig.	
675	Lloyds Bank	Scan.	thr'd - 100& 45	wool	1.0	S	grey	loosely spun
676	Lloyds Bank	Scan.	yarn - 145	wool	1.5	S	mid-brown	'woollen'
677	Lloyds Bank	Scan.	yarn - 40	wool	1.0	Z	mid-brown	'woollen'
678	Lloyds Bank	Scan.	yarn - x2 = 90	wool	1.0	Z	dark brown	'woollen'. Knotted together
1269	16-22 Coppergate	c850-c900	cord - 40	wool	0.8	Z2S	dark brown	combed wool
1270	16-22 Coppergate	c850-c900	thread - 0.14	wool H	1.2	S2Z	madder	
1274	16-22 Coppergate	c900-c950/5	cord - 0.28	wool HM	3.0-4.0	Z14 = (6Z+8Z)S	nat pig n.d.d.	tightly plied
1275	16-22 Coppergate	c900-c930/5	cord - 0.26	wool GM	ave. 4	Z4S	mid-brown n.d.d.	4-ply divided into 2 x 2ply at end with knot

Catalogue No	Site	Period	Cord/Yarn & Length (mm)	Fibre	Diameter	Spin/Ply Direction	Colur/Dye	Comment
1276	16-22 Coppergate	c900-c930/5	cord - 0.23 & 0.16	wool TM	3.0	Z2S	mid-brown	loosely twisted
1310	16-22 Coppergate	c930/5-c975	strand - 95	wool	2.0	S	?	
1311	16-22 Coppergate	c930/5-c975	strand - 15	wool	2.0	Z	?	
1312	16-22 Coppergate	c930/5-c975	cabled cord - 175	wool HM	5.0	S2Z8S	dark brown madder	
1313	16-22 Coppergate	c930/5-c975	thread - 230	wool HM	0.4-0.6	S2Z	mid-brown yellow x	fluffy yarn. With 1285
1314	16-22 Coppergate	c930/5-c975	yarn - 100	wool	1.0	Z2S	?	?combed wool
1315	16-22 Coppergate	c930/5-c975	yarn - 105	wool GM	1.5	S2Z	dark brown madder	?combed wool. Several lengths knotted together
1383	16-22 Coppergate	c975-ear./mid. 11C	cabled cord - 125	wool HM	4.0	Z6S2Z	nat. pig.	
1384	16-22 Coppergate	c975-ear./mid. 11C	cabled cord - 180	wool HM	4.0	Z2S12Z	mid-brown	?combed wool
1385	16-22 Coppergate	c975-ear./mid. 11C	thread - 165	wool	0.9	Z2S	?	combed wool
1461	16-22 Coppergate	Scan.	cord - 260	wool GM	7.5	S11Z	mid-brown madder	
1280	16-22 Coppergate	c900-c930/5	yarn - 25	silk	2.0	S	golden pink	loosely twisted
1357	16-22 Coppergate	c930/5-c975	thread - 50	silk	0.3-0.4	S3Z	pinkish fawn	
1358	16-22 Coppergate	c930/5-c975	threads - tangled	silk	0.1	Z	red-brown	tight twist
1407a	16-22 Coppergate	c975/ ear./mid. 11C	thread - 45	silk	0.3	Z2S	purple-red lichen purple	
1407b	16-22 Coppergate	c975/ ear./mid. 11C	thread - 140	silk	?	S	dark red/brown lichen purple	

Catalogue No	Site	Period	Cord/Yarn & Length (mm)	Fibre	Diameter	Spin/Ply Direction	Colur/Dye	Comment
1407c	16-22 Coppergate	c975/ ear./mid. 11C	thread - 75	silk	?	S	dark red/brown lichen purple	
1409	16-22 Coppergate	c975- ear./mid. 11C	thread - 30	silk	0.2	Z	yellow dye	
1410	16-22 Coppergate	c975- ear./mid. 11C	yarn - short lengths	gold	0.20-0.25	-	-	
1337	16-22 Coppergate	c930/5-c975	cord - 65	veg.	8.0	?S2Z	?	
1338	16-22 Coppergate	c930/5-c975	cord - 5 x 40	?bast	5.0	I5S	?	
1339	16-22 Coppergate	c930/5-c975	cord/binding - 45	?bast	9.0	S?Z	?	
1370	16-22 Coppergate	c975	cord - 90	veg	6.0	S2Z	?	
1405	16-22 Coppergate	c975- ear./mid. 11C	cord - 100	?bast	5.0	S2Z	?	
1406	16-22 Coppergate	c975 ear./mid. 11C	cord - 180	bast	5.0	S-ply	?	

ANGLO-SCANDINAVIAN RAW WOOL STAPLES FROM YORK

Table 9: Raw Wool Staples from 16-22 Coppergate (Ryder 1989)

Catalogue No	Period	Staple Length (mm)	Fleece-type (appearance)	Fleece-type (measured)	Colur/Dye	Appearance
1254	c850-c900	25	H	too decayed	?	hairy lamb. Thin staple, no crimp. Range 25-65μm
1255	c850-c900	25	H	H*	light brown	hairy lamb. straight & coarse, no crimp. fibre roots present

Catalogue No	Period	Staple Length (mm)	Fleece-type (appearance)	Fleece-type (measured)	Colur/Dye	Appearance
1256	c850-c900	6g	?	?	dark brown madder	matted fibres
1283	c950/5-c975	8	-	M	red madder	three staples. Probably not full length
1284	c930/5-c975	50	HM	HM	nat. pig.	several staples each 50mm. Straightish, not too hairy
1285	c930/5-c975	50-60 7.2gs	H	H	mid-brown	matted fibres, some in separate staples. Tapering, wavy but hairy. With 1314
1286	c930/5-c975	20-50 1.4g	HM	H*	light brown	matted fibres, intact staples. Fibre roots present. Like hairy Soay, less hairy than 1291a
1287	c930/5-c975	50	H/HM	H	dark brown nat. pig.	like 1286 but less hairy
1288	c930/5-975	20 0.2g	H/HM	H	light brown na.t pig.	matted fibres, no clear staple or crimp
1289	c930/5-c975	100	HM/M	HM	nat. pig.	tapering staple, shallow wave. Individual fibres hairy
1290	c930/5-c975	20-40 6.5g	HM	HM	light brown	matted fibres, some intact staples
1291a	c930/5-c975	90-130	H	H	light brown nat. pig.	straight hairy lamb. Several staples
1291b	c930/5-c975	20-50	M	H	light brown nat. pig.	adult, shallow wave
1292	c930/5-c975	30-40	GM/M	HM	mid-brown nat. pig.	?lamb, shallow wave
1293a	c930/5-c975	90 x 90	H/HM	H	light brown nat. pig.	straight hairy lamb. Matted pad with 1293b
1293b	c930/5-c975	90 x 90	Sh	GM	light brown nat. pig.	?lamb, medium crimp of Sh. (but consistent with GM)
1294a	c930/5-c975	90-100 0.8g	M	GM	lght brown	typical tapering and wavy staple of medium wool. With 1294b
1294b	c930/5-c975	30-40 0.8g	HM	HM	light brown	with 1294a

Catalogue No	Period	Staple Length (mm)	Fleece-type (appearance)	Fleece-type (measured)	Colur/Dye	Appearance
1361	c975	35-40	H	H	black-stained	straight hairy lamb
1362	c975	15 x 3	Sh/F	F	ginger	lamb, curly like Sh (fine) wool. One carbinsed
1373	c975- ear./mid. 11C	c90	H	H*	mid-brown nat. pig.	straight & hairy, few fine fibres. Fibre roots present
1374	c975- ear./mid. 11C	90	H/HM	H*	?	?8-week lamb. Fibre tips and roots present
1375	c975- ear./mid. 11C	80-130	M	HM	nat. pig.	3-month lamb with curl, like modern longwool (Wensleydale)
1376	c975- ear./mid. 11C	c70	GM	HM*	mid-brown nat. pig.	tapering staple, shallow weave. Fibre roots present
1377	c975- ear./mid. 11C	30	HM	GM*	?	2-3-week lamb, halo hairs projecting beyond bulk of coat (prob. finer @ base = GM). Roots present
1378	c975- ear./mid. 11C	50	M	decayed	dark brown	adult, shallow weave of medium wool.

ANGLO-SCANDINAVIAN SEWING YARNS USED FOR SEAMS AND HEMS OF TEXTILES

Table 10: Sewing Yarns from 16-22 Coppergate (Walton 1989)

Catalogue No	Fibre	Spin/Ply Direction	Diameter (mm)	comments
1259	wool	Z2S	1.8	combed wool
1263	wool	Z2S	0.7	combed wool
1303	wool	Z2S	1.8	combed wool
1309	wool	Z2S	1.5	
1321	carbonised	?Z2S	0.5	
1328	carbonised	Z2S	0.5	
1390	carbonised	Z2S	0.4	

Catalogue No	Fibre	Spin/Ply Direction	Diameter (mm)	comments
1395	carbonised	Z2S	0.6	
1398	carbonised	?Z2S	0.5	
1401	carbonised	Z2S	0.6	
1342	silk	I	0.7	
1343	silk	S	0.5	
1345	silk	Z	0.1-0.2	used double
1349	silk	S	0.5	brown
1349	silk	Z	0.4	red
1349	silk	Z	0.4	brown
1351	silk	I	0.5	
1355	silk	S	0.5	?dyed with kermes
1355	silk	S	0.4-0.5	?dyed with madder
1372	silk	S	0.4	head-dress
1408a	silk	I	0.5	reliquary
1408b	silk	S	0.5-0.7	
1408b	silk	S	0.4	

ANGLO-SCANDINAVIAN MISCELLANEOUS TEXTILES, CORDS AND FIBRES FROM YORK

Table 11: Miscellaneous Items from 16-22 Coppergate (Walton 1989)

Catalogue No	Period	Textile/Cord /Fibre	Dimensions (mm)	Weave	Thr'd Count (per cm)	Fibre	Spin/Diam. (mm)	Colour/Dye	Comments
1340	c930/5-c975	tablet-woven braid	1.47m x 5mm	plain	four-holed tablets	silk & linen - 3/1 in warp	8 loosely 3-plied S- & Z-	madder & m'der/indigotin	tied together at one end with two knots
1359	c930/5-c975	textile	3 x 2	?plain tabby	16/?14	?	Z/S - 0.4/0.5	?	found inside fold of 1355
1360	c930/5-c975	textile	110 x 50 80 x 60	plain tabby	16/14	?	Z/Z - 0.4-0.5/0.6	yellow-brown	textiles in layers in two soil blocks

Catalogue No	Period	Textile/Cord /Fibre	Dimensions (mm)	Weave	Thr'd Count (per cm)	Fibre	Spin/Diam. (mm)	Colour/Dye	Comments
1459	Scan.	textile cast	5 x 5	plain tabby	12/12	?	Z/Z - 0.5/0.5	?	mineralised on weaver's sword beater
1309	c930-/-c975	sock	260 heel to toe 270 widest part 325 round ankle	nålebinding	N/A	wool	S2Z	narrow ankle band - madder	near complete example

APPENDIX 2

TABULATED SYNOPSIS OF THE SCANDINAVIAN PERIOD TEXTILE EVIDENCE FROM SCOTLAND AND THE ISLE OF MAN

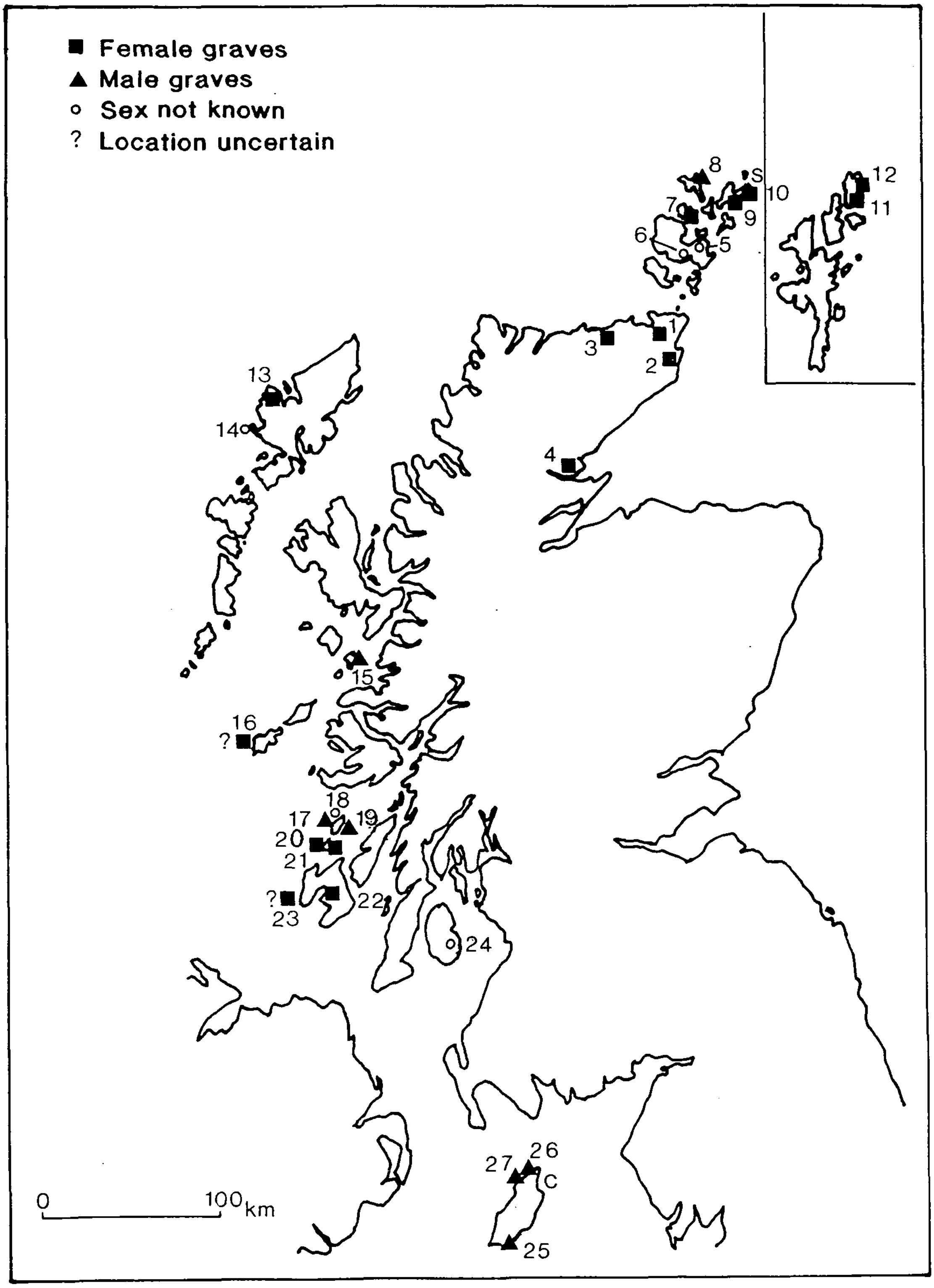
APPENDIX 2

TABULATED SYNOPSIS OF THE SCANDINAVIAN PERIOD TEXTILE EVIDENCE FROM SCOTLAND AND THE ISLE OF MAN

The textile evidence from Scotland and the Isle of Man has been collated and catalogued in unpublished form by the author (Henry 1992). This renders a detailed catalogue here unnecessary. The textile evidence from two additional grave finds, from Scar, Sanday, Orkney and Claghbane, Ramsey, Isle of Man, is included in this synopsis. The remaining entries retain the same numerical order as the detailed catalogue cited above to allow for future research as required (map 1). Scar and Claghbane are represented on the map as: S = Scar and C = Claghbane. Any comments essential to a greater understanding of the evidence presented below are added where it is thought necessary.

The legend applied to the following tables is detailed below for clarity and ease of use.

*	-	before thread count = direction of warp and weft not known.
nat. pig.	-	natural pigment
H	-	hairy fleece-type
HM	-	hairy medium fleece-type
GM	-	generalised medium fleece-type
TM	-	true medium fleece-type



Map 1. Distribution of Norse textiles from Scandinavian period Scotland.
Numbers correspond with those in tables.

TABULATED SYNOPSIS OF SCANDINAVIAN PERIOD TEXTILE EVIDENCE FROM SCOTLAND AND THE ISLE OF MAN

Table 1: Scandinavian Period Textiles from Scotland (Henry 1992)

Catalogue No	Location	Date Found/Exc.	Dimensions (cm)	Weave	ThreadCount (per cm)	Yarn Type	Spin Direction	Colour/ Dye	Comments
1. IL 221	Castletown, Caithness	1786	?	plain tabby	* 13/12	?wool	?	?	imprint on back side of oval brooch. Single find. 10C. Female
2. IL 217	Longhills,Wick Caithness	1940	frag.	plain tabby	?	?wool	Z/Z	?	oval brooch with textile remains round pin fastener = loops of pinafore skirt. 10C. Female
3. IL 334	Reay, Caithness	1913	frag.	?	?	?wool	Z/?	?	remains round pin of oval brooch. 10C. Female
IL 335:1	Reay, Caithness	1913	frag.	?plain tabby	?	?wool	Z/Z	?	imprint on back side of oval brooch. 10C. Female
IL 335:2	Reay, Caithness	1913	frag.	plain tabby	? (high count)	?wool	?	?	imprint on back side of oval brooch. 10C. Female
4. IL 377	Opsidale, Dornoch, Suth.	c1840	?	plain tabby	?	?	?	?	imprint on back side of oval brooch. 10C. Female
5. NA 3 (hood)	St Andrews Parish, Orkney	1867	40L x 42.5W 93.75 Should.	2/2 herringbone	8-10/9-10: 10 - double 18/20 - single	wool HM/HM nat.pig.	Z/Z Wa - thick We - fine	warm brown	hood with fringe: parallels in Denmark. Tablet-woven band with fringe attached
(tablet-woven band)	"	"	upper - 2 x 93.75	2 & 4 hole tablets	Wa - 23 th'ds 4 sheds per cm	wool HM/HM nat.pig.	Z&S/S	brown - shades vary	Wa - 1 & 2 ply. We - 2 ply. threads of various fineness (lower band the same)
"	"	"	lower - 7 x 170	2 & 4 hole tablets	Wa - 150 thr'ds 4 sheds per cm	wool HM/HM nat.pig.	S/S - both ply	light brown	parallel to lower band and fringe of same date in Belfast Museum: found Co. Antrim - 1893
(fringe)	"	"	30 - part of lower band	cabled - 2/2 ply	N/A	wool HM/HM nat.pig.	S-2 ply	light brown	fringe continuation of We of lower band. Hood dated to Scan. period based on Scan. parallels

Catalogue No	Location	Date Found/Exc.	Dimensions (cm)	Weave	ThreadCount (per cm)	Yarn Type	Spin Direction	Colour/ Dye	Comments
6. NA 307a	Greenigoe, Orphir, Orkney	1889	7.5 x 11	2/2 twill Veka-type	* 12/6	wool H/H nat.pig.	Z/Z	rich dark brown	silky sheen. 9/10C
NA 307b	Greenigoe, Orphir, Orkney	1889	frag.	plain tabby	* 12/6	wool GM/GM nat.pig.	Z/Z	rich dark brown	silky sheen. Spin & weave uneven. Sewn to 'a'. 9/10C
NA 307c	Greenigoe, Orphir, Orkney	1889	11.5 x 6	2/2 twill Veka-type	* 10/6	wool GM/H nat.pig.	Z/Z	rich dark brown	silky sheen. 2 pieces: S2 - thicker & softer spin. Loose weave. Parallel @ Birka. 9/10C
NA 307d	Greenigoe, Orphir, Orkney	1889	frag.	2/2 twill Veka-type	* 12/12	wool GM/H nat.pig.	Z/Z	rich dark brown	silky sheen. Sewn to 'c'. Yarns fine, close weave. Spin & weave regular. 9/10C
NA 307e	Greenigoe, Orphir, Orkney	1889	12.5 x 7.5	2/2 diamond twill: Birka-type	* 18/12	wool H/GM nat.pig.	Z/Z	rich dark brown	silky sheen. loose weave. Parallel at Birka. 9/10C. (all Greenigoe textiles dated on this sample & beads from cist grave)
7. IL 729a	Westness, Orkney	1978	2.5 x 2	plain tabby	* 15/25	?wool	Z/Z	?	remains on pin fragment of oval brooch: loop of pinafore skirt. 9C. Female
IL 729b/c	Westness, Orkney	1978	frag.	plain tabby	* 23/25-30	?wool	Z/S4Z	?	remains on pin fragment of oval brooch: loop of pinafore skirt. 9C. Female
IL 735:1	Westness, Orkney	1978	4.5 x 1.5	plain tabby	* 20/12	?	Z/?	?	very faint corroded remains on Fe comb. 9C. Female
IL 735:2	Westness, Orkney	1978	2.5 x 1.5	plain tabby	* 10/7	?	Z/Z	?	very worn down corroded remains on Fe comb. Wool comb in grave. 9C. Female
8. IL 197	Piorowell, Orkney	1839	frag.	plain tabby	* 13.8	?linen	?	?	fine imprint on back side of oval brooch. 9C. ?Male
9. IL 347:1	Broch of Laminess, Ork.	PSAS 1914-15	frag.	?	?	?	Z/?	?	under pin of oval brooch. Close weave. 10C. Female
IL 347:2	Broch of Laminess, Ork.	PSAS 1914-15	frag.	?plain tabby	* 10/?	?	?	?	imprint around pin of oval brooch. 10C. Female
10. IL 343:1	Sanday, Orkney	1914	?	?plain tabby	?	?	Z/?	?	remains around pin of oval brooch. 9C. Female
IL 343:2	Sanday, Orkney	1914	?	tabby or twill	?	?	?	?	imprint on back side of oval brooch. close weave. 9C. Female

Catalogue No	Location	Date Found/Exc.	Dimensions (cm)	Weave	ThreadCount (per cm)	Yarn Type	Spin Direction	Colour/ Dye	Comments
11. IL 222:1	Clibberswick, Shetland	1861	.5 x .5	plain tabby	* 20/14	?wool	Z/Z	?	remains around pin of oval brooch. 9C. Female
IL 223	Clibberswick, Shetland	1861	?	sprang or plaiting	N/A	?wool	?	?	imprint on back side of oval brooch. 9C. Female
IL 224	Clibberswick, Shetland	1861	?	plain tabby	?	?	?	?	imprint on back side of oval brooch. 9C. Female
12. IL 313	Unst, Shetland	1861	?	plain tabby	* 13/14	?linen	?	?	imprint on back side of oval brooch. close, regular weave. 9C. Female
13. IL 799	Kneep, Uig, Lewis	1979	1.1 x 1.1	tabby-repp	* 19/11	?	Z/Z	?	fragment on top of brooch 1. L10/E11C. Female
IL 799	Kneep, Uig, Lewis	1979	4.5 x 3.5	plain tabby	* 16/10	?	Z/Z	?	remains on pin of oval brooch 1. L10/E11C. Female
(3)	Kneep, Uig, Lewis	1979	c2 x 1	?	* 18/?	?	Z/Z	?	remains on pin of oval brooch 1. L10/E11C. female
(4)	Kneep, Uig, Lewis	1979	frag.	plain tabby	* 12-13/20	?	Z/Z	?	remains on pin of brooch 2. L10/E11C. female
(5)	Kneep, Uig, Lewis	1979	frag.	plain tabby	* 14/10	?	Z/Z	?	remains on pin of brooch 2. L10/E11C. female
(6)	Kneep, Uig, Lewis	1979	2 x 1.5	plain tabby	* 10/11	?linen	Z/Z	?	remains on top of brooch 2. L10/E11C. Female
IL 856	Kneep, Uig, Lewis	1979	3 x 2	plain tabby	* 28/16	linen	Z/Z	?	remains on top of brooch 2. L10/E11C. female
IL 853	Kneep, Uig, Lewis	1979	?	diamond twill: Birka-type	32/16	?wool	Z/Z	?	impression on bronze buckle. 20:10 pattern unit to twill. L10/E11C. Female. (date based on ring-headed pin)
14. IL 750	Chaipaval, Harris	PSAS pre-1967	4.3 x 3.6	2/2 herringbone	* 27/20	?wool	?	?	imprint on fragment of back side of oval brooch. 9C. Female
15. IL 164a	Kildonan, Eigg	1875	10 x 6.5	2/2 twill Veka-type	* 13/9	wool HM/HM nat.pig.	Z/Z	warm brown	S1 - tight, fine spin. S2 - soft, thick spin. yarn varies in thickness. 2nd half 9C. Male

Catalogue No	Location	Date Found/Exc.	Dimensions (cm)	Weave	ThreadCount (per cm)	Yarn Type	Spin Direction	Colour/ Dye	Comments
IL 164b	Kildonan, Eigg	1875	7 x 4	plain tabby pile	* 7/3.5	wool HM -nat.pig. pile - TM	Z/S	warm brown	S1 - fine with coarse thr'ds. S2 - thick, soft spin. Tufts slight 'S-' twist. 2nd half 9C. Male
IL 164c	Kildonan, Eigg	1875	frag.	? pile	?	wool GM -nat.pig.	?	?	?matted remains of thick piled fabric. 2nd half 9C. Male
IL 164d:1	Kildonan, Eigg	1875	3.8 x 1.5	tabby x 2 2/2 twillx2	* 26/28 14/10 Veka-t'pe	linen wool	Z/Z tight/soft	?	2 layers tabby & 2 layers twill matted together. 2nd half 9C. Male
IL 164d:2	Kildonan, Eigg	1875	3 x 1.5	tabby x 2 2/2 twillx2	* 26/28 14-16/8 Veka-t'	linen wool	Z/Z tight/soft	?	same as d1. 2nd half of 9C. Male
IL 164d:3	Kildonan, Eigg	1875	2.5 x 2	tabby x 1 2/2 twillx2	* 26/28 14-16/8 Veka-t'	linen wool	Z/Z	?	one layer of tabby & 2 layers of twill. Same as d1 & d2. 2nd half 9C. Male
IL 164d:4	Kildonan, Eigg	1875	2 x 1.2	tabby 2/2 twill	32/16 14-16/8 Veka-t	linen wool	Z/Z	?	linen finer than d1-3, more even spin. Self band on one side, 2 rows paired. 2nd half 9C. Male
16. IL 219a	Tiree, Argyll	1872	1.5 x 1.5	plain tabby	* 26/16	linen	Z/Z	?	remains on edge of oval brooch. 10C. Female
IL 219b	Tiree, Argyll	1872	1 x .5	plain tabby	* 26/16	linen	Z/Z	?	remains on edge of oval brooch. 10C. Female
IL 219c	Tiree, Argyll	1872	frag.	plain tabby	* 16/(24)	linen	Z/Z	?	remains around pin of oval brooch - loop of pinafore skirt. 10C. Female
IL 219d	Tiree, Argyll	1872	frag.	plain tabby	close weave	?wool	?	?	imprint on back side of oval brooch. 10C. Female
17. IL 762	Kiloran Bay, Colonsay	1882	10 x 8	plain tabby	* 9/7	?hemp	Z/Z	?	very loose weave, coarse cloth on conical shield boss. Scan. period. Male
L 1924:6a	Kiloran bay, Colonsay	1882	frag.	plain tabby	* 9/11	?	Z/Z	?	loose weave. Corroded remains on shield boss. Scan. period. Male
L 1924"6b	Kiloran bay, Colonsay	1882	frag.	plain tabby	* 14/7	?	Z/Z	?	uneven weave. Corroded remains on shield boss fragments. Scan. period. Male
18. HR 1571	Machrins, Colonsay	1977	8.5 x 7mm	plain tabby x 2	* 14/14	?linen	Z/Z	dark brown	preserved by oxidisation. Paler sewing yarn on one side. ?Scan. period. c800. ?Female
19. IL 322a	Colonsay, Argyll	?	1 x .8	plain tabby	* 16/6	?	Z/Z	?	remains on socket from spear head. Scan. period. Male
IL 322b	Colonsay Argyll	?	frags.	?	?	?	?	?	impression on fragments of Fe ?pot. Heavily oxidised. Scan. period. Male

Catalogue No	Location	Date Found/Exc.	Dimensions (cm)	Weave	ThreadCount (per cm)	Yarn Type	Spin Direction	Colour/ Dye	Comments
20. FC 183	Carn a Bharraich, Oron	1891	4 x 1.5	plain tabby	* 16/9	?wool	Z/Z	?	fragment of loop of pinafore skirt - ?from brooch. Scan. period. female
FC 185	Carn a Bharraich, Oron	1891	1cm diam.	circular cord	N/A	?linen	?	?	under pin of broken point of brooch - Fe oxide preservation. Scan. period. Female
FC 186	Carn a Bharraich, Oron	1891	frag.	?	?	?	?	?	under hinge end of pin of oval brooch - cloth in which brooch was fastened. Scan period. Female
21. IL 329:1	Carn a Bharraich, Oron	1913	frag.	plain tabby	* 15/11	?wool	ZS(ply)/S	?	remains around pin of oval brooch. L9/E10C Female
IL 329:2	Carn a Bharraich, Oron	1913	frag.	plain tabby	* 14/?	?	Z/Z	?	remains around pin of oval brooch. L9/E10C. Female
IL 330	Carn a Bharraich, Oron	1913	frag.	plain tabby	* 23/14	?wool	ZS(ply)/Z	?	remains around pin of oval brooch - loops of pinafore skirt. L9/E10C. Female
22. IL 138	Ballinaby, Islay	1878	imprint	plain tabby	?	?linen	?	?	imprint on back side of oval brooch. Glass linen smoother in grave. Scan. period. Female
23. IL 215	Islay, Argyll	1788	frag.	plain tabby	* 14/24	?linen	?	?	imprint on back side of oval brooch. 10C. Female
24. IL 356	Kingcross Point, Arran	?	4.5 x 2	plain tabby	* 15/10	?	Z/Z	?	remains on Fe fragment of box mounting. Scan. period

Additional Scandinavian Period Textiles from Scotland: (Report Forthcoming - Gabra-Sanders).
The textile evidence from Scar is in mineralised form. The table briefly summarises the technical details available. The reference numbers are those used by the conservators and relate to the object on which the textile evidence occurs.

ref. 911515	Scar, Sanday, Orkney	1991	On shears to which is attached a spindle-whorl. Several patches of Z/Z plain tabby. Shears consolidated after conservation, textile details therefore blurred.
ref. 911518	Scar, Sanday, Orkney	1991	Several pieces on sword of Z/Z plain tabby with a count of 18/18 threads per cm., in places three layers of textile. Some unevenness of yarn diameter in one system. On hilt one system S-spun low twist yarn in one layer. All bast fibre, probably linen.
ref. 920002	Scar, Sanday, Orkney	1991	Bone comb; textile evidence on three iron rivets. Z/Z plain tabby with count of 18/18 threads per cm. Bast fibre, probably linen
ref. 920029	Scar, Sanday, Orkney	1991	Iron fragment with Z/Z plain tabby. Yarn has low twist.

Catalogue No	Location	Date Found/Exc.	Dimensions (cm)	Weave	ThreadCount (per cm)	Yarn Type	Spin Direction	Colour/ Dye	Comments
ref. 920036	Scar, Sanday, Orkney	1991	On weaving sword. Z/Z plain tabby with high thread count and yarn with low twist. Weft picks float over 4 or 5 warp ends on one piece; probably forms diamond pattern. Possibly reverse of fabric - difficult to assess fully. Unusual piece, only one known from Scan. Scott.						
ref. 920037	Scar, Sanday, Orkney	1991	On sickle. Plain tabby. Consolidated after conservation so textile details blurred.						
ref. ?	Scar, Sanday, Orkney	1991	On equal armed brooch. Impressions from manufacturing process and textile around pin of brooch						

Table 2: Scandinavian Period Textiles from the Isle of Man (Henry 1992)

Catalogue No	Location	Date Found/Exc	Dimensions (cm)	Weave	ThreadCount (per cm)	Yarn Type	Spin Direction	Colour/ Dye	Comments
25. A/B	Camp Keeil Vael	1944	2 frags.	tabby-repp	* 16/22	?linen	Z/Z	?	parallel at Birka. c900. Male
C	Camp Keeil Vael	1944	small frag.	?	* 28/32	?linen	Z/Z	blue ?woad	Poss. hemp or nettle. Blue poss. due to oxidisation from contact with silver. c900. Male
26. A1	Cronk Moar, Jurby	1945	6 x 4	plain tabby pile	* 4/3	wool	Z/S pile: S+Z	?	pile - mainly loose S-spun, some Z-spun. c900. Male
A4	Cronk Moar, Jurby	1945	8 x 8	plain tabby pile	* 3/3	wool	Z/S pile: S	?	pile - loose S-spun. c900. Male
A8a	Cronk Moar, Jurby	1945	5 x 3	plain tabby pile	* 3/2	wool	Z/S	?	pile - loose S-spun. c900. Male
A8b	Cronk Moar, Jurby	1945	4 x 3	plain tabby pile	* 3/3	wool	Z/S	?	poss. same fabric as 'A8a'. c900. Male
A7	Cronk Moar, Jurby	1945	frags.	plain tabby	* 3-4/2-3	wool	Z/S	?	possibly contains pile tufts. Heavily matted. c900. Male
A2,3,5,6,9	Cronk Moar, Jurby	1945	frags. A2 - 4 x 4 A3 - 2 x 2	? a9 - ?pile	?	wool	?	?	possibly all belong to same piece of fabric. c900. Male
A10	Cronk Moar, Jurby	1945	frag.	plain tabby	?	linen	Z/Z	?	parallel at Birka. c900. Male

Catalogue No	Location	Date Found/Exc	Dimensions (cm)	Weave	ThreadCount (per cm)	Yarn Type	Spin Direction	Colour/ Dye	Comments
27.	Ballateare, Jurby	1946	in scabbard	plain tabby	closely woven	?wool	?	?	textile report lost. Layer in sword scabbard. c900. Male
	Ballateare, Jurby	1946	frag.	?	?	?wool	?	?	textile report lost. Layer next to sword in scabbard. c900. Male
	Ballateare, Jurby	1946	frag.	?	?	?wool	?	?	textile report lost. Found near bronzes. c900. Male
	Ballateare, Jurby	1946	frag.	plain tabby	loose weave	wool	?	?	textile report lost. Found on shield boss. c900. Male
	Ballateare, Jurby	1946	frag.	?	?	?wool	?	?	textile report lost. Found near hilt of sword. c900. male

Additional Scandinavian Period Textiles from the Isle of Man (Janaway 1982)

Area A	Claghbane, Ramsey	1979	14 x 12	plain tabby	*12/14	bast: ?linen	Z/Z	?	mineralised on sword
Area B	Claghbane, Ramsey	1979	11 x 14	plain tabby	?	?	?	?	probably same as area A; weave on same alignment
Area C	Claghbane, Ramsey	1979	29 x 14	plain tabby	?	bast: ?linen	?	?	same weave alignment as A & B. Probably all from same fabric. Possibly scabbard binding

APPENDIX 3

GLOSSARY OF TEXTILE TERMS

GLOSSARY OF TEXTILE TERMS

Definitions used in this glossary are based on those from Burnham (1980) and Walton and Eastwood (1988).

<u>BALANCED WEAVE:</u> The number of warp and weft threads per unit area are approximately the same.

<u>BAST FIBRES - PREPARATION FOR SPINNING:</u> To render bast fibres suitable for spinning, several processes have to be undertaken:

1. RETTING: The submersion in water or laying out in moist conditions to separate the fibres, stem and core. This is achieved through bacterial action decomposing the substances that bind them. Three forms of retting can be used: pond retting (stagnant water), river retting (sluggish rivers and streams), dew retting (laying the stems out on fields).
2. DRYING AND BREAKING: After retting, the stems are first dried. Breaking with a wooden mallet or flat stone follows to loosen the bark and fibres, and to break the core of the stem.
3. SCUTCHING: Fibres are removed from the stems by beating. Stems are held in upright notched boards, and beaten with a broad flat hardwood blade.
4. HECKLING: fibres are finally combed to remove any wood particles adhering to the fibres.

<u>BINDING UNIT:</u> The smallest number of threads that produce a weave by repetition.

<u>BROCADE:</u> A supplementary weft thread introduced into the ground weave to create patterns and three-dimensional effects.

<u>COUNTERSHED:</u> The gap in the warp threads through which the weft is passed. With the warp-weighted loom, the countershed is formed when the heddle rod is placed on the fork in the heddle rod cradle (fig. 4.12).

<u>CABLED:</u> Plied threads twisted together, usually in the opposite direction to the twist of the plies i.e. if the plies are twisted in an 'S' direction the cable would be twisted in a 'Z' direction (fig. 4.8).

<u>CARDING:</u> See 'Wool' below.

COMBING: See 'Wool' below.

EFFECT: Patterns produced by varying binding, colour and texture in weaving: brocade effect, pile effect, colour and weave effect etc.

END: Individual warp thread.

EVEN/UNIFORM: The regularity of weave in terms of thread count per centimetre over the whole area of the fabric.

FABRIC: Any material that has been woven, felted or knitted to produce a cohesive unit (see also textile).

FACE: The right side of a textile or weave.

FELT/FULL: The matting of fibres, usually wool, or hair and wool, under heat and pressure. 'Felt' should be applied to non-woven fabrics and 'full' to woven fabrics (plate XLIX).

FIBRE: All substances made up of thread like tissue; animal, vegetable or mineral. Applies especially to substances suitable for spinning.

FILAMENT: A type of fibre with an extreme length, often not easily measured. Silk is the best example of natural fibres.

FLOAT: The portion of end or pick that crosses at least two threads between binding points.

GROUND WEAVE: Any weave that forms the background for a pattern, texture or pile.

HEDDLE ROD: The rod to which every alternate warp thread is loosely tied to enable the shed to be opened and closed (fig. 4.12).

I-TWISTLESS: Any yarn that is used in an un-spun state (fig. 4.7).

LOOM WEIGHT: A fired-clay or stone weight with perforation to which the warp threads are tied in groups in order to keep them taught. Scandinavian period weights were largely bun-shaped (fig. 4.12).

NÅLEBINDING: A type of 'knitting' where loops are worked into a continuous spiral using a needle and lengths of thread (fig. 4.10; plates XI and XII)).

NATURAL SHED: The gap in the warp threads through which the weft is passed. In the case of the warp-weighted loom the natural shed is formed when the heddle rod is off its fork in the heddle rod cradle (fig. 4.12).

PATTERN UNIT: The term for the number of threads used in any given pattern before that pattern starts to repeat itself.

PICK: Individual weft threads.

PILED FABRIC: A textile, usually tabby weave, into which lightly spun threads are woven or sewn, either during or after the weaving process, producing a light, warm, moisture proof fabric (plates XXV and XLI).

PILE TUFTS: The loosely spun threads that are inserted into woven fabric. They can be of varying length and are either woven in unknotted or woven in and knotted during weaving or sewn in after weaving. The beating up of the weft threads holds the pile-tufts in place.

PLYING FIBRES: The twisting together of two or more spun threads, usually in the opposite direction to the spin of the fibre, i.e. two 'S' spun threads being plied in a 'Z' direction are notated as 'S2Z' (fig. 4.8; plate XXXVIII).

REPEAT: Pattern or weave unit that is used to produce a repeat pattern

REPP: Fabric where either the warp or weft threads are so tightly packed that they produce a ribbed surface, tabby-repp and twill-repp etc.

RETTING: See 'Bast Fibres' above.

REVERSE: The back or wrong side of a textile.

ROOING: The plucking by hand of loose fleece from the sheep.

SATIN WEAVE: Binding system based on unit of five or more ends, and a number of picks equal to, or a multiple of, the number of ends. Each end passes over or under four or more adjacent picks and under or over the next one. To give a smooth finish, the binding points are set over two or more ends on successive picks (fig. 4.3; plate XVIX).

SCUTCHING: see 'Bast Fibres' above.

SELVEDGES: The firm, fray-proof vertical edges of the woven cloth formed by reversing the weft thread around the outside warp threads (plate XIII). The warp threads can be 'sistered' (doubled) at the edges to produce a firmer selvedge.

SHED: The opening in the warp that allows the passage of the pick (fig. 4.12).

SKIN WOOL: Wool removed from the skin of a dead animal.

SPIN: The twisting of fibres into continuous thread; in the Scandinavian period by hand, or with a spindle.

SPINDLE: A narrow wooden rod, onto which the spun fibre is wound, thickening slightly towards the lower end in order to hold the whorl in place. The spindle rotates throughout the spinning process, with the speed of the rotation determining the fineness of the yarn.

SPINDLE WHORL: A bun-shaped, perforated weight made from fired-clay or stone which is attached to the lower end of the spindle to act as a flywheel in order to keep the spindle rotating . The combined weight of whorl and spindle helps to determine the fineness of the thread.

SPRANG 'PLAITING': A loose elastic fabric formed by twisting adjacent warp threads without the use of wefts (plate VI). Warps are attached to a frame, plaited two by two in alternate rows from both ends simultaneously and secured with sticks each time. The sticks are moved as each new row is created (fig. 4.11)).

S-SPIN: Thread spun in an anti-clockwise direction. The fibres lie in the same direction as the central stroke of the letter 'S' (fig. 4.7).

STARTING-BORDER: The tablet-woven border attached to the horizontal beam of the warp-weighted loom forming a firm edge to ensure the spacing of the warp threads, these being an integral part of the starting-border. Indicative of the warp-weighted loom.

TABBY WEAVE: The simplest weave where the weft thread passes over and under alternate warps (fig. 4.1; plate XVII). Variations include basket and half-basket.

TABLET-WEAVING: A method of weaving where tablets threaded with warp threads are twisted, the twist is held in place with weft threads which don't show. Tablets are usually square with two or four holes through which the warp is threaded. To achieve a plain weave the tablets are turned a quarter or half turn opening the shed through which the weft is passed (fig. 4.9). Patterns can be achieved by alternating the direction of the twist and by using threads of varying colours, spin direction and fineness.

TEXTILE: Any material that has been woven, felted or knitted to produce a cohesive unit (see also fabric).

THREAD: Spun fibre producing a long strand suitable for weaving, sewing or knitting (see also yarn).

TWILL WEAVE: A weave which appears to have lines on the diagonal achieved by the weft passing over and under warp threads in a regular pattern. Each row is stepped to one side of the row above (figs. 4.2; plate XVIII). A binding unit of over two and under two is a 2/2 twill, variants of which are herringbone (a warp-faced chevron twill), where the pattern is achieved by reversing the order in which the warp threads are knitted to the heddle rods and diamond, where the pattern is reversed in warp and weft. Other variations include: chevron, diamond and lozenge twill.

WARP: The main threads on the loom which run vertically on a warp-weighted loom.

WARP FACE: The side of the textile where the warp predominates.

WARP-FACED WEAVE: Weave where the warp predominates on the face, or face and reverse of the fabric, the weft threads are virtually concealed: warp-faced tabby, warp-faced twill, warp-faced satin etc.

WARP-WEIGHTED LOOM: A vertical loom where the warp threads are held taught by the use of loom weights. Generally assumed to be the most commonly used loom in areas of Scandinavian influence during the Scandinavian period (fig. 4.12).

WEAVE: The interlacing of warp and weft threads in a specific order to produce a textile.

WEFT: The threads which run horizontally on a warp-weighted loom and are passed by the weaver from the side to interlace with the warp.

WEFT FACE: The side of a textile where the weft predominates.

WEFT-FACED WEAVE: A weave where the weft predominates on the face, or the face and reverse of a textile, the warp thread are virtually concealed, weft-faced tabby, weft-faced twill, weft-faced satin etc.

WEFT-TWINING: simple form of weaving where shedding device is not necessary. Two or more weft threads are twined around each other as they are passed round each warp end. The twining can be in an 'S' or 'Z' direction. Variations include: weft-twining with half-twist and weft-twining with full twist.

WOOL - PREPARATION FOR SPINNING: Before wool can be spun it has to be carded or combed:
CARDING: The alignment of fibres to enable them to lie in a parallel formation in readiness for spinning. Produces a hard, smooth, even thread and is associated with 'worsted' textiles.
COMBING: The untangling and separating of the short, curly fibres from the longer, straighter hairs to produce fibres that are crossed and lie in all directions in preparation for spinning. Produces a soft, fluffy thread and is associated with 'woollen' textiles.

WOOL CARDER: Used in pairs and consisting of a wooden handle and board to which a sheet of leather is attached, inclined wire teeth being inserted into this. To card wool, small amounts of wool are placed on one carder and pulled apart with the other; the wool eventually being evenly distributed over and between each one. Once achieved, one card is moved in the reverse direction producing rolags (rolls) of wool that can then be spun.

WOOL COMB/HECKLE: Used heated in pairs and consisting of iron teeth set in a T-shaped wooden bar with a long handle. To comb wool the fleece is drawn between the two combs in order to separate the short curly fibres from the longer, straighter ones.

'WOOLLEN' YARN: Wool that has been carded in preparation for spinning, it produces a soft yarn with projecting fibres (plate XV).

'WORSTED' YARN: Wool that has been combed in preparation for spinning, it produces a smooth, strong yarn (plate XVI).

YARN: Spun fibre producing a long strand suitable for weaving, sewing or knitting (see also thread).

Z-SPIN: Threads spun in a clockwise direction. The fibres lie in the same direction as the central stroke of the letter 'Z' (fig. 4.7).

APPENDIX 4

WOOL FIBRES

APPENDIX 2

WOOL FIBRES

FLEECE-TYPE CATEGORIES (from Ryder 1964a; 1969; 1974; 1983; 1987b)

Main text: section 4.2.1.3; table 4.1; fig. 4.6

Ancestral Coat

The *ancestral coat* of the newly domesticated Neolithic sheep, and comparable to today's Mouflon, had an outer coat of bristly kemps, which obscured very fine underwool.

Hairy Medium and Generalised Medium

The first change is detectable during the Bronze Age, and is characterised by a narrowing of the outer coat, the kemps, which produced a skewed distribution of mostly fine fibres, with a few hairy ones greater than sixty microns in diameter. Ryder has named this fleece-type *hairy medium* which is like today's Hairy Soay, found on St Kilda. Further narrowing of the kemps changed them into wool fibres of medium diameter, again a skewed distribution is evident with a maximum diameter of fifty-five microns. This fibre is similar to that of the Woolly Soay, also found on St Kilda, and designated *generalised medium.*

True Hairy

During the Iron Age, further changes to fleece took place. Ryder suggests that a *true hairy* fleece evolved out of the *hairy medium* one, where kemps transformed into long continuously growing hairs, intermediate between kemp and wool. The diameter distribution is a continuous, yet skewed one from fine to coarse fibres. The fleece is synonymous with that of the Swaledale, Scottish Blackface and Orkney sheep.

True Medium, Shortwool and True Fine

The Roman period saw the last major change to pre-industrial fleece-types. Three more types have been recognised by Ryder which he maintains derived from the *generalised medium* fleece. With the *true medium*, the fine fibres became coarser, displaying symmetrical long wool with a non-hairy upper-limit of sixty microns. This fleece appears to have been the ancestral coat of the longwool breeds such as the Cotswold Longwool. The *shortwool* fleece is characterised by a shortened fibre diameter range with a symmetrical distribution. It evolved due to the continuing narrowing of the outer coat in conjunction with a coarsening of the finer fibres; the extremes of the fibre diameters merge. *Shortwool* was probably the forerunner of the shortwool fleeces of breeds like the Southdown and Norfolk Horn. Finally, the fleece that is at the opposite end of the evolutionary scale to the *ancestral coat* is the *true fine* wool, comparable to the Merino. The outer coat and medium fibres continued to narrow producing a symmetrical diameter range; the fine fibres having a diameter of twenty microns and an upper limit of forty microns.

RAW WOOL STAPLES (from Ryder 1989, 308-310)

Main text: section 4.2.1.6; plate XXVII

Wool staples form three basic shapes: tapering, 'blocky' and curly. As such, they are used to indicate fleece-type. Tapering staples are synonymous with hairy fleeces, where the tip normally contains long, hairy fibres only. 'Blocky' staples, with their characteristic straight end indicate uniformity in fibre diameter and length. This staple type is common to shorter and finer fleeces, the fibre is usually wavy. Curly staples contain fibres of medium diameter, which is consistent with longwools.

Fleece-typing through the examination of raw wool staples is not however, as straightforward as it would at first appear. Ryder points out that the year of shedding is an important factor, with characteristic staple formation clearest from the second shedding onwards. In adult sheep, staple length is assumed to correlate with annual fleece growth. In lambs however, staples are shorter and may differ in appearance to their adult counterpart. The fleece can for instance, be finer than is normal in an adult of the same breed. As such, these elements are important considerations when assessing fleece-types from raw wool staples.

The method of harvesting has implications for both cultural and evolutionary aspects of wool use and production. Where fleece has been shorn, cut ends are visible when examined under light microscopy. In contrast, where rooing has occurred during moulting, the fleece has 'brush ends', normal to naturally shed fleece. Where growing fibres have been plucked after slaughter, dark root ends are detectable. Shorn fleece suggests that the breed of sheep from which it has come have ceased to shed their coats naturally, whereas where rooing is evident, the indication points to breeds that moult on an annual bases. Such evidence not only makes available information on fleece-type but also the evolutionary nature of sheep breeds. Culturally, the method used to harvest the wool, enhances our knowledge of the technology available to any given society.

NATURAL FLEECE COLOUR: EVOLUTION (From Ryder 1990, 139-143)

Main text: 4.5.1

Sheep prior to the Bronze Age had hair rather than fleece. From the Bronze Age, selective breeding appears to have occurred to produce wool suitable for cloth production. The predominate colour at this time was brown, with a fleece similar to the Soay; white wool on the belly and brown on the upper body. Wool textiles produced from white wool during the Bronze Age probably came from the belly of the sheep or from the white portion of pie- and skewbald sheep.

White (non-pigmented) fleece appears to have become common during the Iron Age. It is probable that sheep were bred to produce white wool suitable for dyeing. It is possible to dye naturally pigmented wool but the natural pigment affects the purity of dye colour. White wool is therefore likely to have been exploited to a greater extent for dyeing purposes. Naturally coloured wool was though, still widely used in textile production, a practice that continues in Orkney and Shetland. Orkney and Shetland sheep, which are survivors of Iron Age breeds, have fleeces ranging from brown and black to grey and white, and pie- and skewbald, thus presenting an extensive repertoire with which to produce naturally colour-patterned textiles.

It seems evident from analysed wool that there was a gradual loss of colour during the evolution of fleece. The major change in colour occurred between the Bronze Age Soay type sheep and the multi-coloured Iron Age breeds. Loss of and change of colour thus led to greater variety in the textiles produced from naturally coloured wools, as well as facilitating the use of dyes to give a wide variety of hues to yarns and textiles.

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