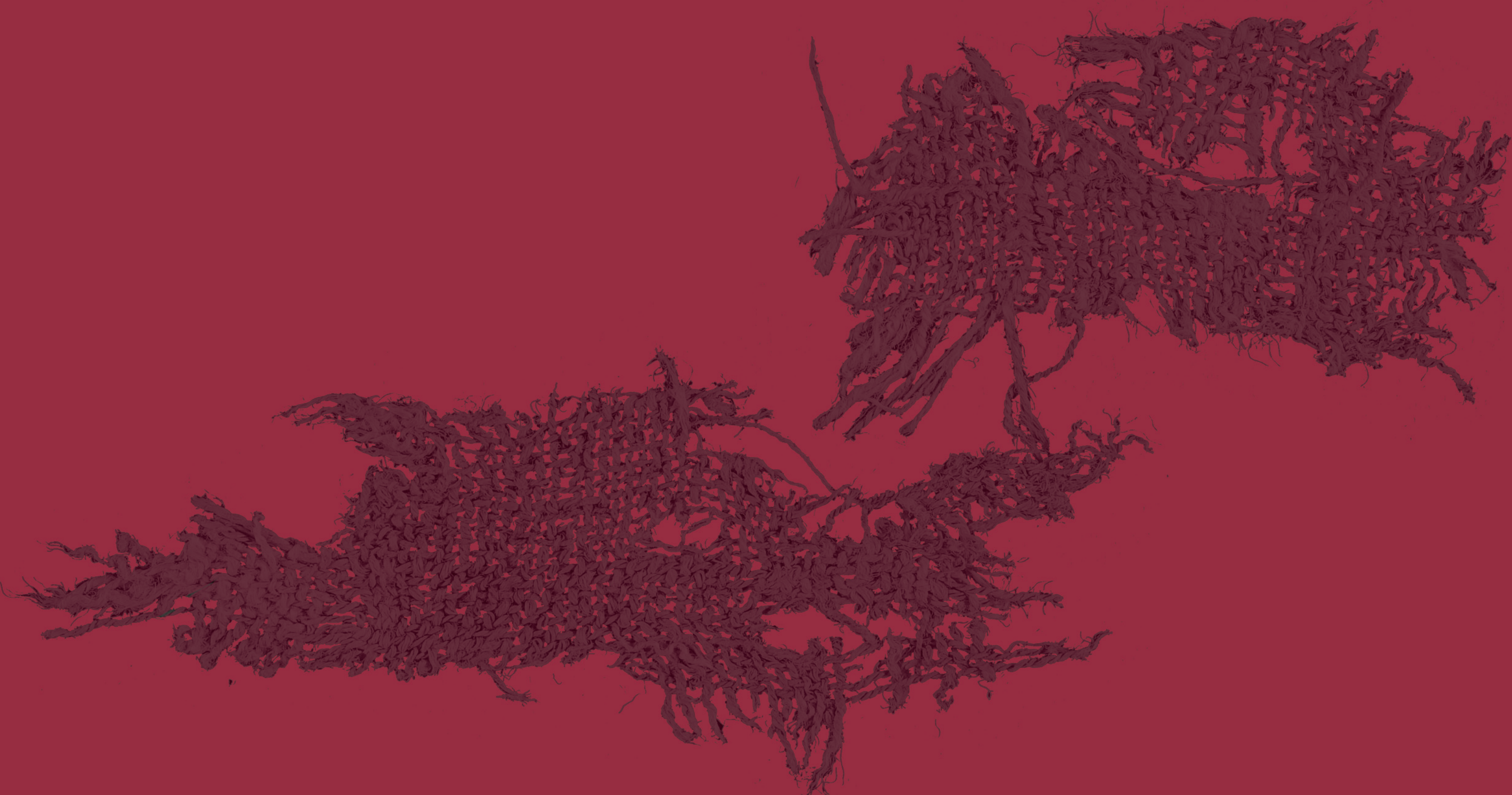
Nº 57

ARCHAEOLOGICAL TEXTILES REVIEW



2015 issue

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Editorial

2015 has been a great year for archaeological textiles, with many interesting conferences, new publications and exciting new research projects, and thus also for the *Archaeological Textiles Review*. At ATR's Annual General Meeting in Copenhagen in May, we bid Carol Christiansen farewell from the editorial board and welcomed Joanne Cutler (University of Cambridge) to the fold. We are in the final stages of digitising back issues of ATN/ATR and by the New Year, issues 1-45 will be available as print-on-demand hard copies that can be purchased via the University of Copenhagen webshop, while issues 46-56 will be available free of charge as PDFs on the ATN/ATR homepage http://www.atnfriends.com/.

The wider archaeological textile community has also seen some exciting changes in the past year: The Danish National Research Foundation's Centre for Textile Research has reached its final year of project funding, but will, as of 2016 continue as a research centre at the Saxo Institute, University of Copenhagen. Eva Andersson Strand has been appointed Associate Professor for Textile Archaeology at the Saxo Institute, and former editor Susanna Harris has been appointed Lecturer in Archaeology at the University of Glasgow. In sadder news, the renowned textile expert Michael Ryder died at the beginning of the year, leaving an enormous legacy to the textile community.

It is wonderful to see how textile studies has become more visible in recent decades in mainstream archaeology and historical studies, which has manifested itself in increasingly interdisciplinary publications, many of which can be found in our recent publications pages below. We are particularly pleased to be able to announce a number of new textile projects this year: Romina Laurito's *Textile Technology in Central Tyrrhenian Italy from Late Prehistory to the Etruscan Period*, Sue Harrington and Susan Möller-Wiering's recent work on early Anglo-Saxon textiles from Lakenheath in Suffolk, England, Ellen Harlizius-Klück's *Textile MATRIX* exhibition in Munich and two PhD projects: Gabriela Ruß-Popa's ongoing comparison of textile technology in the Dürrnberg salt mines in Austria and Chehrābād in Iran, and Lise Ræder Knudsen's completed study of Iron Age tablet weaving from Denmark.

We are delighted to see the diverse directions in which textile studies continue to develop. Indeed, the current volume includes contributions that cover a huge geographical and chronological span, from the Chalcolithic period in the Levant (Shamir) to the 17th and 18th centuries in the Czech Republic (Bravermanová and Březinová) and Siberia (Glushkova, Tataurov and Tikhonov). The materials presented also display a great diversity: there are Bronze Age moss fibre garments from Scotland (Harris and Gleba), silk flowers from Polish graves (Grupa) and patterned silk weaves from Denmark (Skals). New insights into a range of specific textile techniques are also a theme in this volume, such as tablet weaving (Merthen), experiments in plain gauze (Mokdad) and finger-loop braiding in Hallstatt (Grömer, Kania and Boutrup). But it is not just textile manufacturing methods that are discussed in this volume: other technologies in which textiles may have played an instrumental role also get a mention in Émeline Retournard's discussion of metal ore processing in the French Alps. Ongoing work in the field of archaeological finds processing has produced some exciting new developments, also presented in this volume: first, a system for the digital documentation of organic materials (Nowak-Böck and Voß), the software for which has been made freely available by the authors for all of us to use. Second, Natalie Susmann introduces us to a new system for the identification and classification of Mediterranean murex dye production sites. As always, we are very grateful to our many peer reviewers in the textile community who are instrumental in helping us to publish such high-quality research papers.

The next Annual General Meeting of the *Archaeological Textiles Review* will take place on 10th February 2016 in Rome in conjunction with the *Contextualising Textile Production in Italy in the 1st millennium BCE* conference taking place on the 11th and 12th February 2016 at the National Etruscan Museum of Villa Giulia and the Danish Academy in Rome and organised by Romina Laurito and Margarita Gleba.

We thank you for your continued support and remind you to renew your subscription as soon as possible in the New Year. We welcome contributions to the next issue (*ATR* 58) and would encourage you to send them to us as soon as they are ready, so that we can spread the editing workload evenly over the coming year. The next deadline for contributions is **1st June 2016**. Please also remember to send us any news of new projects, publications and conferences, so that we can continue to act as a hub for our growing archaeological textiles community.

The Editors

Susanna Harris and Margarita Gleba

Bronze Age Moss Fibre Garments from Scotland – the Jury's Out

Introduction

The periodic re-evaluation of early and unusual fibre identifications has proved important in textile research (*e.g.* Ryder 1965; Bender Jørgensen 2013). In light of recent discoveries of early to middle Bronze Age burials with mats and fibrous material in Scotland, for example at Langwell Farm, Strath Oykel (Lelong 2009) and Forteviot, Perth and Kinross (Brophy and Nobel 2011, 798), it is timely to re-evaluate earlier finds of this period. Of particular interest are the claims for hair moss fibre garments or shrouds.

In the early 20th century, Ludovic McLellan Mann, a keen amateur archaeologist, reported several hair moss items found in Bronze Age burials and related contexts. The sources include Mann's 1928 excavation notes, indicating a garment from Greenoakhill (Henshall 1950, 153) (Greenoakhill, Moss Fragments, Glasgow Museums, ARCHNN.1450), an apron of moss fibre (*Polytrichum commune*) from North Cairn Farm (Mann 1923, 107) (North Cairn Farm, Moss fibre garment, Glasgow Museums ARCHNN.3170) and Mann's 1936 press release of Ferniegair moss fabric reported in Welfare (1977, 5) (Ferniegair, Shroud of moss fibres with fragments of bone, Glasgow Museums, ARCHNN.1802). The identification of hair moss was seriously doubted both by Audrey Henshall and H.G. Welfare, who each examined some of these finds (Henshall 1950, 153; Welfare 1977, 7) (Table 1) (Fig. 1).

Hair moss string and basketry items have been more securely identified in other Bronze Age and later contexts in the British Isles. A rope of hair moss (*Polytrichum commune*), as well as wadding of other types of moss (*Neckera complanata, Eurhynchium striata*), were used as caulking in Boat No. 3 from North Ferriby in the north of England which is dated to the early Bronze Age (OxA-9198-9 & OxA-9524, 3575 ±24 BP, at 95% confidence 2030-1780 cal BC) (Wright and Churchill 1965, 5, pl. I upper, pl. VIII lower; Wright *et al.* 2001, 732). There have also been reports of pollen evidence for sphagnum moss (*Sphagnum sp.)* in Scottish early Bronze-Age burials and cremation urns where it is identified as layers or packing (Warsop 1996, 140; Mills 1995, 132-3 in Brück 2004, 180). A four-ply plait and bundles of "fringe-like apparatus made

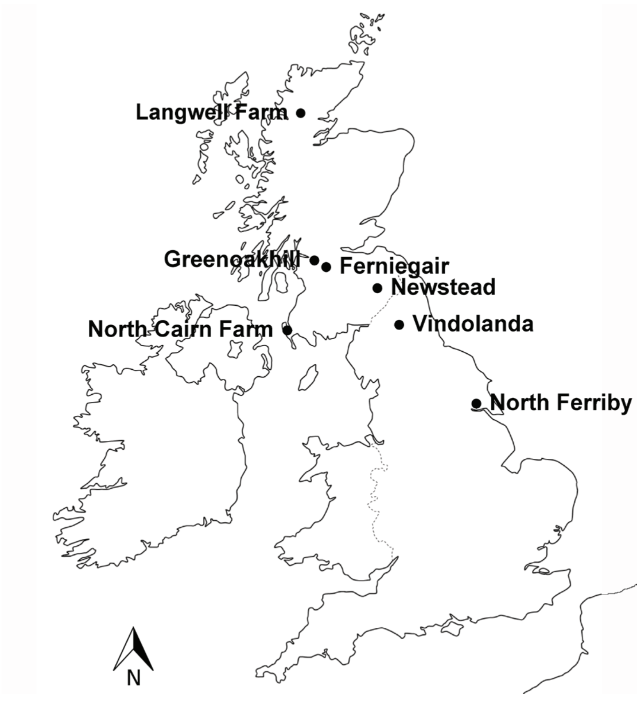

Fig. 1. Map of the British Isles with location of key sites mentioned in the text (Map: Susanna Harris).

Site and county	Object and accession number	Archaeological context	Mann's assessment	Subsequent assessment	Current research
North Cairn Farm, Dumfries and Galloway	Moss fibre garment, ARCHNN.3170	Recovered from the edge of a cairn	Hair moss apron; fibres knitted together along a twig	Henshall (1950, 153): too fine and soft to be moss	Fibrous bundle. Fibre analysis: most likely silk. Unlikely Bronze Age
Greenoakhill, Glasgow	Moss fragments, ARCHNN.1450	Cist containing inhumation of boy with Food Vessel	Hair moss garment covering the body and among the bones. Comparable to North Cairn Farm apron	Henshall (1950, 153): moss garment apparently not preserved	Compressed organic material. No weave structure. Fibre identification necessary
Ferniegair, South Lanarkshire	Shroud of moss fibres with fragments of bone, ARCHNN.1802	Cist 2, inhumation with inverted, enlarged Food Vessel	Inhumation covered by a length of fabric woven from moss	Welfare (1977, 9): unlikely to be moss as they are too coarse	Roughly parallel fibrous strands (Ø 3.5-10mm). Rather coarse to be moss. Friable and immobilised with adhesive, making fibre analysis less likely to yield good results

Table 1. Bronze Age fibres, hair moss garments or shrouds identified by Mann, subsequent assessments and current research. Finds accessioned at the Glasgow Museums Resource Centre, Glasgow.

of moss" were recovered in the late 19th century from a multi-period site at Lochlea Crannog, South Ayrshire (Munro *et al.* 1879, 192, fig. 109). Henshall considers these genuine hair moss items dating to the late 1st and 2nd centuries AD (1950, 154). There are also two Roman artefacts identified as hair moss caps. A cap (made of *Polytrichum commune*) was identified at Vindolanda Roman fort in the north of England. It is dated to AD 97-103 (Wild 1994). A similar cap was excavated from the inner ditch of Newstead Roman fort in Scotland. It is thought to be dated to around AD 86 (Wild 1994, 64). In the original report, the Newstead find is referred to as an unfinished basket made of cleaned stems of the hair moss *Polytrichum commune,* which were identified through comparison with hair moss articles in the Kew Garden collections (Curle 1911, 108, 358, pl. XV). These two near-contemporary Roman finds may reflect an earlier tradition of this region rather than a Roman one.

The abovementioned finds show that the use of hair moss fibres, and other mosses, in Bronze-Age Scotland should not be treated as completely fanciful. If proved correct, it would be significant because moss fibre, and more specifically hair moss, is only rarely identified in Britain and the neighbouring areas of Europe, although moss has recently been identified in an early Bronze-Age oak coffin burial from Trindhøj, Denmark[1]. As none of the Scottish Bronze Age hair moss fibres have been the subject of rigorous scientific testing, their fibre origins remain dubious. The purpose of this research is to review the Scottish hair moss clothing or shroud claim and carry out fibre identification of the "hair moss apron" from North Cairn Farm in the hope of bringing clarity to this interesting issue.

North Cairn Farm

At North Cairn Farm Mann reported a hank of hair moss fibres made into some kind of garment:

> "The fibres were made into skeins or hanks. The hanks were doubled at the middle, where they were knitted together by the same fibres along a twig of pliable tough wood. From this the hanks were hung closely together, making an apron-like object" (Mann 1923, 107).

These were recovered from the edge of a cairn at North Cairn Farm, Corsewall. Henshall later examined the North Cairn Farm find and wrote: "That the moss of which it is formed is in fact *P. commune* is doubtful, for the remains are finer and softer to handle than the other fabrics made of this moss; indeed its whole appearance and texture is different from any other work. […] There seem to be small hanks with cross-binding about 3 inches apart" (Henshall 1950, 153).

Technological analysis

The North Cairn Farm artefact was examined by one of the authors (Susanna Harris) at the Glasgow Museums Resource Centre in 2014. On examination it was noted that the North Cairn Farm artefact fits the first part of Henshall's description (1950, 153). The fibres are noticeably soft to the touch, even when wearing latex gloves (Fig. 2). However, the cross-binding (in today's terminology twining or weft twining) described could not be observed anywhere within the mass of fibres, and there is no sign of the twig mentioned by Mann. The find as it is today is best described as a mass of fine, dark grey fibres measuring

Fig. 2. North Cairn Farm fibres, ARCHNN 3170 (© CSG CIC Glasgow Museums Collection).

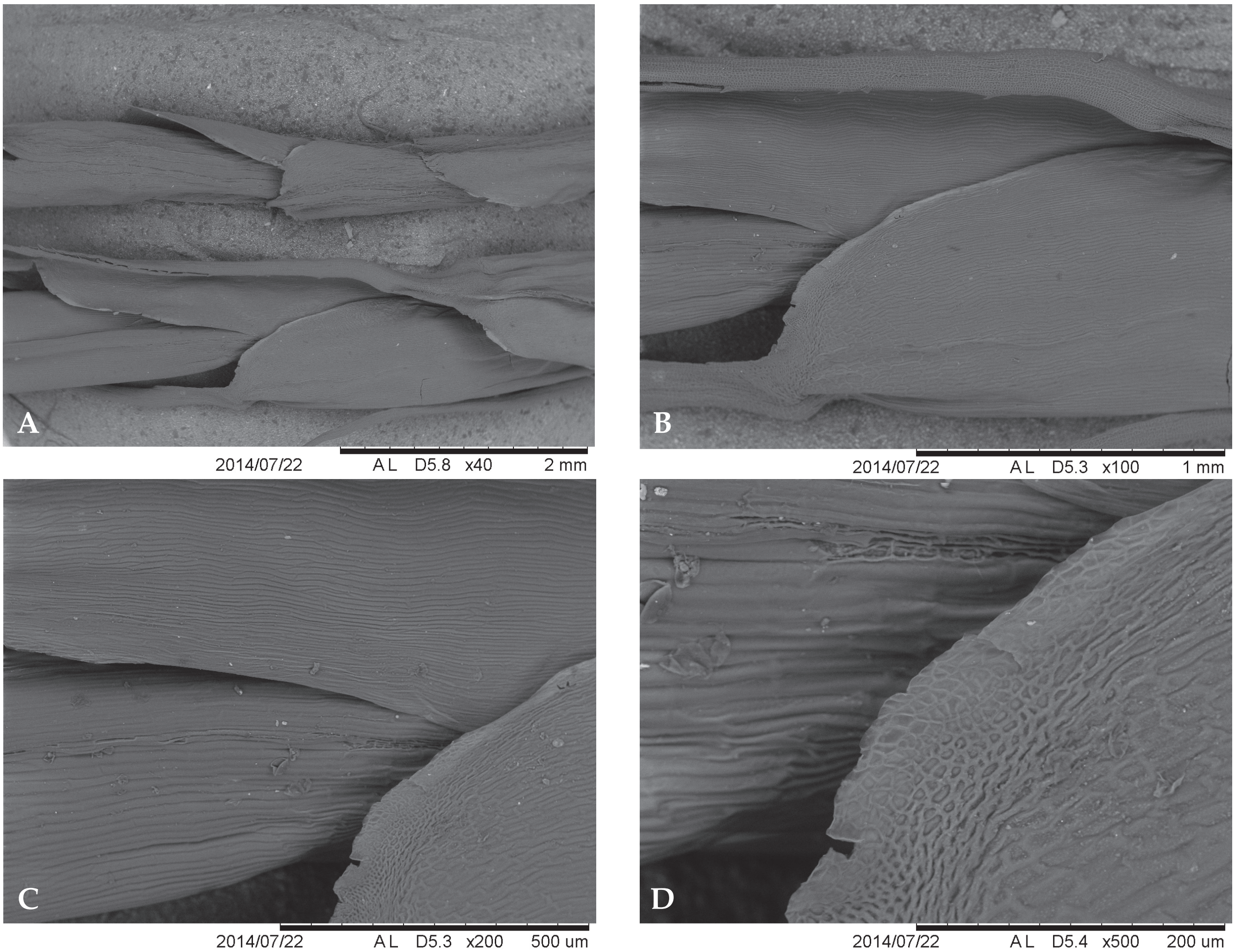

Fig. 3. Reference collection hair moss (*Polytrichum commune*) with leaves attached. Scanning Electron Micrograph at: a) x40 (tip and base), b) x100, c) x200, d) x500. Whole stems of hair moss were gathered from a water-sodden boggy area from the Outer Hebrides, Scotland by Sherry Doyle (Photo: Susanna Harris and Margarita Gleba).

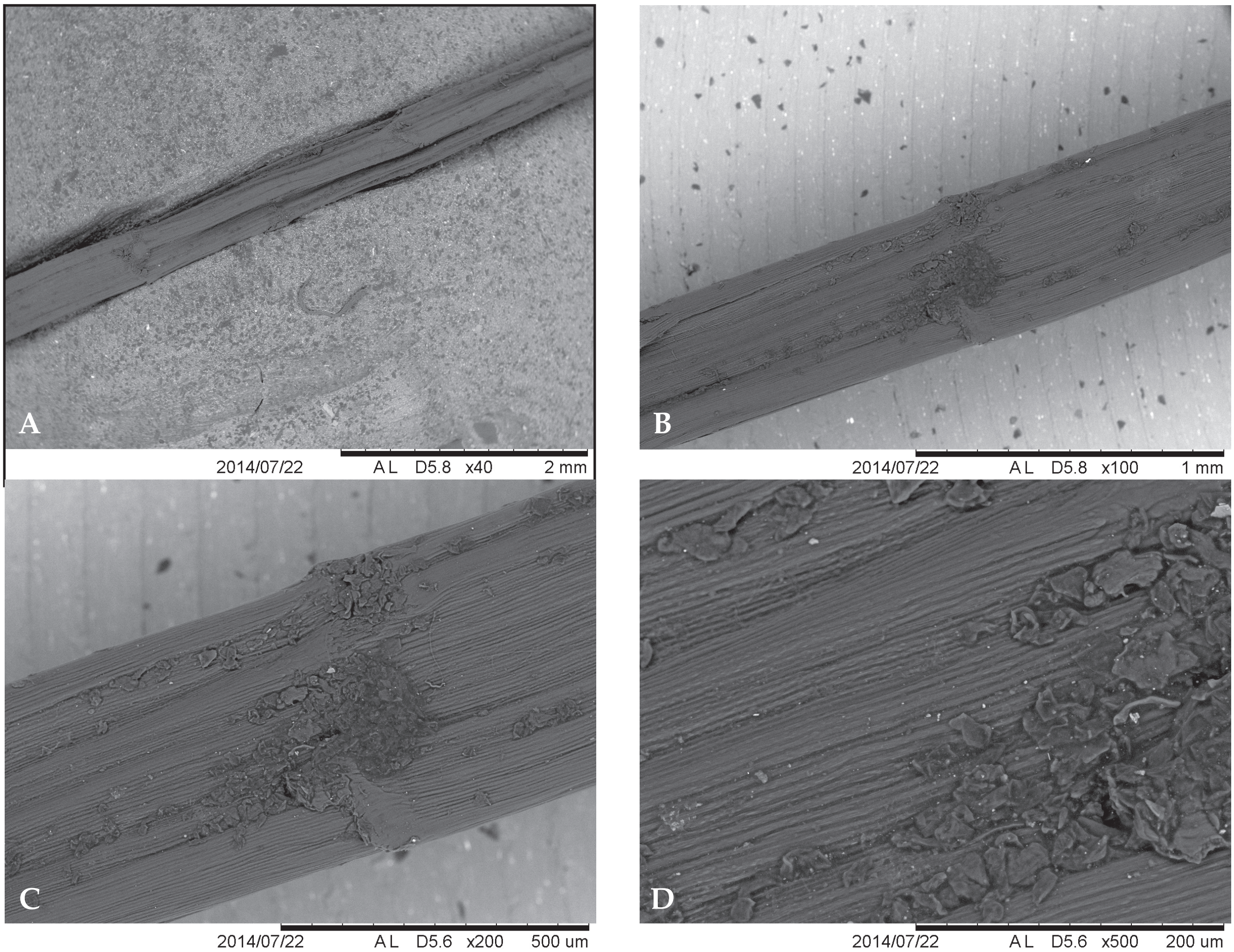

Fig. 4. Reference collection hair moss (*Polytrichum commune*) stripped of leaves. Scanning Electron Micrograph at: a) x40, b) x100, c) x200, d) x500. Whole stems of hair moss were gathered from a water-sodden boggy area from the Outer Hebrides, Scotland by Sherry Doyle (Photo: Susanna Harris and Margarita Gleba).

roughly 24 x 27 cm, coated with a light clay soil with no visible weave structure. At first glance the fibres looked spun, but on closer examination with a low-powered microscope there were bundles of fibre with no determinable s or z twist as would be characteristic of spinning. Two 5 mm samples of the fibres were taken for species identification (ARCHNN 3170.1 and ARCHNN 3170.2).

Fibre identification

The fibres were examined using a Hitachi TM3000 TableTop Scanning Electron Microscope (SEM) at the McDonald Institute for Archaeological Research, University of Cambridge, UK. In preparation, the samples were placed on a metal stub with a carbon tab and no coating was used. The following instrumental settings were used: analytical condition mode at 15.00 kV accelerating voltage, compositional imaging and working distance of 5-10 mm. The fibres were examined longitudinally for morphological features. The features were compared with Susanna Harris's reference collection of plant and animal fibres, including processed and unprocessed fibres. It includes the standard plant and animal fibres expected for the Bronze Age (flax, nettle, tree bast, wool) and later periods (cotton, hemp, silk) plus hair moss fibre (*Polytrichum commune*) and cotton grass (*Eriophorum angustifolium*). Scanning electron micrographs of hair moss and cotton grass lint from its seed bolls are illustrated in this paper for comparative purposes, as they are not commonly illustrated elsewhere (Figs 3, 4, 5 and 6). These plants are commonly occurring in Scotland today. The cotton grass was collected fresh in the summer in Caithness by Susanna Harris and the hair moss was collected fresh in the summer in the Outer Hebrides by Sherry Doyle. Both samples were

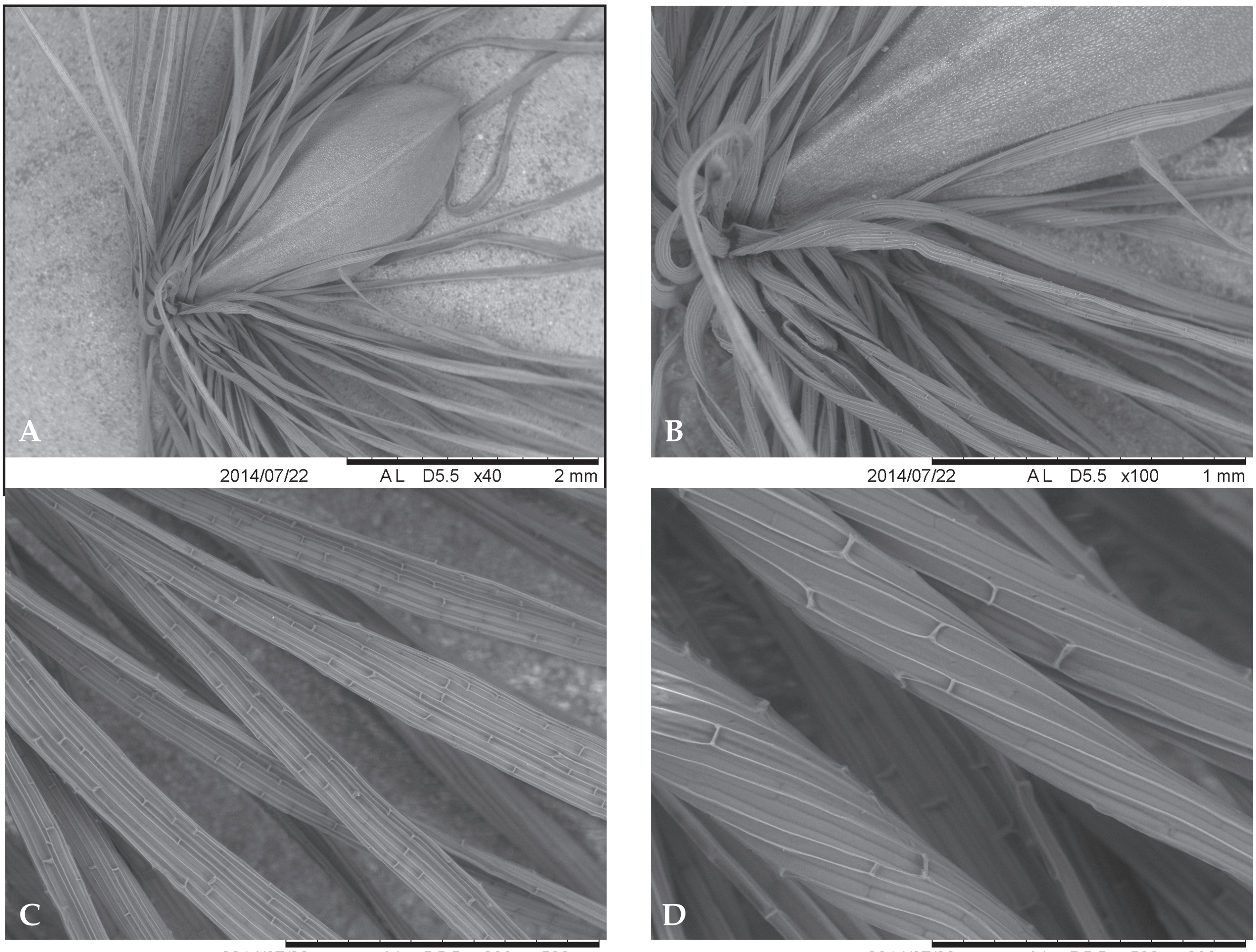

Fig. 5. Reference collection cotton grass lint (*Eriophorum angustifolium*), Scanning Electron Micrograph at: a) x40, b) x100, c) x200, d) x500 gathered in Caithness, Scotland by Susanna Harris (Photo: Susanna Harris and Margarita Gleba).

subsequently air dried. The lint was not processed in any further way. The hair moss fibres are illustrated unprocessed and with the leaves stripped off.

The fibres were covered in fine soil which can be seen by the naked eye and in the SEM micrographs which supports the report that they were dug from the edge of a Bronze Age cairn (Fig. 6). The fibres had none of the characteristics of hair moss fibre: there were no leaves nor scars where the leaves had been removed, and the stem diameter was substantially smaller than that of the reference collection hair moss sample. Five fibre diameters were taken ranging between 14.7 and 15.7 μm, falling uniformly around 15 μm, while the hair moss fibre reference samples have a diameter (stem without leaves) of 455-480 μm. Neither did the fibres have the characteristics of plant bast fibre such as flax or hemp, such as knee-joint dislocations (Catling and Grayson 1982). In addition, no scales were visible and the fibres had a homogenous diameter along their length, which suggests they are unlikely to be wool. The fibres have some of the angular ridges of cotton, however, they are too long even for mercerised cotton and lack the characteristic twisted ribbon appearance. Therefore, the fibre is neither hair moss, bast nor wool and is also unlikely to be cotton.

This leads to the possibility that the fibres are silk or artificial. Artificial fibres first appeared in the 1920s, so the discovery date allows this possibility. The fibres are flattish, with a slight turn and ridges, and a somewhat triangular cross-section. They are irregular, pointing to a natural, rather than synthetic fibre with roughly eight fibres in a bundle. The bundles and 15 μm diameter is not unusual for silk, and they do not have the regular longitudinal striations or ridges characteristic for artificial fibres. The results of the SEM analysis suggest with high confidence the fibre is silk.

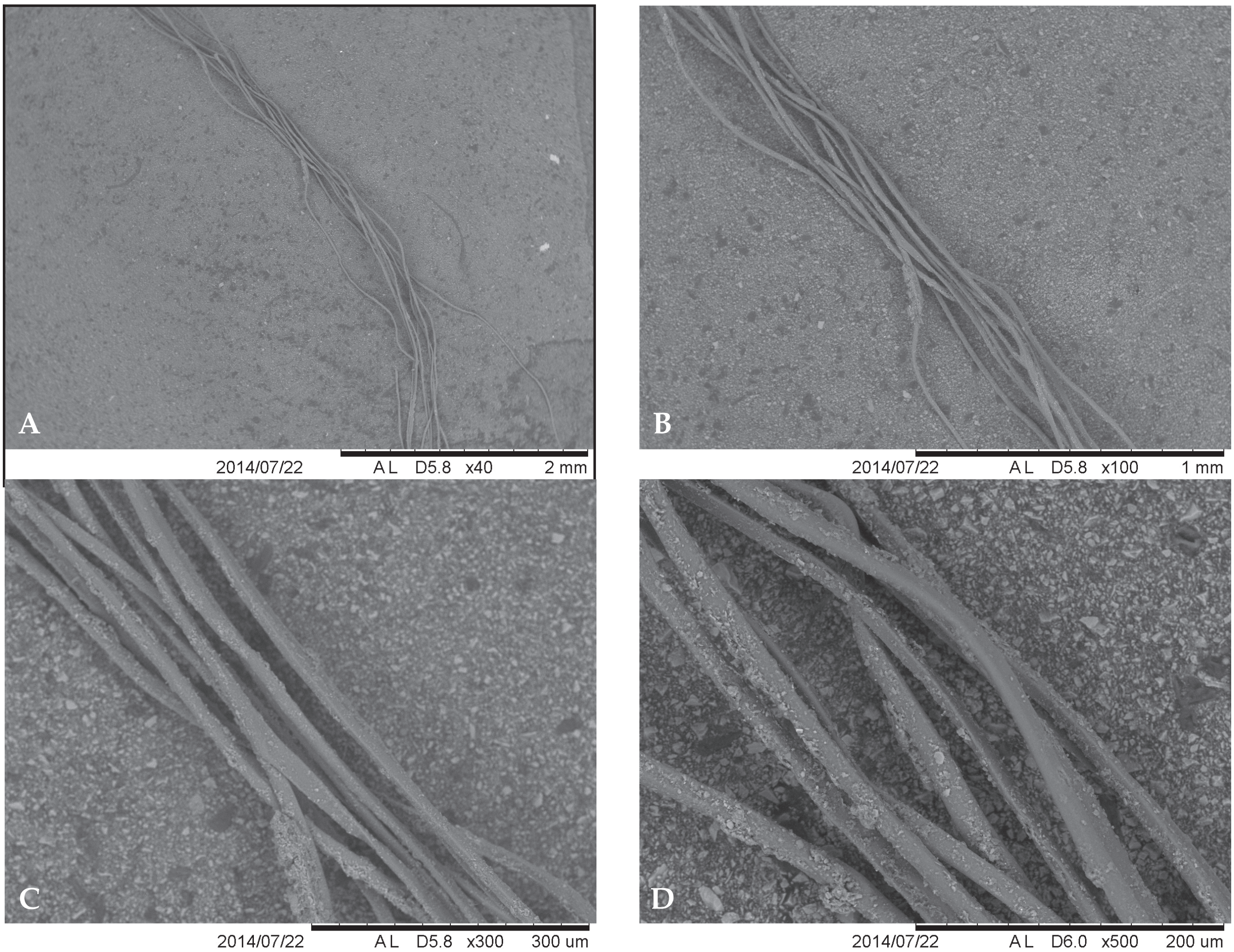

Fig. 6. North Cairn Farm fibres (Glasgow Museums, ARCHNN.3170.1) identified as most likely silk. Scanning Electron Micrograph at: a) x40, b) x100, c) x300 and d) x500 (Photo: Margarita Gleba, published with permission of Culture and Sport Glasgow, Glasgow Museums).

Fig. 7. North Cairn Farm fibres (Glasgow Museums, ARCHNN.3170.1) Scanning Electron Micrograph at x1000, with view of fibre transverse cross section (Photo: Margarita Gleba, published with permission of Culture and Sport Glasgow, Glasgow Museums).

Fig. 8. Human tibia with dark, friable organic remains from Ferniegair burial, Hamilton (Glasgow Museums, ARCHNN.1802). Some areas retain the structure of coarse plant stems or fibre bundles (Photo: Susanna Harris, published with permission of Culture and Sport Glasgow, Glasgow Museums).

Fig. 9. Compressed organic material with hand written notes from Greenoakhill, Glasgow. Coins are used to weigh down the paper (Glasgow Museums, ARCHNN.1450) (Photo: Susanna Harris, published with permission of Culture and Sport Glasgow, Glasgow Museums).

This is supported by the impression of the fibres in the visual analysis, which on closer examination turned out to be fibre bundles – this is also a characteristic of silk.

Contextualisation

Silk was not known in Europe until the Roman period and earlier reports of silk finds have been discredited on scientific grounds (Bender Jørgensen 2013). The identification of the North Cairn Farm fibres as silk casts serious doubt on the antiquity of this find. There is additional doubt as to their origin. First, the find was dug up at the edge of a cairn by a farmer and therefore lacks secure context. Confusingly, Mann reports the find spot as North Cairn Farm near Corsewall, but it is archived as Stoneykirk. Mann was also secretive about his find spots. The Glasgow museums ARCHNN number is given to those finds whose provenance is uncertain, although they clearly belong to the Mann collection[2]. It seems odd that the twining that Henshall mentioned was not observed by the current author. This suggests that some of the find is missing (including the twig attached to the fibres reported by Mann), and that this is a different artefact from that observed by Henshall, or that she was wrong. This is curious as the first half of Henshall's observations are valid and there is no reason to doubt them.

Ferniegair and Greenoakhill

The "Shroud of moss fibres with fragments of bone from Ferniegair burial" (Fig. 8) and the "Moss fragments" from Greenoakhill, Glasgow (Fig. 9) were examined by one of the authors (Susanna Harris) at the Glasgow Museums Resource Centre in 2009. Both come from inhumations with Food Vessel pottery; the overall date range for this pottery type in Scotland is 2140-1520 cal BC (Sheridan 2004, 249). At the time, neither was deemed appropriate for fibre analysis, and the Ferniegair find, likely made of a plant material, possibly coarse stems, was judged too friable and immobilised with an adhesive to be suitable for microscopic fibre analysis. Chemical methods have been developed for treating this type of immobilised fibrous artefact prior to microscopic analysis. These are most likely to aid only in the differentiation of plant and animal fibres, which in this case seems most likely to be plant material. As reported above, both Henshall and Welfare doubted the hair moss interpretations of these finds (Table 1). One of the authors (Susanna Harris) agrees that it seems unlikely that the Ferniegair fibres are hair moss, as even in their friable, immobilised state the organic matter resembles coarse plant stems rather than hair moss. The Ferniegair find is similar in context to the reported basketry from Langwell Farm Cist (Lelong 2009, 12, pl. 2). The right fibula of the human bone from this burial is dated 2200-1960 cal BC

(SUERC-24680, 3690±35, 2δ 95.4% 2200-1960 cal BC) (Lelong *et al.,* in press). However, the disturbance of the Langwell Farm cist shortly after its discovery has precluded scientific analysis of this possible basketry material. The accessioned item from Greenoakhill does not clearly relate to Mann's description and no weave structure was observed; on reflection the Greenoakhill remains could be matted plant fibres used as packing and, given their unconsolidated state, a fibre identification would be judicious.

Conclusion

The idea of Bronze Age hair moss (*Polytrichum commune*) garments and shrouds in Scotland originates from Ludovic McLellan Mann's reports and archive notes written in the early 20th century. His identification of hair moss was conducted in an era before scientific fibre analysis became common in Britain. The results of the SEM fibre analysis presented here suggest the North Cairn Farm fibrous bundle, referred to as an apron, is made of silk. The poor context and identification of silk lead to the conclusion that the North Cairn Farm "apron" is highly unlikely to be of Bronze Age date. If the museum wishes to pursue this issue, the fibres could be radiocarbon-dated. That hair moss was used as a fibre or plant matting material in Bronze Age Scotland remains unproven, but its identification in two hats dating to the Roman period, one in northern England the other in southern Scotland, and as rope in the Bronze Age boat from Ferriby in northern England leaves it as a distinct possibility. That other mosses were used as caulking in Boat No. 3 from North Ferriby (*Neckera complanata, Eurhynchium striata*), plus evidence that sphagnum moss (*Sphagnum sp.*) may have been used as a packing or padding material in early Bronze Age funerary contexts as identified through pollen adds further interest to this subject matter. Fibre analyses of other reported hair moss finds and indeed systematic fibre analysis of new finds may clarify the issue. In the meantime, old references to hair moss in the Bronze Age in Scotland should be treated with caution until there is a conclusive fibre analysis of this plant species from a secure context.

Notes

1. Personal comment by Ulla Mannering. The find is listed in Bender Jørgensen 1986, 188, no. 69, but the moss is not mentioned.
2. Personal comment by Jane Flint 29.05.14.

Acknowledgements

Thanks to Katinka Dalglish for the photograph of the North Cairn Farm fibres, Jane Flint for organising access to the archive and helping with sample permissions, Sherry Doyle for collecting the hair moss reference samples, Caroline Cartwright for advice on reference collections, Pippa White for proof reading and the useful comments of Ulla Mannering, Ben Roberts and two anonymous reviewers.

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Orit Shamir

Textiles from the Chalcolithic Period, Early and Middle Bronze Age in the Southern Levant

Introduction

The Chalcolithic period in the southern Levant (4700/4500–3700/3600 BC; Rowan and Lovell 2011, 1) is characterised by rural settlements based on crop and livestock agriculture. Changes and inventions occurred during this period. For the first time, the production of ceramics was enriched by the introduction of the potter's wheel and improved firing techniques. Also for the first time, tools as well as cult vessels were cast in copper. Some of these objects were produced using the "lost-wax technique". Along with this specialised copper manufacture, basalt, bone, shell and ivory industries also flourished, producing items such as bowls, chalices, statues, figurines and pendants. The lands that are today known as Israel, Palestine and Jordan were at the forefront of global human development.

Textiles, basketry and other organic artefacts dating to the late Chalcolithic period have also been found, especially in the c. 400 natural caves in the Judaean Desert in Israel (for a map see Sebbane, Misch-Brandel and Master 2014, 17). The caves are spread out in the deep canyons and along the high escarpment west of the Dead Sea and the Jordan Valley. They were used for living, burials and refuge. The artefacts are made from a variety of materials and production techniques that reflect the social and economic characteristics of the people who occupied them during various periods. These caves have been key repositories for organic artefacts for thousands of years. The hills around Jerusalem cast a rain shadow forming a region with both extremely low rainfall and low relative humidity. Such inhospitable conditions meant that the area lacked extensive human occupation in all but a few periods, the Chalcolithic and Roman chief among them. In those rare periods, the caves were used mainly for refuge. We know the specific historical circumstances of Jewish refugees in the Roman period, but in the Chalcolithic it is not clear what state of affairs drove people into the wilderness. In both periods, caches of organic objects have added immeasurably to our understanding of the ancient world.

Without the excavations and surveys of the Judaean Desert caves our understanding of the organic artefacts and the use of linen textiles in the southern Levant would have been very poor until the Roman period (Shamir 2014, 140).

The Chalcolithic textiles found in the Judaean Desert offer exceptional insights into early textile production, which entailed a long series of processes from the production of fibres – requiring knowledge of the area's agriculture – to the processing of fibres – involving specialised knowledge of fibre properties and textile production. One of the central questions regarding Chalcolithic textiles concerns their differences and similarities with respect to textiles in neighbouring regions, such as Mesopotamia, Egypt and other contemporaneous cultures (*e.g.* the Neolithic lake

dwelling settlements of Switzerland, which represent some of the oldest finds of this nature discovered in Europe: Médard 2012, 367).
The most important Chalcolithic sites in the southern Levant that have yielded textiles are the Cave of the Treasure and the Cave of the Warrior, but Chalcolithic textiles have also been found in many other caves, including Nahal Ze'elim southwest of the Dead Sea, the Qarantal Cave (Cave VI/46) (Schick 2002, 234) and the Cave of the Sandal (Cave VIII/28) (Eshel and Zissu 2002, 119), both near Jericho. This article presents a survey of the textiles from the Chalcolithic period in the southern Levant and discusses it in light of contemporary material from other regions. Some of the finds will be reviewed in detail below, while a complete list is presented in Table 1, and will also be discussed in comparison to the early and middle Bronze Age textiles.

Nahal Mishmar: The Cave of the Treasure
This cave is the only Chalcolithic burial site in the southern Levant with evidence of exceptional quantities of copper and ivory artefacts (Joffe 2003, 57). The hoard, which was wrapped in a mat, included 432 copper, bronze, ivory and stone decorated objects: 240 mace heads, about 100 sceptres, five crowns, powder horns, tools and weapons. Organic materials found at the Cave of the Treasure include textiles, parts of looms, basketry items, ropes and shuttles. Inorganic artefacts connected with spinning and weaving include stone spindle whorls and one perforated fragment of a bowl which may have been used for spinning (Bar-Adon 1980). The Chalcolithic stratigraphy of the Cave of the Treasure had been disturbed by the later Roman occupancy, and the finds were mixed. At first glance, linen textiles of the Chalcolithic and Roman periods are similar: they have the same colour – undyed cream – and the same weaving technique: a simple tabby

Site	**No. of Chalcolithic Textiles**	**No. of Other Textiles**	**Publication**
Cave of the Treasure	67	25 Roman	Bar-Adon 1980 (published 46 out of 91)
Northern Judean Desert	47		Schick 2002
Lower Wadi el-Makkukh (3 caves) and Makkukh-Qarantal cliff (1 cave)	80	-	Patrich, Arubas and Agur 1988-89; Schick 1998; Shamir and Schick, forthcoming
Cave of the Warrior	3 (shroud, kilt, sash)		Schick 1998
Christmas Cave	53	71 Roman	Shamir and Sukenik 2011
Wadi Murabba'at	2		Crowfoot and Crowfoot 1961 Pers. obs.
Pool Cave	5	20 Roman	Shamir 2015
Nahal Ze'elim	16		Aharoni 1961, 23; Pers. obs.
Nahal 'Arugot	11	2 Roman 1 Islamic	Pers. obs.
Cave of the Horror	1	5	Aharoni 1962
Nahal Yishai	2	2 Roman 10 Islamic	Pers. obs.
Teleilat Ghassul	carbonised		Crowfoot 1954, 432; 1960, 519, Pers. obs. at the Classics and Archaeology at Loyola Marymount University
Nahal Lahat Cave	5		Schick 2002, 231; Pers. obs.
Sinai, *nawamis* sites	unpublished		Schick 2002, 231
Yoram Cave	unpublished		Goldman 2014

Table 1. Summary – Linen textiles from the Chalcolithic period.
NB: Textiles dating to the Chalcolithic period were not found at the Cave of Letters (Yadin 1963) or at the Qumran caves (Shamir and Sukenik 2011).

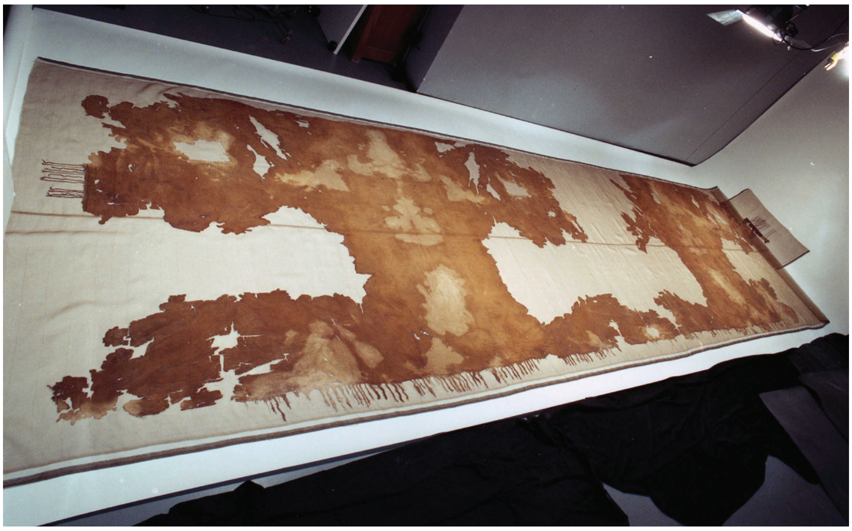

Fig. 1. Cave of the Warrior, linen shroud (Photo: Clara Amit, Israel Antiquities Authority).

Fig. 2. Cave of the Warrior, 'package' of cloth (Photo: Clara Amit, IAA).

weave. As a result, the first publication of textiles from the Cave of the Treasure did not distinguish textiles dating to the Chalcolithic period from those from the Roman period (Bar-Adon 1980). Some scholars used this information to infer that animal fibre was used to make textiles during the Chalcolithic, *e.g.* Frangipane *et. al.* (2009, 27) who wrote that "the only other very early example of a textile made from animal fibers, from the Nahal Mishmar Cave, Israel, is dated to the middle of the 4th millennium". However, we know this is not the case.

The research of Tamar Schick concerning the Cave of the Warrior (Schick 1998) enabled us to distinguish between the textiles from these periods. In this work the textiles from the Cave of the Treasure (including those which were not published) were partly sorted first by Tamar Schick and then by the present author. We sorted and catalogued 87 Chalcolithic linen textiles and 35 Roman-period wool and linen textiles. It is important to note that, in Bar-Adon's publication, s-spun refers to the textiles from the Roman period, while ss-spun refers to the textiles that are from the Chalcolithic period, although he did not know this distinction when he published this material. The Chalcolithic textiles have the characteristic mixture of s-spun and S-plied threads and indicate splicing.

The Cave of the Warrior

The Cave of the Warrior is located near Jericho. A male skeleton (the so-called 'warrior') was found in flexed

Fig. 3. Cave of the Warrior, selvedge elaboration and weft fringes (Photo: Clara Amit, IAA).

Fig. 4. Cave of the Warrior, the deceased was lying on a large plaited reed mat accompanied by a wooden bowl, sandals and basket (Photo: Clara Amit, IAA).

position, wrapped in a linen shroud (Fig. 1). He was buried according to the method of primary burial, in which the body is interred, intact, shortly after death. Interestingly, this method was not the norm in the Chalcolithic period. Most burials discovered from that time were secondary burials in which the bones were collected and deposited in ossuaries. In addition, it is important to note that it is a single burial, as opposed to the multiple burials in ossuaries. The height of the skeleton is approximately 168 cm, and the age at death was estimated at about 45-50 years.

The 'package' of cloth (Fig. 2) was opened at the Conservation Laboratory of the Israel Antiquities Authority by the conservator, Olga Nagnvishki. It was a tangled mass of folded, creased cloth in a fragile condition, covered – like the other objects found in the cave – in a layer of red ochre, which had possibly been sprinkled onto the textile as part of the burial ritual. At first it was impossible to determine what lay within the bundle.

The shroud is a large rectangular linen cloth, 7 m long and 2 m wide, designed and manufactured as a single sheet, and is the largest Chalcolithic textile ever discovered thus far. It is decorated with painted or smeared black asphalt bands and undyed fringes 18 cm in length and secured by knots at their ends. A kilt, smaller than the shroud, was found crumpled inside the latter. One edge of the kilt terminated in a fringe, beautifully formed by 54 cm-long, evenly-spaced tassels. Only the textiles from this cave show

Fig. 5. Nahal Ze'elim, two separate linen textiles wrapped a treasure of c. 12,000 beads, IAA No. 53-1305 (Photo: Clara Amit, IAA).

selvedge elaboration and weft fringes (Fig. 3). The deceased was lying on a large, plaited reed mat. He was accompanied by additional objects, including a flint knife, a bow, arrows, a wooden bowl, sandals and a walking stick (Fig. 4) (Schick 1998).

The good physical state of the skeleton, the heavily worn teeth, the V-shaped wooden bowl, the dung on one sandal, the absence of pottery, and the burial in a marginal area all indicate that the deceased was a pastoral nomad (Ashkenazi and Goren 2010)[1].

Nahal Ze'elim

A treasure of about 12,000 white and blue steatite beads (Bar-Yosef Mayer and Porat 2010) and brownish-red carnelian beads, wrapped in two separate and delicate linen textiles (Fig. 5), was found at Nahal Ze'elimin in 1960 (Aharoni 1961).

Another important discovery from Nahal Ze'elim is a small bag made of white and blue steatite beads in a geometric-diagonal pattern, using linen threads and leather thongs. The handles, decorated with beads, were also preserved (Shamir 2014).

The Cave of the Sandal

In the Cave of the Sandal, burials of seven adults were discovered together with Chalcolithic artefacts such as copper tools and pottery (Eshel and Zissu 2002, 119; Khalaily 2002, 129) alongside a cut and knotted textile (Fig. 12) decorated with fringes and double 'hollow bands'.

Chalcolithic textile production

Flax and linen

The raw material used in all Chalcolithic textiles is flax (*Linum usitatissimum*), which was a principal oil and fibre source in the ancient world and probably the earliest domesticated plant used for textiles (Weiss and Zohary 2011, 249; Zohary, Hopf and Weiss 2012, 1-2). It is considered to be the first fibre and oil crop used in Neolithic Near Eastern agriculture and is often mentioned in the context of the Near Eastern Neolithic 'founder crops' assemblage (Abbo *et. al.* 2014, 52). The Neolithic domestication of flax was an essential prerequisite for Chalcolithic textiles as experimental fibre extraction of wild flax in Israel proved that these plants had surfaces which were too heavily textured to allow for the creation of threads suitable for textiles (Abbo *et. al.* 2014, 59).

Flax was the sole material used for the manufacture of textiles in the southern Levant until the middle Bronze Age (Shamir 2002, 21* and see Rast-Eicher 2005). Linen threads are known to have been present there 10,000 years ago, as they were discovered attached to a comb in the Murabba'at caves (Schick 1995; Shimoy 1995).

Linen fabrics from the Pre-Pottery Neolithic period were preserved only at the cave deposits of Nahal Hemar (Schick 1988; Shimoy and Jucha 1988). They were not woven, but made in a variety of techniques such as looping and knotted netting (Schick 1988; Barber 1997, 191); that is, without the use of a loom. These techniques – looping and knotted netting – disappear in the southern Levant by the Chalcolithic period. The first loom in the southern Levant appeared in the Chalcolithic period and was a horizontal ground loom.

Although sheep were already domesticated at this time, their fleece was kempier and less pliable than wool in the later periods. That appears to explain why wool was not yet a favoured fibre (Schick 2002, 238). Possibly the oldest example of woollen textile is from the North Caucasus dating to 3700-3200 BC (Shishlina *et al.* 2003, 331; 339), but wool with continuous growth appears later: not before the 2nd millennium BC or the end of the Bronze Age (Breniquet 2010, 55).

Fig. 6. Cave of the Treasure, splicing, IAA No. 2002-9206 (Photo: Clara Amit, IAA).

Spinning and splicing

The Chalcolithic linen threads from this region are s-spun, coinciding with the natural spin direction of flax fibres. The textiles have the characteristic mixture of s-spun and S-plied threads. Plied threads are considered characteristic of early textiles (Schick 2002, 238) until the middle Bronze Age in the southern Levant, and indicate splicing (Fig. 6). Late Bronze Age textiles are already s-spun (*e.g.* Shamir and Baginski 1993).

The term 'splicing' is used to describe the addition of fibre bundles (strips) to produce a continuous thread. Flax fibre was removed from the stem of the flax plant by stripping. The flat strips consist of distinct bundles of fibres lying side by side.

The ends of individual fibres or fibre bundles were overlapped and twisted or spliced together by rolling the ends between the thumb and index finger, secured by the adhesive properties of the plant's natural pectin (Barber 1991, 47; Granger-Taylor 1998, 103; Leuzinger and Rast-Eicher 2011, 537; Gleba and Mannering 2012, 10; Wild and Wild 2014, 73). As in Europe, the change from splicing to spinning occurred during the Bronze Age, when combing was introduced as a further processing stage to produce fine, separated fibres. This method meant that a single yarn could be spun continuously instead of splicing it (Leuzinger and Rast-Eicher 2011, 540; Rast-Eicher 2012, 381).

Although the production of spliced thread is possible without a spindle, the process appears to be difficult without rotation, as the spliced flax thread requires quite a lot of spinning (Leuzinger and Rast-Eicher 2011, 540). Scenes of splicing are depicted on wall paintings in Egypt from the Middle Kingdom (Barber 1991, 44-48; 53, Figs. 2.5. 2.6; Barber 1997, 192). The earliest Egyptian textile is a piece of linen from the Fayyum, dated to the early 5th millennium BC (Caton-Thompson and Gardner 1934, 46; Hall 1986, 11; Vogelsang-Eastwood 2000, 268), and shows clear evidence of splicing. This textile is crude, the weave is plain weave, but rather loose and uneven, and the thread is coarse. Moreover, it is z-spun, S-plied, unlike other textiles found in Egypt, as though the strong later tradition had not yet been settled upon (Barber 1991, 48; 145). Splicing was the standard method in Egypt until Ptolemaic times and in Lower Nubia until the Middle Ages (Wild and Wild 2014, 73-74). Splicing is also known in Europe, for example at Neolithic (second half of the 5th millennium BC) pile-dwelling settlements in eastern Switzerland (Leuzinger and Rast-Eicher 2011). It appears to have been one of the earliest yarn-making technologies used by the prehistoric inhabitants of Europe (Gleba and Mannering 2012, 10), the southern Levant and Egypt.

A few of the Judaean Desert Chalcolithic textiles have threads of varied thickness in the same cloth. The spinning tightness or the angle of spinning is between 45^0 and 20^0 (Emery 1966, 11-12). In contrast to later periods, during the Chalcolithic period there are usually no differences between the warp and the weft with regard to spinning characteristics.

Spindles, whorls and spinning bowls

In the southern Levant a suspended spindle has been used for thousands of years from the Neolithic period;

Fig. 7. Cave of the Treasure, remains of the horizontal ground loom, IAA Nos. 1961-1172, 1961-1174 (Photo: Clara Amit, IAA).

it is still in use by the Bedouins today (Shamir 1996, 149). Hundreds of spindle whorls were found in the Beer Sheva Valley Chalcolithic settlement sites. They were discussed by Levy and Gilead who stated that flax was grown in the Jordan Valley and spun in the Beer Sheva Valley (Levy and Gilead 2013a; 2013b). Very few whorls were found in the caves: four spindle whorls made of stone (two chalk, one basalt and one unidentified stone) and four made of reused ceramics were discovered at the Cave of the Treasure (Bar-Adon 1980, 183-185) and are typical of this period.

Spinning bowls with interior handles (1-4) were used to stop the ball of rove rolling away, for plying and for holding water because dampness is helpful to the spinning of linen yarn. They are depicted in Egyptian wall paintings and models and actual spinning bowls have been found on excavations such as at Neve Ur and Bires·Safadi (Dothan 1963; Perrot *et. al.* 1967, 223; Barber 1991, 48; 77-78; Levy and Gilead 2013a, 32). The use of spinning bowls is likely to have been very limited in the southern Levant compared to Egypt, and the suspended spindle with a spindle whorl was used here usually without the bowl.

Horizontal ground loom

Remains of wooden beams from a horizontal ground loom (Fig. 7) were found only at the Cave of the Treasure (Bar-Adon 1980, 178-182). This equipment was ideal for producing narrow textile strips like the bandage found in the Cave of the Warrior. The bandage was not just a strip of a larger piece of fabric but was a cloth with finished selvedges (Schick 1998, 17). This type of loom is also known from Egypt (Roth 1951, 3; 8; Forbes 1956, 192; 195; Broudy 1979, 38-44). The earliest depiction is on a bowl from 5000 BC found in Egypt (Vogelsang-Eastwood 2000, 276). This kind of loom was used by many cultures of the ancient Near East and is still in use today, for example in Turkey and amongst the Bedouins. Because of its size and the shape of the small beams, Breniquet (2010, 52) suggested that the loom from the Cave of the Treasure was a backstrap loom (with one bar attached to a fixed object and the other to the weaver, usually by means of a strap around the back), but there are no indications for the use of this loom in the southern Levant. It was and still is predominantly used in Central and South America.

No. of threads per cm (warp/weft)	Site
9-45/7-30	The Cave of the Treasure
11-14/8-11	The Pool Cave
7-28/7-22	Judaean Desert caves: Lower Wadi el-Makkukh
11-32/10-22	Northern Judaean Desert: Cave VIII/9
11-46/9-26	Cave VI/46
14-16/7-8	Cave X/31
10-20/10-14	Cave III/3
9-28/9-20	Cave III/7
15-20/11-13	The Cave of the Warrior
12-13/13-14	Teleilat Ghassul

Table 2. Thread counts in Chalcolithic textiles.

Fig. 8. Cave of the Treasure, very delicate linen textile, 60-151-d, IAA No.1961-1269 (Photo: Clara Amit, IAA).

Although Bar-Adon (1980, 182-183) thought that elongated perforated stones found at the Cave of the Treasure might be loom weights, there is no evidence for loom weights in Israel until the Middle Bronze Age I period (Shamir 1996, 139). Uri Davidovich, who examined all the stones from the Treasure Cave, did not find such stones. However, bone shuttles were found there, one of them bearing a thread in the hole (Bar-Adon 1980, 177).

The horizontal ground loom was replaced by the warp-weighted loom during the Middle Bronze Age II period (Shamir 1996, 139) (and not before) in the southern Levant. It had already been in use in Anatolia in the Neolithic period (Çatal Hüyük: Barber 1991, 129-132; 166).

Weaving

The predominant weaves found in the Chalcolithic southern Levant are various types of plain weave (tabby). Some are executed using a balanced tabby weave, in which the number of threads per cm in the warp equals that in the weft. A few textiles are warp-faced tabbies, in which the number of warp threads per cm is significantly higher than the number of wefts. The weaves range in density from very loose to very dense, the majority being of a medium density. At the Cave of the Treasure, the number of threads per cm ranges between 9 and 45 in the warp, and 7 and 30 in the weft. One specimen (60-151-d, IAA No.1961-1269, Fig. 8) is very delicate, even transparent, with 44-45 warp threads per cm and 30 weft threads per cm (Bar-Adon 1980, 173, Fig. 1).

Edges

Hems and selvedges were noticed at the Cave of the Treasure. Hems are the edges of fabrics which were cut along the warps, folded two or more times

Fig. 9. Cave of the Treasure, textile decorated with single weft blue thread, IAA No. 2012-9003 (Photo: Clara Amit, IAA).

Fig. 10. Nahal Mishmar, undyed cream warp threads and dark brown weft threads, IAA No. 2012-9006 (Photo: Clara Amit, IAA).

Fig. 11. Cave of the Treasure, linen undyed and undecorated, IAA 2002-9221 (Photo: Clara Amit, IAA).

Fig. 12. Northern Judaean Desert, textile decorated with fringes and 'hollow bands' (Photo: Clara Amit, IAA).

and sewn, which means that they were cut from an originally larger piece. Plain and reinforced selvedges were found among the Chalcolithic textiles. A complex treatment of the edge is discerned at northern Judaean Desert caves (Schick 2002, 231; 234): the decorative lines were woven in a soumak trapping technique and the warps were braided and twisted, becoming strands in a fringe. Only the textiles from the Cave of the Warrior show selvedge elaboration, a weft fringe, terminal decorative bands in basket and half basket weave, warp tassels and a narrow warp stripe of yarn with concentrated tannins (Schick 1998, 6-22).

Colour and decoration

Painted or decorated textiles from the Chalcolithic period are rare and dyed textiles were not found. Most of the Chalcolithic textiles in this region are undyed, ranging from off-white through to cream and beige. The lack of decoration on most of the textiles is understandable due to the fact that linen does not easily absorb dye, with the exception of blue dye (Shamir and Sukenik 2011, 216). A few of the textiles are bleached. Bleaching was a long process intended to whiten linen textiles, which are naturally of a grey-brown colour. The textiles were soaked in cleaning and whitening chemicals and then exposed to the sun for weeks, during which time they became white (Forbes 1956, 95).

As noted above, coloured (but not dyed) textiles were found at the Cave of the Warrior with black bands of paint or smeared asphalt. In addition, reddish spots on the shroud of the male burial have been identified as ochre, possibly sprinkled onto the textile as part of the burial ritual (Koren 1998, 101). The shroud is decorated with fringes at the warp (54 cm long) and the weft. One of the textiles from the Cave of the Treasure (IAA 2012-9003, Fig. 9) is decorated with a single blue weft thread. A textile from Nahal Mishmar (IAA 2012-9006 Fig. 10) has undyed cream warp threads and dark brown weft threads. Nahal Ze'elim textile No. 2006-9025 is a linen strip with two preserved selvedges, decorated with a running stitch in a brown colour. The others are not decorated or dyed, not even No. 61-29/7-a (IAA2002-9221, Fig. 11) which Bar-Adon (1980, 162) claimed was decorated with selfbands.

A textile from the northern Judaean Desert from Qarantal Cliff (cave VI/46) is decorated with fringes and double 'hollow bands'. The missing threads suggest that colour threads, now disintegrated, might have decorated this textile (Fig. 12; Schick 2002, 234). The undulating surface of textiles that looks as if the cloth had been intentionally pleated was noticed at Cave VIII/9 in the northern Judaean Desert (Schick 2002, 236, Figs. 26-27), as sometimes seen in Egyptian funerary dress (Landi and Hall 1979). At Lower Wadi el-Makkukh and the adjacent area (Shamir and Schick forthcoming), one textile has the warp made of undyed cream and different shades of brown and is decorated with a somewhat darker brownish band. The weft is made of different shades of brown and red. The red colour was probably obtained from ochre.

Quality

The labour required to produce flax threads, from the initial state of growth to the last stage of spinning, includes multiple steps of processing and implies both a high level of skill and a great deal of labour. The quality of the Chalcolithic textiles is generally high, flax fibre processing having been based on thousands of years of experience of using tree bast fibres (Leuzinger and Rast-Eicher 2011, 535). Weaving faults are rare, indicating a long tradition, although a few faults were observed at the northern Judaean Desert caves (Schick 2002, 224; 231; 235).

Use

It is impossible to identify the use of the textiles at the Cave of the Treasure because they are all small and usually without edges or sewing. A scrap of fabric was found inside a mace head in the treasure. Cave 2 nearby the Cave of the Treasure yielded clothing remains found on a skeleton (Bar-Adon 1980, 153). The shroud at the Cave of the Warrior was made especially for that purpose. Garments, including a kilt and a sash inside the shroud, were also found at the Cave of the Warrior (Schick 1998).

At Ze'elim thousands of beads were found wrapped in two linen textiles, but it is difficult to determine whether that textile was in secondary use. It is worth mentioning that among the fragments in the Judaean Desert caves there are narrow, cut, band-like items, probably in secondary use for tying or bandages. In general, the fragments may have originated from garments. But one from the Cave of the Treasure is in primary use, its width is 7 cm and both selvedges are preserved with a length of 25 cm (Fig. 8) (Bar-Adon 1980, 173).

Origin

The textiles considered here probably originated from southern Levant sites. Flax could be grown in the Jordan Valley at sites such as 'En Gedi (Bar-Adon 1980, 185), Jericho or the Beth She'an Valley (Schick 2002, 238). These sites are suitable for flax cultivation as the plant needs plenty of water and a hot climate. Thousands of years later, during the Roman period but also during the Iron Age, these areas were famous for their linen products (Diocletian's Price Edict section 26; Pausanias 5.5.2; Shamir 1996; 142; Shamir 2007).

Bar-Adon assumed that some of the textiles found at the Cave of the Treasure were produced there. However, almost no fibres or threads have been found that were ready for use except a ball of fine linen thread wound around a small stone (Bar-Adon 1980, 211), and only a few artefacts related to spinning and weaving were found in the cave. Schick concluded that the textiles found in the northern Judaean Desert caves were most likely not woven there (Schick 2002). The spinning and weaving of these textiles may have been done in semi-arid zone sites which have yielded many spindle whorls, such as at Bir es-Safadi, Teleilat Ghassul and Gilat (Levy and Gilead 2013a, 26-27; 41).

Fig. 13. SEM photo of early Bronze Age plain weave from Ramon I rock shelter (Photo: Einat Nativ Roth and Janet Levy of the Archaeological Division, Ben Gurion University of the Negev).

Fig. 14. Rishon le-Zion. A linen textile and threads (IAA No. 1996-9304). Middle Bronze Age II. (Photo: Clara Amit, IAA).

In any case, these textiles did not originate in Egypt, as they are completely different from the textiles from the Fayyum. According to Barber (1991, 145) "one has to suspect from this mixture of details that one is looking at the very beginning of the art in Egypt, and that the technology of textiles had only fairly recently spread southwest from Palestine".

Flax that was cultivated in the Near East was not grown in Egypt as a wild plant. Flax is not native to Egypt and it is possible that it was imported into Egypt from the Levant (Vogelsang-Eastwood 2000, 269).

Early and middle Bronze Age textiles

The abundance of Chalcolithic textiles is impressive in comparison to the rarity of such remains from the early Bronze Age. Up until today, with the exception of the linen textile from Bareqet (Shamir 2005), a few textiles from the Rock Shelter in the Makhtesh Ramon (Fig. 13; Shamir and Rosen 2015) and threads adhering to metal from Hurvat Gilan (excavated by Y. Cohen) and Gesher (excavated by S. Cohen; pers. obs.), almost no early Bronze Age textiles have been found.

Middle Bronze II textiles and threads were found at Rishon le-Zion (Fig. 14) indicating that splicing still existed in this period (Shamir, forthcoming).

All the fabrics in Israel from the Neolithic until the early Bronze Age were made of linen. Wool textiles are found for the first time at Jericho in the middle Bronze Age (Crowfoot 1960, 521; Shamir, pers. obs., University College London).

Conclusion

Nahal Hemar yielded fabrics which were not made on a loom. Neolithic textiles have been found in Asia Minor (Çatal Hüyük and Çayönü in south-eastern Turkey: McCorriston 1997, 519) and in Mesopotamia, where textiles rarely survive (Breniquet 2010, 52), but tabby textile imprints on clay and bitumen from Jarmo (northern Iraq) dating to 7000 BC suggest the use of a loom (Adovasio 1977). A cylinder seal from Susa dating to the fourth millennium BC shows a ground loom, weavers and the preparation of a warp (Breniquet 2010, 53; 62), and, as noted, the earliest depiction is on a bowl from Egypt dated to 5000 BC (Vogelsang-Eastwood 2000, 276).

The first woven textile assemblages are the Judaean Desert Chalcolithic textiles and other organic items; these have almost no parallel outside the Judaean Desert due to differences in terms of preservation (Davidovich 2008). Textile production during this period was carried out on a large scale as indicated by sites with a sudden and dramatic profusion of spindle whorls such as at Bir es-Safadi, Teleilat Ghassul and Gilat – evidence of the intensification of spinning (Levy and Gilead 2013a, 26-27, 41), as also found in the Chalcolithic culture of the Golan Heights (Epstein 1998, Fig. 21).

According to Davidovich (2008), the caves were used mainly for refuge. This is further demonstrated by the analysis of the material culture assemblages, including pottery, stone and ivory, the manufacture of copper artefacts, and the use of the potter's wheel, as well as by comparing the pattern of cave use in the late Chalcolithic with that of other historical case studies, such as those of the Bar Kokhba period (132–135 AD). In both periods the nearly inaccessible caves were used for refuge and not as dwellings.

Textiles dating to the Chalcolithic period are the earliest examples of loom-woven fabrics found in Israel, and provide exceptional insight into early textile production. This serves to confirm not only that the production techniques of textile crafts were already well advanced during the 5th and 4th millennia BC, but also that cloth production during the Chalcolithic period in the southern Levant was limited in its variety.

Note

1. The artefacts from the Cave of the Warrior were exhibited in the Natural Museum in New York in 1998, at the Institute for the Study of the Ancient World in New York and in San Francisco in 2014 at the exhibition *Masters of Fire: Copper Age Art from Israel* (Sebbane, Misch-Brandel and Master 2014; Shamir 2014).

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Photos of Chalcolithic textiles of the Israel Antiquities Authority can be found at http://www.antiquities.org.il/t/search_en.aspx?indicator=21

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Claudia Merthen

Brocaded in Gold

Two Tablet-Woven Baldrics at the Germanisches Nationalmuseum, Nuremberg, Germany

Introduction

In the collection of weapons and arms at the Germanisches Nationalmuseum (GNM), Nuremberg, Germany, there are two magnificent sabres from Morocco (Figs 1 and 2). They are on loan from the Paul Wolfgang Merkel'sche Familienstiftung (Diefenbacher *et al.* 2006). These sabres, listed under inventory numbers W3273 and W3274, attracted my attention during a visit to the storerooms of the Department of Weapons and Hunting Culture because of their textile parts. The broad bands to carry these weapons seemed to be especially interesting because they are tablet-woven in a special technique and due to their unexpected and mostly unknown usage. There has been no previous investigation or publication, either of these objects or on the woven straps of these 'Nimchas', the technical term for this kind of sabre. As the baldrics and sabres form an ensemble, the latter had to be taken into account as well. So the purpose of the investigation was to explore not only the technique and technology of the baldrics but also the cultural-historical context of the sabres. The following represents the first results of this research.

Cultural-historical background

Nimchas are swords of a special shape, construction and origin (Stone 1961, 469). There is some variety within their parts, the hilt and blade and especially the scabbard. Nimchas like W3273 and W3274 seem to belong to a separate group, which – beside some features of the swords themselves – is ostentatious in the design of the scabbard and the baldric. The baldrics are sparsely documented since most Nimchas are preserved without them. Nevertheless, they form an important part of the Nimcha ensembles, because they were made for presentation and splendour as well.

The Nimchas from the GNM can be dated to the end of 18th or to the beginning of 19th century AD, as shown by comparison with parallel examples (so far these stem only from the art market, such as the Nimcha from Meknès, northern Morocco: MarocAntics 2015). At first glance they look identical, but they are not (Fig. 3). The green colour of W3273 is darker than that of W3274 which has more yellow in the textile parts, in the enamel paste of the mounts, locket and chape, on the scabbard and also in the velvet that covers the scabbard which can be seen between the mounts. This set-up of a main colour is characteristic of each of the complete ensembles I have found so far to draw comparisons from. They are only a few, and the dominating colour can be green, blue or red. As there are many Nimchas where the scabbards have the same appearance and construction as those at the GNM, it is quite likely that they originally also had the same kind of extravagant baldrics.

Description

The textile parts of the baldrics consists of tablet-woven bands, tassels made of cords and – for W3273 – cords to attach the baldric to the two suspension rings on the scabbard. There are also some additional metal parts, probably made of silver: the ends of the textile hanger and several ornaments in the form of hollow spheres and cones. My research deals with the straps used for hanging the sabres across the shoulder:

Fig. 1. Baldric W3273 from the Germanisches Nationalmuseum (© Claudia Merthen).

Fig. 2. Baldric W3274 from the Germanisches Nationalmuseum (© Claudia Merthen).

the baldrics. They are 1 m in length and 4.5-5 cm in width and made of green-dyed silk (Figs 4 and 5), as revealed by investigation of single filaments through the binocular microscope (Hauptmann 1951, 126 fig. 145, 127 fig. 146). The fibres are without serizin coating ('silk bast') and have the characteristic 'lice' which are formed during the removal of the bast and the further processing of the material (Hauptmann 1951, 66). For this reason the silk can be identified as mulberry silk.

The straps are tablet-woven in a brocading technique; 65 and 67 tablets, respectively, ordered alternating in Z and S direction, were turned in one direction continuously for very long parts of the bands – either forward or backward. There are only a very few points where a change in the turning direction can be determined; sometimes they are hidden within a pattern in a perfect manner. The number and position of the warp threads crossing the brocading weft on the

Fig. 3. Different kinds of colour in baldrics W3274 and W3273 (© Claudia Merthen).

Fig. 4. Detail of baldric W3273 (© Claudia Merthen).

Fig. 5. Detail of baldric W3274 (© Claudia Merthen).

surface of the weave form a sequence that reveals that these tablets had six holes. On both selvedges, three tablets with two threads in every hole were used. The warp consisted of singles of s-spun silk filaments, the weft of a looser, lightly s-turned bundle of fibres (Fig. 6). Because one end of the baldric W3274 is broken, it is possible to get an impression from the 'inside' of the weaving, the quality of the threads and the original colour of the silk.

There are technical aspects that are so far known only from these baldrics. The secondary weft for brocading uses a group of eight wires with a round cross-section made of gilded silver; this was determined through X-ray fluorescence spectroscopy. At the beginning and the end of the brocaded pattern these wires cross the back to reach the corresponding position on the front (Figs 7 and 8). When the pattern covers nearly the whole band, the wires turn around the warp threads of the third tablets from the edges. All the pattern lines are created by the warp crossing the brocading weft by a different number of threads.

The patterns on both bands are very similar. They are constructed symmetrically. The main pattern is made from netted rhombuses and star-like motifs, connected with stripes resembling knots and groups of smaller rhombuses. On W3273, an eight-pointed star with a star or sun inscribed follows three rhombuses. This pattern is repeated three times and finishes with three rhombuses. On W3274, the pattern starts with three rhombuses at each end. After these an eight-pointed star follows, with zigzag lines inside, after which there is another rhombus with a regular six-pointed star in the centre. Narrow stripes frame the middle pattern with arrows, crosses and rhombuses and also a zigzag line not made particularly regularly or carefully. The broad pattern on both sides finishes with a small rhombus and a star motifs, respectively. The turning points of the tablets are hardly visible; the motifs were constructed very skillfully to cover the floating warp threads.

Fig. 6. View from 'inside' baldric W3274 (© Claudia Merthen).

Discussion

The technique and shape of both baldrics at the GNM are so similar that they could have been made at the same workshop or by the same hand. This kind of brocading, including the use of tablets with six holes and a bundle of wires for the secondary patterning weft, seems to be known only from Nimcha ensembles with preserved baldrics. The baldric technique and patterns on the other Nimcha ensembles noted so far bear a striking resemblance to those from the GNM (MarocAntics 2015; from Morocco, probably late 19th – mid 20th century AD: Schiettecatte and Nieminen 2015; from Morocco/Mahgreb, no date specified: Teulière 2015, fig. at the end of the website; and perhaps also the Nimcha pictured in Stone 1961, 469 fig. 594 no. 1, but this is still to be confirmed). Where the provenance is known, they come from northern Morocco.

Striking analogies in technique and pattern can be found in the bands used as head-dresses by Jewish women in Morocco (Collingwood 1982, 343 pl. 202), documented in photographs from Jean Besancenot dated to 1935 (Centre de la culture judeo-marocaine, phototèque, http://www.judaisme-marocain.org/objets_popup.php?id=17620 [1.10.2015]). It is conceivable that the Jewish imagery and that from the baldrics interrelate and that this weft brocading technique is a special one exclusive to Morocco.

Visual resemblance for the warp crossing the brocading gold weft could also be found within the right-hand edge of a band from a 12th-century chasuble from Palermo (Collingwood 1982, 345 pl. 203), in a band on the chasuble attributed to St. Wolfgang, bishop of Regensburg, 11th/12th century (Spies 2000, 120 fig. left) and in a mosque motif on a mitre from the 12th/13th century (Spies 2000, 179 fig. right above). Here the weft passes under more than one warp so that the warp forms a special appearance. This kind of warp crossing seems to be a matter of technique, but in these cases the tablet should have had four holes.

Conclusion and perspectives

Nimchas with their preserved baldrics are a hitherto unexplored research area in tablet weaving and well worth studying. Therefore, by expanding my investigation to the Moroccan and Jewish set of brocading techniques and patterns, I hope to further knowledge in this area.

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Fig. 7. The back of baldric W3273 (© Claudia Merthen).

Fig. 8. The back of baldric W3274 (© Claudia Merthen).

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Textiles of the 17th and 18th Centuries from the Excavations at Tara Fortress, Siberia, Russia

Introduction
There were several key moments in the formation of the Russian Empire: one of these was the accession of Siberia. At the end of the 16th century, Russian expeditions travelled thousands of miles to the east of the Ural Mountains and reached the coast of the Pacific Ocean. In 1594, by order of the Russian Tsar Feodor I, Prince Andrew Yeletsky was sent to Siberia with a large army (about 2,500 men). To consolidate Russian influence in the region, Yeletsky was ordered to build a fortified city with a small fortress – Tara. Its purpose was to protect Russian lands in Western Siberia from steppe nomads. Other aims were to defeat Khan Kuchum, the previous ruler of Siberia, to conquer and take tribute from the Tatars, who lived on the banks of the Irtysh River, and to establish arable land in the new territory. Tara was a military, commercial, and diplomatic centre for Russia in the south of Western Siberia for almost two centuries.
During the entire 17th century, the fortress of Tara was constantly besieged by nomads – the Dzungars, Kalmyks and Kazakhs, who came from the steppes of Central Asia. For the whole of this century the population lived under the protection of two lines of fortifications – the *burg* and the castle. For this entire period, the size of Tara was confined within the walls that were built in 1594. As a result, the area of the fortress contains a huge cultural layer, *c.* 2.5-4 m thick. Tara fortress is now a small town, located 300 km north of Omsk, one of the regional centres of Western Siberia (Fig. 1). Archaeological excavations have been conducted there since 2007. Archaeologists of the Omsk branch of the Institute of Archaeology and Ethnography of SB RAS work as part of the programme of historical and archaeological study of the culture of the first inhabitants of Siberia. The objective of this work is to study the historical plan of the fortress, the appearance of its inhabitants, the fortification systems and armaments of the fortress,

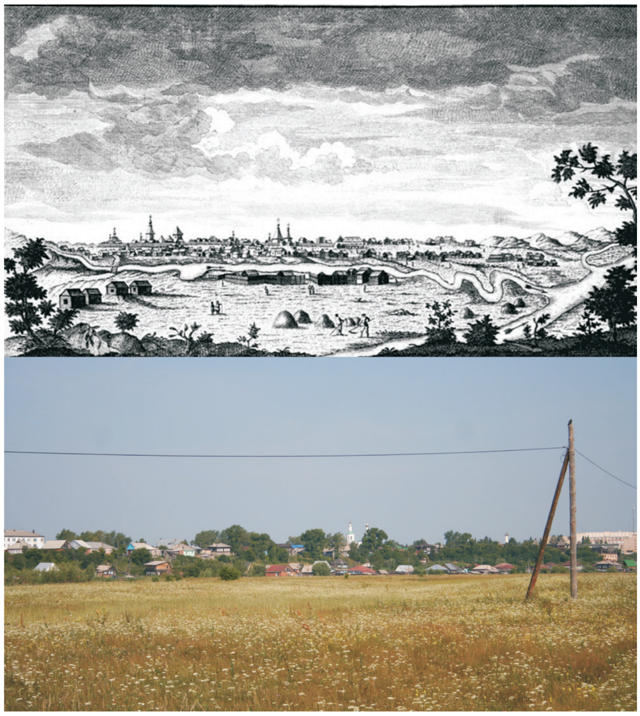

Fig. 1. Tara fortress at the beginning of the 18th century (Drawing: Lurcenius) and modern Tara (Photo: Authors).

Fig. 2. Wooden construction from the beginning of the 17th century (Photo: Authors).

as well as the correlation between the evidence from written documents and the archaeological materials regarding key events in Siberian history.

Specialists and students at Omsk State University, Tomsk State University and the Tara branch of Omsk State Pedagogical University have been working together in the study of Tara fortress. The general management of the excavations is carried out by Sergey F. Tataurov. The uniqueness of Tara as an archaeological site is the abovementioned thick cultural layer. The beginning of its formation dates back to the founding of the city of Tara. In the 1970s, the construction of several buildings (administration, post office, Palace of Culture) destroyed part of the earlier occupation levels, but the central part of the earlier settlement is still preserved (Fig. 2).

During the course of eight field seasons, about 1,000 m^2 of the territory of the fortress were excavated and many archaeological finds were recovered, including wooden objects (dishes, kitchen utensils, vessels, floats for nets and fishing rods, pine bark, children's toys), leather objects (shoes, belts, a cover for a weapon), woven and knitted items made from sheep wool and horsehair (fragments of clothes and stockings) and twisted and braided products made from plant fibres (ropes and one example of a shoe insole). The numerous woven, knitted and twisted and braided products that have been preserved are mainly from the lower layer, dating from the end of the 16th century to the first half of the 18th century. The recovery of the textile fragments, which vary in size from a few square centimetres to several square decimetres, provides a unique opportunity to study the clothing of the city's inhabitants during this period. Approximately 200 fragments of textiles and ropes have been found so far; to date, 68 samples have been studied.

Methodology

The textile and rope fragments at Tara fortress were recovered during the excavation of a private estate. They were found at a depth of about 3 m from the surface and deeper (fourth and fifth building horizons: not later than the beginning of the 18th century), in the areas between the wooden buildings: all the complexes of the estate studied were damaged by fire, but outside the residential properties a large number of organic material objects were preserved. Of the 68 samples studied, 31 are woven, seven are knitted, and 30 are braided and twisted plant fibres.

The study of the samples was carried out in the laboratory of historical research at Surgut State Pedagogical University, using established methods (Glushkova *et al.* 2011): visual inspection; examination under the binocular microscope; sampling for chemical analysis to detect dyes; structural analysis (weave type, thread density in warp and weft, spin direction, twist angle and diameter of threads, thread evenness, *etc.*); searching for technological analogies and reconstructions of some of the textiles (physical modelling using an experimental method and woven reconstructions).

The use of the textiles

It was in the initial period after the fortress's foundation that the range of clothing items worn by the inhabitants of Russian Siberia was established. Ermak's earlier campaign (1581-1585), which led to the defeat of the Siberian khanate, showed that the Russians had no knowledge of the geographical and climatic conditions of this region. For this reason, there were a high number of cases of frostbite and death from hypothermia among the first Russians in Siberia. The clearest example of this is the campaign of Prince Semen Bolkhovsky in Western Siberia in 1583, when he and his 300 men were completely unprepared for the winter in Isker (the capital of Khan Kuchum) and died from hunger and cold. Because the Russian army were not prepared for the harsh Siberian conditions, military garrisons in Siberian towns and fortresses did not have a special uniform before the middle of the 18th century, when uniforms were gradually introduced (Alisov *et al*. 2014, 89).

There were two ways to obtain a textile in the fortress of Tara. The first was to produce it at home (in this case, the manufacturing technology of the archaeological textiles can be compared with the technology of textile production in the towns of the European part of Russia). The second was to buy it from merchants, who came with the caravans from the Bukhara khanate, located in Central Asia to the south of the Aral Sea. These merchants appeared in Tara with Chinese textiles, especially silk, and textiles from Bukhara, made of cotton.

The first Russians who lived in Siberia quickly understood that to survive during the cold Siberian winters it was vital to have warm clothing. One way of achieving this was to use items of clothing made from wool, primarily special clothes which were worn under the usual shirts, trousers and dresses, creating several layers of clothing. This also included the insulation of the legs using long wool socks and stockings (Fig. 3). These wool garments are highly visible among the clothing collection recovered from the excavations at Tara, but are not mentioned in written sources. However, in Siberian folklore, in the form of traditional riddles popular with young children, there are a lot of references to multiple layers of clothing: "grandfather sits dressed in a hundred coats", "there are one hundred pieces of clothing and all without fasteners".

Another method of ensuring clothing was warm was to use the materials and parts of the costume used by the indigenous population of Western Siberia. For the population of Tara this is primarily seen in the use of felt. Almost from the time of its foundation, Tara fortress became the centre of Russian trade in Western Siberia with Central Asia. The first caravan came to Tara in the spring of 1595, six months after its construction. A very large range of felt products – hats, shoes, outerwear, rugs, blankets, *etc.* – were among the goods that were transported by Bukhara merchants. When peoples from Bukhara settled in Tara (at the beginning of the 17th century), felt began to be produced locally. This was facilitated by the fact that Siberian Tatars and immigrants from Central Asia engaged in sheep breeding, thereby ensuring the supply of raw material needed for this craft. The Russians began to make felt themselves in the 17th century. Using this technique they produced padded armour, which made it possible to withstand the Siberian cold on long military patrols.

The inhabitants of Tara also began to use special boots made from felted wool – *valenki* ('Shoes felted' 1959; Forrester 2007). It should be noted that this type of boots, worn by Siberian peoples, began to be used much earlier than in European Russia, where their widespread use only began in the 19th century (for the process of making *valenki*, see 'Technology for manufacturing boots' n.d.).

A few tools for the production of *valenki* and felt covers for shoes (*tver*) were found during the Tara excavations. There is an interesting story connected with the covers. The Russian emperor Peter the Great approved regulations relating to the uniforms for officers of certain ranks. One of the points in these regulations was the obligation to wear a specific type of footwear. But in Siberia, due to the low temperatures, it was possible to get frostbitten feet just in the time it took an officer to travel in a cab from his home to his place of service. So on top of his boots he wore warm felted covers, which were removed at the entrance to the room and put to dry (Bogomolov and Tataurov 2010, 91-96). In addition to the use of felt for padded armour and *valenki*, it is traditional for Russians to insert a felt lining into winter hats.

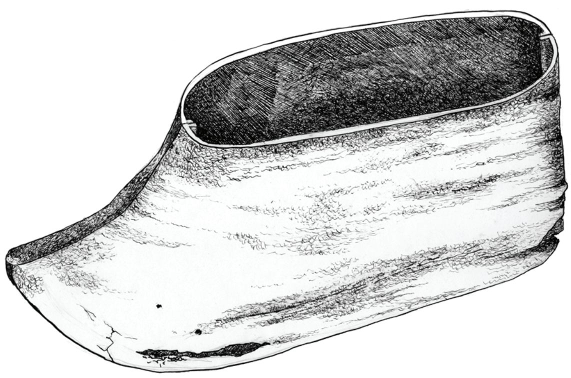

Fig. 3. Felted boots made from sheep wool (Drawing: Authors).

Description of the textiles

The information on the Tara textiles presented here represents a first overview of the material, which will be presented in detail once the rest of the collection has been fully studied. Based on the analysis of the textile samples studied to date, the textiles in Tara were made in two ways: either using a simple horizontal loom or by hand knitting. Both plain weave (Fig. 4) and 2/2 twill (Fig. 5) woven textiles are present. Twill fabrics are dominant in the collection.

Woven material

All the samples of 2/2 twill fabric have the same type of thread (0.8-1 mm, z-spun) and an even density in the warp and weft: from 7-8 to 10-11 threads per cm (the general characteristics of the different weaves are given in Table 1). These fabrics are made from wool of natural colours. Plain wool weaves are more varied. There are textiles with thin and uniform threads, but with different spinning directions (z- or s-spun; Fig. 6). There are also fragments of home-produced textiles made from coarse threads. Some of the fabrics are made with the same type of z-spun thread in warp and weft. One sample was a dense and fine fabric

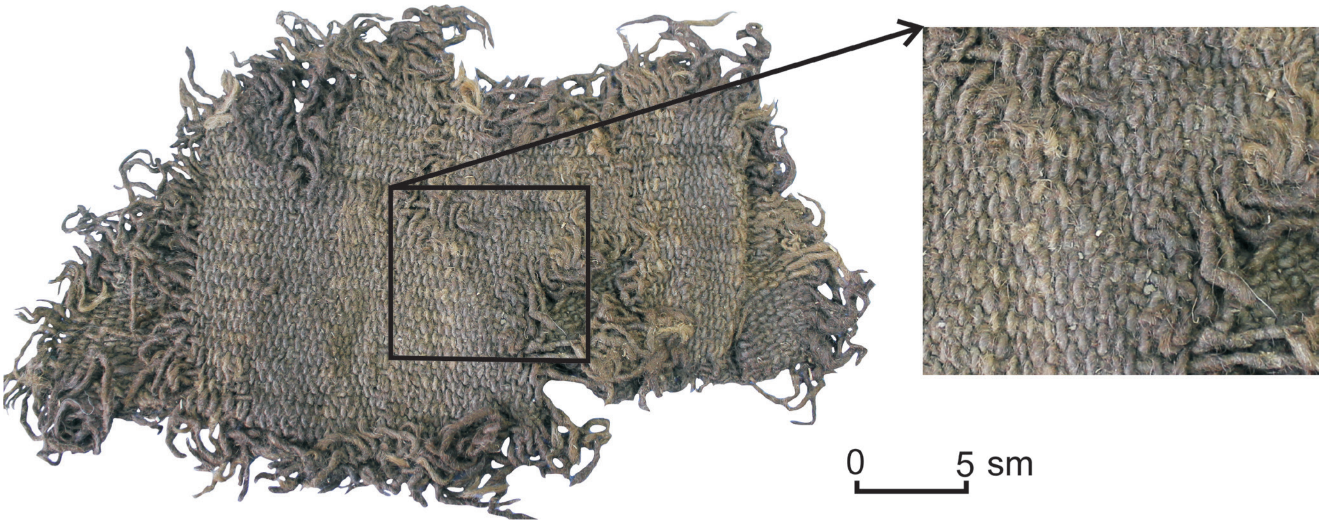

Fig. 4. Plain weave fabric (the scale is in cm) (Photo: Authors)

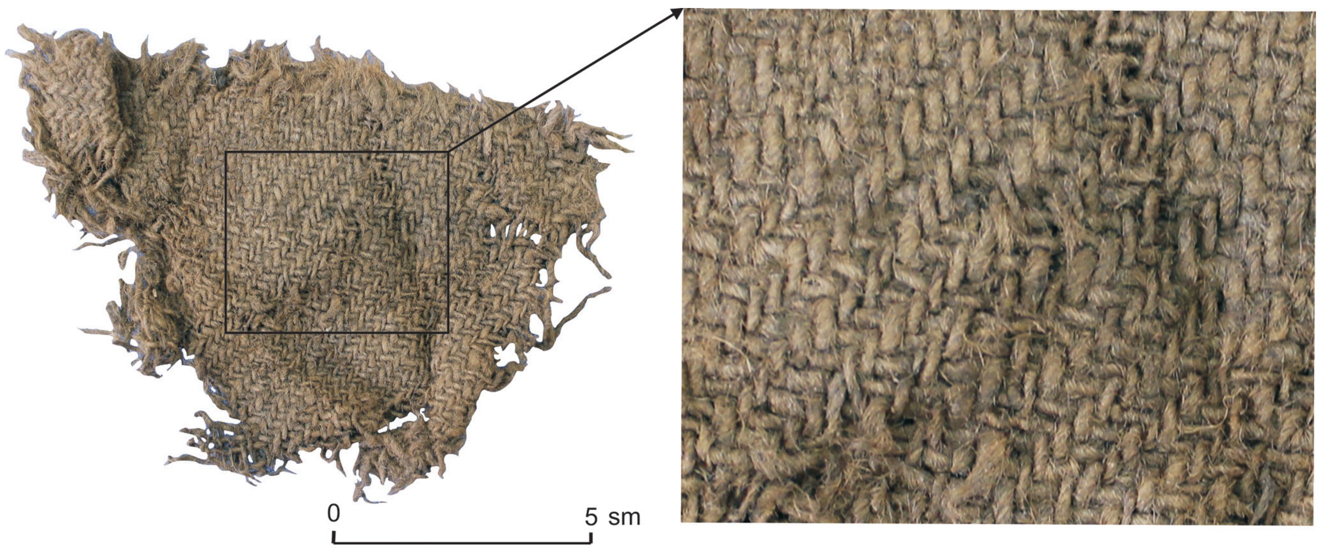

Fig. 5. 2/2 twill (the scale is in cm) (Photo: Authors).

woven from thin, s-spun thread. The fabric collection also includes a sample of plain weave with a warp rib structure (rep), using the same yarn in warp and weft (Fig. 7).

Knitted materials

The knitted materials are single-needle-knitted items made from an s-spun and a z-spun thread twisted together. The samples of knitted textiles have holes, cuts, *etc*. This makes it possible to identify more precisely the methods of manufacture while the well-preserved parts provide information on technological characteristics. Among the products are woollen stockings knitted with one needle (Fig. 8), as well as fragments cut from knitted fabric for use as foot-wraps (secondary use textiles).

Discussion

The materials demonstrate a clear variety of textile types, which are likely to correspond to different textile traditions:

First textile tradition

The first textile tradition involved the production of plain weave fabrics characterised by a uniform density in both warp and weft, mixing both z- and s-spun thread. This weaving technique, known in Russia from the 16th century (Nahlik 1963; Glushkova and Shulaeva 2013b), makes it possible to obtain a dense and uniform covering of fibres on both sides of the textile fabric, and it is a prerequisite for making warm and windproof clothing. Not surprisingly, this cloth was very popular in Siberia.

However, the manufacture of this material requires special conditions: a horizontal loom to obtain uniform

	Warp			**Weft**		
Weave	Spin direction	Thread diameter mm	Threads per cm	Spin direction	Thread diameter mm	Threads per cm
Plain weave	z (mainly)	0.6-0.7 to 1.5-2.2	10-11	s (mainly)	0.6-0.7 to 2.2	10-11
2/2 twill	z	0.8-1.0	7-8 to 10-11	z	0.5-0.7 to 1.0	5-9
Plain weave warp rep	z	0.8-1.0	10	z	0.7-1.0	5

Table 1. General characteristics of the textile samples.

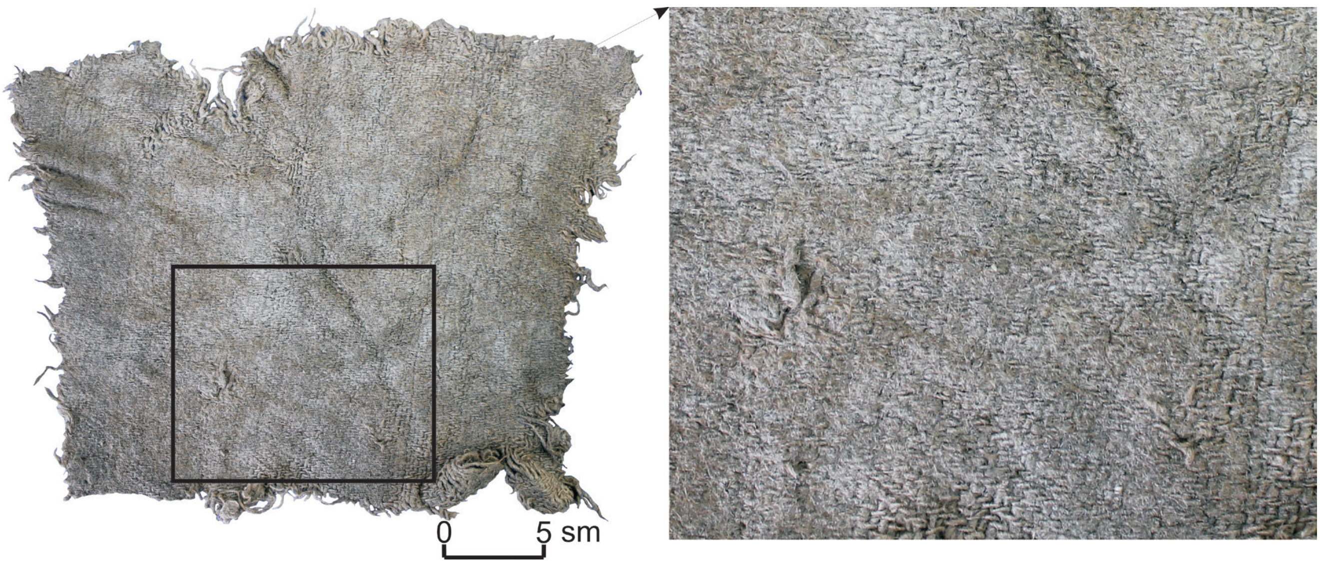

Fig. 6. Fabric weaves with s-spun thread in one thread system and z-spun thread in the other (the scale is in cm) (Photo: Authors).

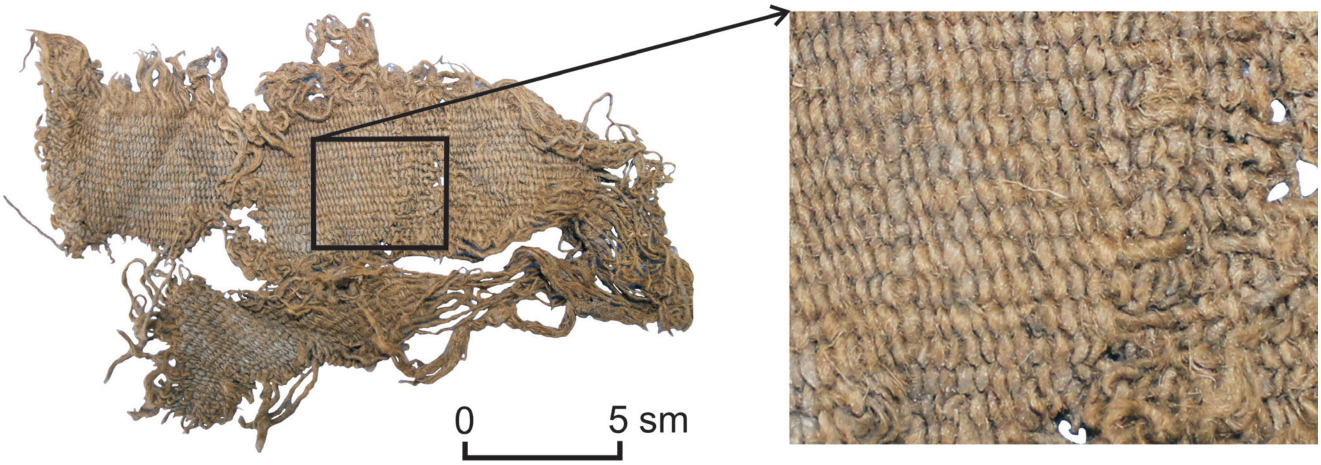

Fig. 7. Plain weave with warp rib structure (the scale is in cm) (Photo: Authors).

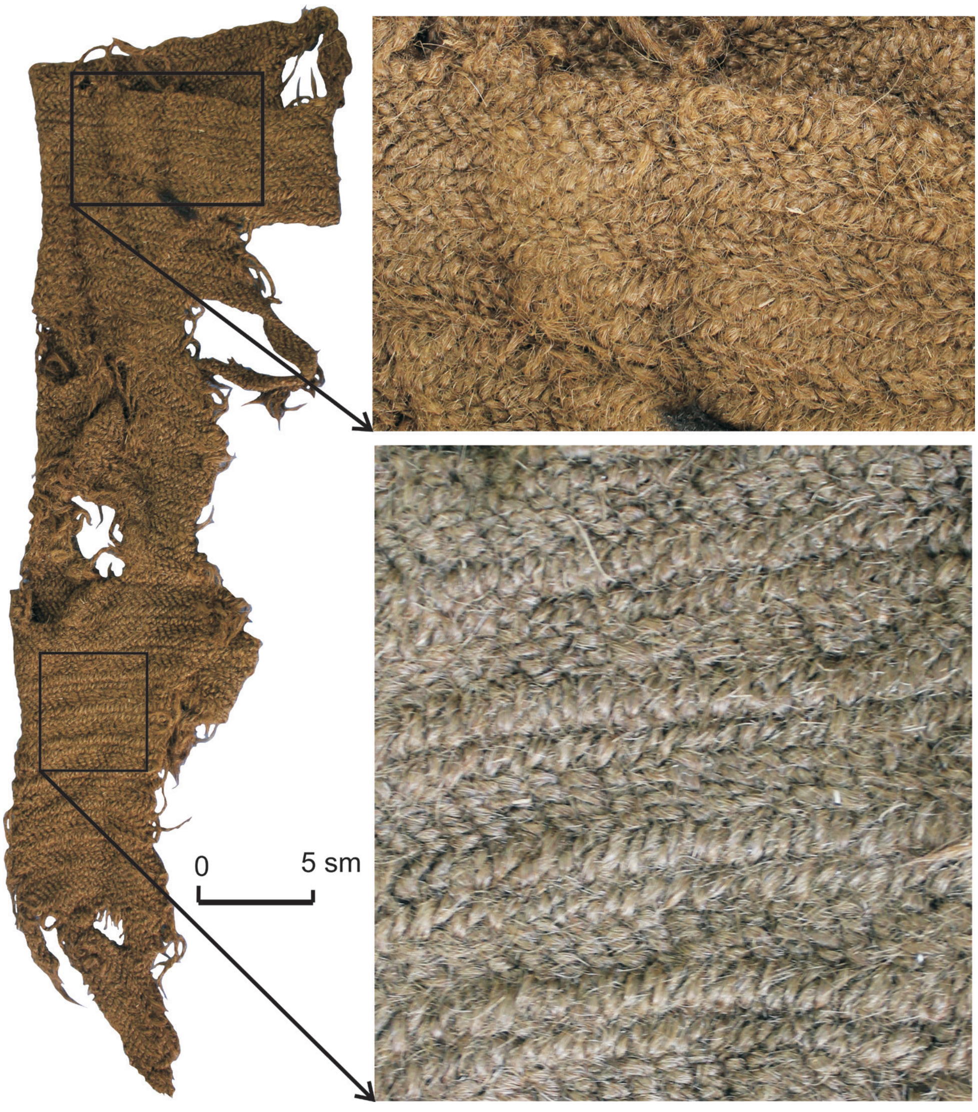

Fig. 8. Wool stockings knitted with one needle (the scale is in cm) (Photo: Authors).

density; separate spinning of the warp and the weft threads; arrangements for felting the fabric surface (a special room or a trough, tub and hot water) and, most importantly, skilled knowledge. Workshops were necessary for the production of fine fabrics of good quality, but these were absent in Tara. The tradition of making a thick cloth of low quality (*sermyagi*) had spread in Western Siberia by the end of the 17th century (Vilkov 1967, 85). We believe that low-quality textiles, such as the examples found in Tara, would not have been transported for trade, because they would only yield a small profit at high cost.

Second textile tradition

The second textile tradition involved the manufacture of plain weave textiles with threads spun in the same direction in warp and weft. This fabric category has several variants. The first of these is a simple wool fabric in a regular weave with the same z-spun thread in warp and weft. The fabrics of this type are usually quite thick with threads of home-production quality. One example is similar in appearance to a foot-wrap, and may be a fragment of this type of textile. The second variant also has z-spun thread in both the warp and the weft, but the fabric has a warp rib effect: the warp is twice the density of the weft or more. The third variant consists of very good quality textiles made using thin threads, spun in the same direction, in both warp and weft, with relatively high density in both thread systems. Most likely, these textiles were produced in handicraft centres in Siberia.

Third textile tradition

The third textile tradition involved the production of 2/2 twills. The twill weave of some fabrics has an error in the structure of the weave, which suggests that they were made by inexperienced craftspeople or using a simple device. Consistent technological characteristics of fabrics of this type (use of the same z-spun thread, even density 2/2 twill) suggest mass manufacture and the fairly simple conditions available within the peasant economy. Even density in the warp and weft (from 7-8 to 10-11 threads per cm) suggests that the loom used was probably a horizontal loom. Small differences in density indicate that different reeds were used. Fabrics of this kind were common in Russia and Siberia from the 16th to the 19th century, with no chronological differences in the technological characteristics (Novgorod, Mangazeya, Tobolsk, Staroturukhansk, archaeological sites of Tomsk-Narym area near the Ob River: see Nahlik 1963; Vizgalov *et al.* 2006; Matveev, Glushkova and Anoshko 2011; Glushkova and Shulaeva 2013a). Thus, the analysis of the technology of twill weave fabrics provides information on the mass production and well-established textile traditions in the manufacture of a 2/2 twill.

The techniques and methods used for the manufacture of plain weave fabrics were varied. For fabrics with thin, uniform threads, high density in the warp and weft, and no weaving errors, a more advanced type of horizontal loom would have been used, according to the known textile traditions of Russia and Siberia (Nahlik, 1963; Glushkova, Shulaeva 2013b). Fabrics with thick and uneven threads, low and irregular thread density and frequent weaving errors suggest the use of rudimentary horizontal looms.

The knitted products made using a single needle and plied wool yarns of different fineness are very similar in structure, which may indicate that they were made using the same method of production.

It is noticeable that a large number of twisted and braided items made from plant fibre are present (ropes as well as a shoe insole), while fabrics made from this raw material are absent. This is probably primarily due to their more rapid decomposition in the soil after deposition, or to the re-use of plant fibre fabrics (secondary and then reuse as rags for household purposes) due to their good hygroscopic and wear properties.

Conclusion

The textiles recovered from the Tara excavations are quite varied with regard to the characteristics of the threads, structure and surface texture, but there are no high-quality imported fabrics among the samples, as known from historical collections of 17th century textiles (Glushkova and Shulaeva 2013b). At the same time, it is possible to identify different textile techniques. This is likely to indicate the production of textiles in different centres and in different territories, representing different technological weaving traditions. The present conclusion is that the higher-quality plain and twill weave textiles recovered from the Tara excavation were imported.

Fabrics well known in other territories of Siberia are also present in the Tara collection; for example, 2/2 woollen twill. This indicates that they were manufactured in different territories inhabited by the Russian population, using the same technology. We assume a local home production for thick cloth fabrics (*sermyagi*), as well as thick coarse striped fabrics (not discussed here).

The textiles from the archaeological excavations at Tara fortress enable us to conclude that the vast majority of fabrics manufactured in the 17th and the first half of the 18th century came here from the European part of Russia. Clothing was not supplied for the non-military population, however. Due to the fact that until the middle of the 18th century Tara was a military and administrative centre, the local textile industry did not develop. At the end of the 18th century and during the 19th century, the population of Siberia began cultivating flax on a large scale (Alisov *et al.* 2014, 105). This made a significant contribution to the development of weaving in the villages of the region, which is reflected in the variety of local products, in the dress of the townspeople and the interior decoration of their homes.

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Karina Grömer, Katrin Kania and Joy Boutrup

Iron Age Finger-Loop Braiding

Finds from the Hallstatt Salt Mine

Introduction

The salt mine at Hallstatt in Austria is known for its rich organic finds from the middle Bronze (1600-1200 BC) and early Iron Age (Hallstatt Period, *c.* 800-400 BC), including wood, fur, leather, tree bast and textiles. It has been explored archaeologically by the Prehistoric Department of the Natural History Museum in Vienna (Reschreiter 2005; Kern *et al.* 2009), under the direction of Fritz-Eckart Barth in the years 1960-2000 and Hans Reschreiter since 2001. The textile finds (Grömer *et al.* 2013) are mainly products in different weaving patterns made on the warp-weighted loom (tabby, basket weave, twill variants), and of band looms (tabby rep ribbons and tablet weaving) decorated in different patterns with natural-shade and dyed yarns. With the help of dye analysis methods (chromatography), experts were able to confirm that complex dyeing techniques such as vat and mordant dyeing were known as far back as the Bronze Age and the Hallstatt period. Woad has been identified as a blue dye at Hallstatt, as well as weld and scentless chamomile for yellow and hedge bedstraw and dyer's madder for red. The fabrics from the salt mines are mainly made from wool, and some are of extraordinarily fine quality. Hallstatt presents a unique situation, and the textiles found there allow us to study in detail the development of textile technology in the period from 1500 to 400 BC.

Among the narrow fabrics there are two fragments which were made using braiding techniques (HallTex 301: Inv.Nr. 73.399 and HallTex 306: Inv.Nr. 75.936). In the present article, the focus will be on those braids because they represent a technique which had not previously been found at Hallstatt. We will discuss different braiding techniques and explore the possibility of tracing the fragments back to an early version of loop braiding. The bands in question were found during archaeological excavations in 1961 and

Fig. 1. HallTex 301 (below) and 306 (above): Braided bands from the Hallstatt salt mine, early Iron Age (Photo: Sebastian Becker, © NHM Wien).

1966 by Fritz-Eckart Barth in the early Iron Age part of the Hallstatt salt mine (Fig. 1). The braided fragments were found in the *Kilbwerk* (excavation reports: Barth 1969 and 1974) but in a part called *verlaugtes Heidengebirge*, meaning prehistoric layers that were disturbed during salt extraction in early modern and recent times. The prehistoric origin of the textiles in question was thus unclear going by the archaeological context, as prehistoric as well as modern items could be found in this part of the mine. Additionally, the appearance of the bands is similar to modern shoelaces still used in the Salzkammergut region of Austria, and no comparable finds were known from the Iron Age in Central Europe at the date of the excavation. So the items were considered modern intrusions in the disturbed area of the mine; a scientific analysis has been neglected till now.

^{14}C dating carried out within the *DressID* EU project yielded the surprising result that the braids are of Iron Age origin (Fig. 2). The radiocarbon dating showed a range of dates from 800 to 500 BC, and after calibration the age spans a period of ca. 340 years between 756 and 414 cal BC (van Strydonck and Grömer 2013, 191).

Technical description

HallTex 301 (Fig. 3-4)

HallTex 301 (Inv.Nr. 73.399) is the longer of both pieces of band. It is torn at both ends, but the width is complete. The remaining length is 14.5 cm with a width of 1 to 1.1 cm in the more compact part. It is braided from 15 ends. The colour sequence is one dark (blue or black) followed by one red, repeated four times, then seven green-bluish ends. The seven bluish-green ends might originally have been four green-blue and three greenish ends, but the colours are now not different enough to tell for sure. Most of the ends consist of two single yarns running double as a pair. Only two of the dark ends are made of a pair of plied yarns. The two threads in each pair lie completely parallel to each other, without crossovers. This suggests in our opinion that the band was made in a loop-braiding technique.

Characteristics of the threads:

- *red*: 0.8 mm z-twist single yarn, wool
- *dark blue:* 0.8-0.9 mm Sz-twist two-ply yarn, wool (2 pairs of threads)
- *green-blue:* 0.9 mm z-twist single yarn, wool (2 pairs of threads)
- *green*: 0.6-1.1 mm s-twist single yarn, wool.

The green threads are the most irregular in thickness; on average, they are about 0.9 mm in diameter.

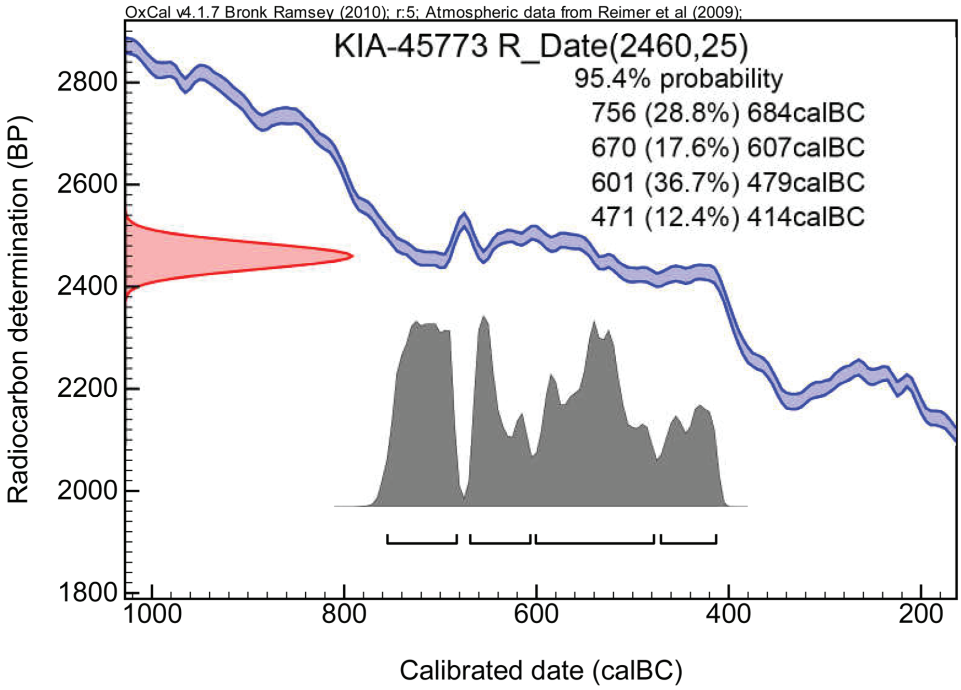

Fig. 2. ^{14}C-dating of braid HallTex 301 (Graph: Mark von Strydonck, © KIK/IRPA Brussels).

Fig. 3. HallTex 301: a) structure of the band; b) microscope image of the plied dark thread; c) detail of the reddish yarn, DinoLite Digital Microscope 250x (Photos: a) Sebastian Becker, b)-c) Karina Grömer, © NHM Wien).

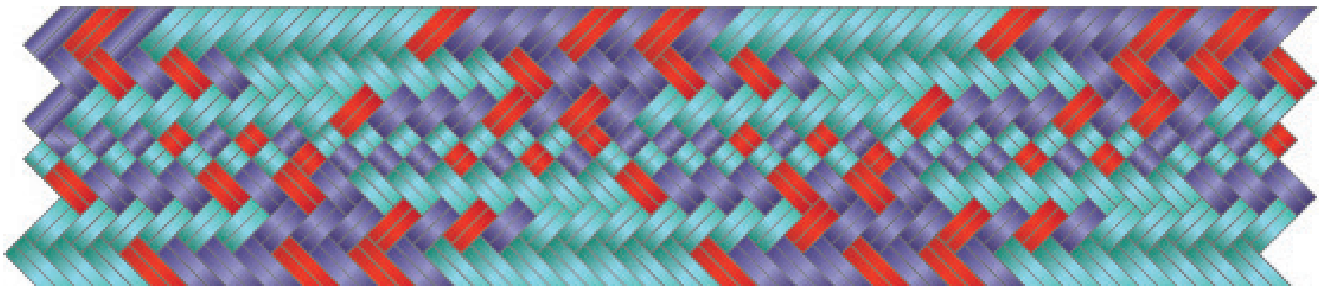

Fig. 4. Schematic image of the braided band HallTex 301 (Drawing: Joy Boutrup).

Fig. 5. HallTex 306: a) structure of the band; b) details; c) microscope image of the green thread; d) detail of the reddish yarn, DinoLite Digital Microscope 250x (Photos: a) Andreas Rausch; b)-d) Karina Grömer, © NHM Wien).

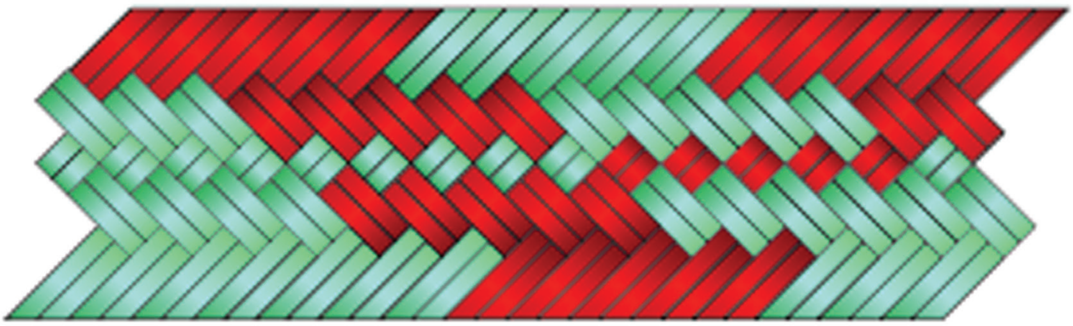

Fig. 6. Schematic drawing of the braided band HallTex 306 (Drawing: Joy Boutrup).

The microscope images show that the fibre material was carefully prepared (Fig. 3b-c): the fibres lie parallel to each other in the yarn, indicating that the wool was combed. The threads were spun with a high twist, resulting in high-quality, smooth, resilient threads. This kind of fibre preparation and spinning is very similar to other textile finds from early Iron Age Hallstatt (Rast-Eicher 2013, Fig. 60).

HallTex 306 (Fig. 5-6)

HallTex 306 (Inv.Nr. 75.936) is also a braided band, but significantly narrower than HallTex 301 and more damaged. The band is tied into a knot that is positioned close to the middle of the piece. The preserved length is 6.5 cm, the width is 0.6-0.8 cm. The band is braided from 10 ends, each consisting of a pair of yarns. The colour sequence of the ends is five green, five red. The ends are braided according to the following pattern (Fig. 6): under two ends, over two ends, under one, over two, under two.

Characteristics of the threads:

- *red*: 0.6-0.7 mm z-twist single yarn, wool
- *green*: 0.4-0.6 mm z-twist single yarn, wool

The fact that the two threads in each pair of yarn, in both bands, always run parallel to each other without crossovers may indicate that the band was made in a loop-braiding technique.

Braiding technique of the bands

As with many textile techniques, the end product does not always allow a detailed reconstruction of the technique employed. Just as different loom constructions can be used to weave a fabric with the same characteristics, several different braiding methods could have been used to braid the bands HallTex 301 and HallTex 306.

The patterns in both bands can be described as follows: the middle of the band appears to be braided in a basket weave-like braid, as the active end goes over one under one. The pattern on the sides are more reminiscent of a twill, going over two and under two ends. This change in the braiding pattern also results in a structural change, it might be part of the intended overall design of the bands. Though the narrower band also shows this, it is most clearly visible in the wider band HallTex 301. Both bands were probably made using a similar technique, with patterning achieved by using yarn in several different colours. Making bands like this is possible both with single ends and with loops using a loop-braiding technique. This is made by letting the fingers hold the individual loops, and then braiding by shifting them between the fingers, either by pulling them through the loops or just over and under in a weaving-like movement. Interestingly, the pairs of threads making up the individual ends lie very parallel to each other and do not cross over within the band. The bands do not correspond to the typical 'recipes' (descriptions) for loop-braiding (Speiser 2000, 20-21), where the threads are crossed by passing loops through each other. The odd number of ends and the two threads making up each end indicate that most probably a different technique was used – though this typical loop-braiding method cannot be excluded completely.

A slightly different loop-braiding technique uses both legs of one loop as one end. This technique is described in the Tollemache manuscript, dated to the 15th century (Tollemache 1997, fol. 41 v):

[62] A lace broad party of 7 bows not according to the broad lace of 7 bows parti a forseyd. Take 7 bows of 2 colours & thett 4 of one colour over A B C D left & 3 over another colour on B C D right. Then shall A right take the bow of D left reversed upward then low the left bows then shall A left take the bow of D right reversed upward & then begin again.

To make a band like HallTex 301 using the technique from the Tollemache manuscript, two people must work together to braid fifteen loops in the following way:

Person 1 holds four loops on the left hand (L1 a,b,c,d) and three loops on the right hand (R1 b,c,d). Person 2 holds four loops on both hands (L2 a,b,c,d, R2 a,b,c,d).

R1 goes with the index finger over one, under two and over one of the loops on L2, grasping the loop on L2d (the little finger loop); the loops on R2 are moved one finger downward to free the index finger R2a.

R2 goes with the index finger over two and under one loop on the same hand and takes the loop from L2d; the loops on L2 are moved one finger downward to free the index finger L2a.

L2 goes with the index finger over one, under two and over one loop on R1 and takes the loop from L1d; the loops on L1 are moved one finger downward to free the index finger L1a.

L1 goes with the index finger over two and under one loop on the same hand and takes the loop from R1d; the loops on R1 are moved one finger downward to free the index finger R1a.

In contrast, braiding the band using free ends (Fig. 7) can be done by one person on their own. One hand holds eight, the other hand seven pairs of threads (ends). The hand with eight ends takes the outermost end over two, under two, over two and under one end; the end then moves to the other hand.

Tests of the two different methods for braiding bands

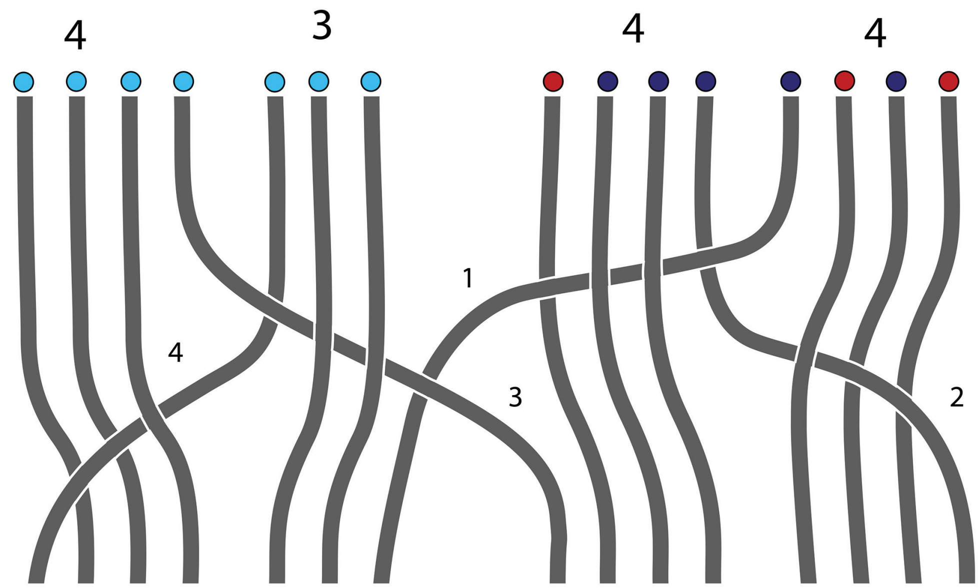

Fig. 7. Schematic drawing for free-end braiding of HallTex 301 (Drawing: Joy Boutrup).

like those at Hallstatt have shown that there is almost no discernible difference for a short piece of braid done with loop-braiding or with free-end braiding. However, the fact that the pairs that make up the ends always run parallel speaks in favour of the loop braiding-method as they would more easily cross if made with free ends. The way the ends turn at the edge of the braid also suggest this method, as does the fact that when using the free-end method the pattern becomes more open in the middle than in the original bands.

Braiding in European prehistory

A wide range of textile production methods – including braiding techniques usually employed for mats and basketry – are known from the Stone Age (*e.g.* Medard 2010, 95-101). Braided borders on woven textiles are also known from Bronze Age Central Europe (*e.g.* Hallstatt or Mitterberg: Grömer 2015, Fig. 67), as well as northern Europe (Broholm and Hald 1940, 73-78). These tightly-plaited borders are a means of reinforcing a fabric edge.

Braiding with three or four ends was also used to create fringes to finish woven textiles after they were taken off the loom (*e.g.* Stone Age: Lüscherz: Médard 2010, Fig. 101d; Iron Age: cloaks of Hunteburg and Thorsberg: Schlabow 1976, fig. 71, 117, 120). However, as we have seen, plaiting was also used to produce narrow bands in parallel with different band-weaving techniques such as tabby rep and tablet weaving which is well-represented in Hallstatt. In contrast to the weaving techniques, plaited bands have no warp and weft, only one thread system. The threads run at an angle to the longitudinal edges. Separately-made plaited bands, but sewn on woven fabrics, could be identified on the so-called 'Rieserferner leggings' (Bazzanella *et al.* 2005, fig. 6). They were found together with woollen socks and remnants of leather shoes at the Vedretta di Ries glacier (Rieserferner Gletscher) on the border between Italy and Austria. The ensemble dates to the period from the 8th to the 6th centuries BC. The two pairs of leg warmers were sewn from bigger pieces of twill fabric. A rectangular piece of cloth was sewn to form a tube. On the left 'under-legging' a plaited ribbon was inserted vertically along one of the seams – maybe to make the tube more elastic. The lateral plaited ribbon was made of 12 double interlaced threads and is 1.5 cm wide. It is sewn together from two pieces, which differ in colour: one is of grey wool and the other of natural brown wool.

Comparative finds of finger-loop braided bands

In contrast to the method of braiding with loops, as known, for example, from medieval London (Boutrup 2010; Crowfoot *et al.* 2006, Fig. 107), there is only scant evidence for the braiding technique with loops described above, using both legs of one loop as one end. A description of how to make a band using this technique is preserved in the Tollemache Manuscript, dated to the 15th century, as presented above. Some other braided pieces from late medieval Germany and Sweden were also made using this technique;

furthermore, it is widely known in Greece and South America (J. Boutrup, unpublished observations).

Bands braided using a similar technique have survived in different contexts. Such a piece, flat and braided with double yarn, was used for instance for a reliquary at the cathedral treasury of Halberstadt in the 14th century AD (Stiftung Dom und Schlösser in Sachsen Anhalt, Reliquienbörse Nr. 57A; J. Boutrup unpublished research). The Royal Armoury in Stockholm also houses a horse harness that was made using this technique in 1673 in France (Livrustkammaren Stockholm, Object number 8876; J. Boutrup, 'New insight into loop braiding', Lecture *CIETA* conference, Brussels 2009). In the Danish National Archives, Copenhagen, a wedding contract from 1590 between Princess Anne of Denmark and King James VI of Scotland also has five seal strings made with this special type of loop braiding (J. Boutrup 2008, 14).

Conclusion

The braided bands from Hallstatt might have been made using the finger-loop braiding technique. It is often not possible to say with any certainty whether a braided band was made using free ends or a loop-braiding technique without tell-tale mistakes. Some details, such as the parallel position of the single threads making up an end, suggest the use of a loop-braiding technique. In some cases, loop-braiding can be clearly identified by characteristic mistakes, but this is more often the case in the loop-braiding techniques where loops are passed through each other. Whether made with single ends or with loops, the bands from Hallstatt are a fine indication of how much variety can be found in the production of textiles in the Iron Age, including braiding techniques. The long duration of their use – starting in the Iron Age at the latest and going at least until the 17th century (*e.g.* on the Faroe Islands: Hald 1975) – and their wide geographical spread not only within Europe, but even beyond, are truly remarkable. Loss of knowledge of craft techniques in our western European cultural context, brought on by industrialisation, can lead to misinterpretations of finds made using methods such as the loop-braiding technique presented here. Those misinterpretations include wrong assumptions about the age of textile finds. In the case of HallTex 301 and HallTex 306, a radiocarbon dating showed the true age of the textiles and helped us to gain better, more accurate knowledge of the achievements of textile producers in the Iron Age.

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Małgorzata Grupa

Preliminary Analyses of Silk Flowers from Modern Graves in Poland

Introduction

Remains of infants, children, young males and females from wealthy families in Poland in the Baroque period (*c.* 17th-18th centuries) were usually richly decorated, including the grave equipment and catafalques used during burial ceremonies, which were covered with very popular wreaths and crowns, made from natural and artificial flowers.[1] These elements symbolised the young age and innocence of the deceased. Additional elements consisted of precious haberdashery made from silver, gold or fake precious metal threads (Grupa 2005, 31–32).[2] The type and quantity of deposited flowers depended mainly on the season and the parents' wealth. Spring and summer delivered a variety of colourful field and meadow flowers that were used for decorating bodies while single flowers or small bunches were put into coffins.[3] In autumn and winter, decorations were made of thin wire, textile, paper or glass, arranged into forms resembling commonly-known plants (Drążkowska 2007, 491).

In the course of archaeological explorations of cemeteries and churches, archaeologists frequently report the presence of artificial flowers and wreaths in children's burials; wreaths of natural flowers are rare.[4] Flowers act as symbols of beauty and love but, due to their delicacy, fade away quickly, as Ryken *et al.* have pointed out: "That is the symbolism of flowers appearing in the Book of Psalms, in the Old and New Testament, when they speak about human beings who one day bloom like flowers, only to disappear on the next day" (Ryken and Wilhoit 1998, 416). It is difficult to establish, based on the archaeological materials, how far artificial flowers go back in material culture history. They appear in grave equipment and in both Catholic and Protestant rites from the 17th century onward (Westphalen 2007, 130-131; Guszpit *et al.* 2010, 632).

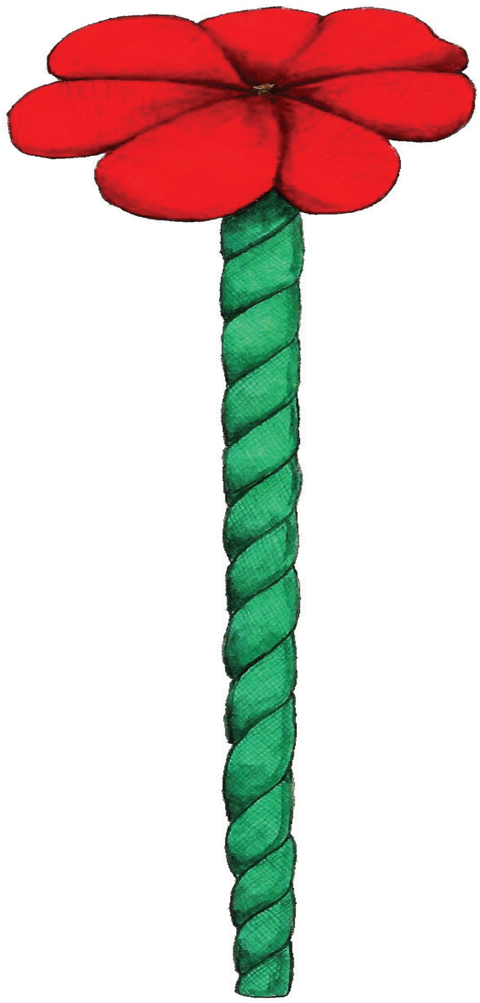

Fig. 1. Reconstruction of artificial flower from the grave of Anna Vasa (Drawing: M. Nowak).

Fig. 2. White lily flower from Gniew (Photo: A. Wojciechowska).

Types of artificial flowers

Artificial flowers were manufactured using various materials, although their base usually included brass wire imitating gold, different kinds of silk and paper. The wire frequently created frames of flower calyces and leaves, and then yarn, textile and paper filled the space between the wire construction. Flowers were made in different sizes. Princess Anna Wazówna, who died in 1625, had the simplest form of artificial flowers put into her grave (Grupa 2005, 32): a wooden slat *c.* 1 m long was wound round spirally with silk fabric and, at one end, a primitive calyx made of silk in plain weave was fastened with a metal rivet (Fig. 1). Other examples of flowers found in graves involve much more elaborate constructions and vary in size from 1 to 12 cm (Fig. 2). Their proportions depend on the technique of the grave wreaths, small bunches or coffin decorations.

Sometimes flowers were made out of loose yarn. Yarn strands were put alongside one another and fixed with some kind of glue (*e.g.* starch or egg white, applied in such a way as not to make spots on the surface). When it dried, the calyx and leaves were cut out of them, constructing, *e.g.,* carnations, cornflowers, ox-eye daisies and forget-me-nots. The calyx was fixed onto the metal wire by wrapping the textile and the wire with silk thread or thinner wire.

The other method was to build a metal frame filled with silk thread, interlaced in different directions, making a delicate net, or using textile in plain weave or satin weave and adding petals (Fig. 3). These have been found in the form of three-dimensional flowers resembling roses, lilies (Fig. 2) or tulips. To produce silk flowers, various forms of textile were used. Archaeologists report silk yarn, fabric in plain weave and silk ribbons and bands (Table 2).

Exploring the crypt in St. Catherine's Chapel in the Church of St. Nicolas in Gniew, archaeologists excavated several kinds of artificial flowers in child burials, five of which resemble white lilies (Fig. 3). A lily, "in accordance with Greek mythology, was made of Hera's milk; Aphrodite, the goddess of love, hated the flower as a symbol of virginity. Christianity adopted the symbol as an interpretation of innocence, purity, virginity, hope, the Holy Virgin Mary" (Kopaliński 2006, 197). Each flower consists of four petals, with edges bent outwards, made in plain weave textile, originally probably white, but at present blue or green. The latter is secondary colouring resulting from corrosion products or from the brass wire used in the internal and external frame of the flowers. In addition, the petals' rims were wound round with decoratively twisted thin wire. Silk yarn placed on petal surfaces combined with brass wire gave the impression of gold glittering. The stem was tangled with petals and probably iron wire and the whole construction was wrapped round with more delicate brass wire and silk yarn (Wojciechowska 2012, 27).

Site	White lily	Dog-rose	Forget-me-not	Others
Bytom Odrzański	-	-	-	X
Gniew	X	X	X	X
Gdańsk	X	X		X
Kwidzyn	X	-	-	-
Toruń	-	-	-	X

Table 1. Flower species excavated in Polish sites

Site	Glued silk yarn	Plain weave	Bands	Felt	Paper
Bytom Odrzański	-	X	X	-	-
Gniew	X	X	X	-	X
Gdańsk	X	-	-	X	X
Kwidzyn	X	-	-	-	X
Toruń	-	X	-	-	-

Table 2. Materials used for artificial flower production

The same technique was applied to another two flowers, although their shape was different: not a lily, but a briar rose,

> "which symbolizes evanescence, death, resurrection; particularly a faded rose, which expresses fragility of life and happiness, as well as grief of losing them. It is an attribute of the world of the blessed souls in the Elysian Fields. What blooms in nature the most beautifully, like roses, lilies, violets, also fades rapidly; similarly – the most beautiful flowers of human life die particularly quickly" (Kopaliński 2006, 363).

The petals are directed to the outside and the edges are rolled slightly inwards. The flower underlying structure served not only for decoration, but also, as in the case of the lily, to maintain the whole construction, fastening the thin wire of the petals. The textile placed between this underlying structure and a petal was not silk yarn like the ones described

Fig. 3. Flower calyx made of paper from Gniew (Photo: Dawid Grupa).

Fig. 4. Wreath reconstruction from Gniew (Drawing: M. Nowak).

above, but linen. Delicate wires stick out from the flower middle, probably imitating stamens. The stem end is folded, presumably as a result of being part of some construction. One of the flowers discussed above is well preserved, because only one of its petals is missing, while the other consists of three petals, with the other parts, *i.e.* the stem and the underlying structure, barely left (Wojciechowska 2012, 28).

Other flowers imitated carnations or a plant called chicory, which was commonly accessible in the 18th century, thus making it easy to imitate. As Drążkowska describes,

> "[f]lowers were made of identical textile and the same form: one of two longer edges of silk narrow strip was cut and frayed. Next, this cut fragment was folded and its bottom part was tied round with string. The others were pressed flat to make imitation of flower buds" (Drążkowska 2007, 492).

Some flowers had metal wire as a stem or a branch or serving as part of a bigger construction. At present the flowers are pale yellow but they may have been golden in the past, glittering on children's garments. In 1899 G.W. Gessmann prepared a dictionary of flower language, which explained how it was possible to express difficult news arranging sophisticated bunches of flowers. He described a carnation as a flower symbolising "My heart is filled with yearning" (quoted in Biederman 2001, 182). Putting carnations into graves could have been interpreted as longing for a person who passed away too soon.

The last type of flowers recognised during grave crypt exploration can be described as small ones in plain weave. As Drążkowska describes, "[t]hey were formed of a narrow fabric strip and one of longer edges was cut into regular rounded wave, while the opposite edge was tied with string" (Drążkowska 2007, 493). Some of them have preserved stems of thin brass wire with leaves. The flowers were originally white or blue. Petal shape and flower form suggest a forget-me-not, defined by G.W. Gessmann as "These words remind of desire to see the other person – do not forget me" (quoted in Biederman 2001, 183).

Apart from textiles, paper was also used to make artificial flowers, but these do not survive well. Wreaths from Gniew revealed tiny, 1 cm-wide forget-me-not calyces made of paper (Fig. 3).

Another (southern) crypt, located in St Ann's Chapel in Gniew also contained elements of wreaths and artificial flowers resembling parrot tulips (Fig. 4) very carefully made from brass wire, silk and white glass beads. Thin wire was used to construct leaves, branches and flower frames. Petals resembling butterfly wings were made of thin silk yarn, making the structure transparent. The whole composition was wrapped with thicker silk yarn and all these elements

Fig. 5. Flowers made of delicate soft felt from Gdańsk (Photo: Dawid Grupa).

were fastened around a metal stalk with a flower on the top (Grupa *et al.* 2013, 138–139; Grupa *et al.* 2015, 117).

The excavations at St. John's Church in Gdańsk uncovered a metal wreath with textile flowers. The hoop of brass wire had flowers of glued yarn resembling common chicory or carnation, between which bundles of wire twisted into spirals were placed (imitating small flowers or buds). The archaeologists also identified flower relics similar to lilies and dog-roses. The base of the flowers were formed of a brass wire, the empty space was filled with stiff paper and the external surface was covered with silk yarn placed vertically (Drążkowska 2007, 492–493). Similar flowers were excavated in the grave of a young woman buried in Kwidzyn Cathedral (Grupa 2014, 18). Of exceptional interest are the objects made of delicate soft felt, in one or two colours, with a diameter not exceeding 2 cm and placed in layers on top of one another (Fig. 5). This find is unique.

The southern crypt in Gniew contained two children's bonnets decorated with artificial flowers of silk bands in plain weave, with diameters of 1.5-2 cm; one rim was creased making a circle imitating a flower petal. Some others had another layer of petals with a smaller diameter and different colours (Grupa *et al.* 2015, 56, 104, fig. 34, 35). Band flowers also decorated several coffin pillows were found in the child's crypt of Schonaich family in Bytom Odrzański. The find contained three pillows with band flowers 6.3 cm wide and rims decorated with delicate stripes placed in four corners (Grupa 2011, 15, 86). Flowers were made of silk fabric in plain weave, paper or yarn, placed parallel and glued with some substance (Table 2) like isinglass or plant resin and petal shapes were cut out when the structure was dry (yarn serving for making flowers might have been of poorer quality and its short sections could be glued and shaped without any difficulty). Identifying textile colours is impossible at present, because as pigments decomposed they lost their original colours, turned golden brown and became partly soaked with metal corrosion products: brass (green) and iron (rusty brown).

Silk of poorer quality is recorded in written sources of haberdashers guilds (Bogucka 1956, 114). This kind of silk was produced in central Europe, probably in Poland as well, because mulberries have appeared in Pomerania. Haberdashers decorated various types of headdress for both males and females and probably produced artificial flowers in their workshops. Archaeologists have recorded lower-quality silk bands in the southern crypt of the church at Gniew, out of 300 items made of silk bands, 13 are evidently different. In each example the warp consists of two strands, each of which has a z-twist (Grupa *et al.* 2015, 49–51). Short yarn sections had to be twisted to be used in weaving. In this case, the fact confirms its local production.

Flowers and regulations

The range and quantity of decoration used for burials were regulated administratively all over Europe. Sumptuary laws from Kołobrzeg, Gdańsk, Szczecin, Toruń, Stralsund, Hamburg and Leipzig define exactly how many and in what way flowers could be used together with golden haberdashery to dress deceased infants, girls and young boys. The restriction was justified as a measure to protect citizens' finances (Kizik 1998, 90–91; Grupa 2005, 32). However, these regulations were obviously not so strictly obeyed, as there are several examples of laws forbidding excessive adornment of bodies and coffins and reiterating the punishment for not respecting them. Despite all of these administrative efforts, the custom found its way into the funeral culture of 16th-18th-century Europe.

Legislators usually did not interfere in wreath construction and the kinds of flowers used, but rather defined materials regarded as too expensive for the purpose. From iconography we know of only small and modest maiden wreaths. Archaeology, however, complement this information and thanks to excavations in various churches, we have a much more detailed knowledge of wreath relics, artificial flowers and haberdashery than sumptuary law regulations indicate.

Ribbons and artificial flowers were also used to decorate various headdresses. Information on the subject can be found for example in court records, where cap-makers and haberdashers try to establish the range of their activities in decorating headgear. In the 18th century the work was partially taken over by milliners, making huge constructions for women's headgear. It is difficult to establish, however, which professional group was responsible for manufacturing grave wreaths – haberdashers, hat-makers or craftsmen making gold wire? The latter professional group belonged to the wealthiest in Gdańsk, being granted a special sumptuary law by the town's authorities in the 18th century (Grupa 2005, 91).

Notes

1. It was reported that sometimes the body was decorated with natural, dry or artificial flowers. The burials of Frederic Christian and Mary Catherine in Roskilde Cathedral provide evidence of plants, identified as rosemary and lavender. The same herbs also filled pillows and mattresses placed inside their coffins (Østergård 1993, 220–221; Grupa 2005, 32).
2. In archaeological contexts we usually find artefacts made of brass wire, which originally imitated gold, called 'fake haberdashery'. The surfaces of these types of archaeological objects are coated with corrosion products, giving evidence of copper in the alloy (Grupa 2013, 135).
3. One of the children found in Gniew was equipped with a bunch of flowers, consisting of three artificial flowers made of metal wire tied with silk ribbon.
4. At the site of Szczuczyn, coffin no 17 contained remains of a small boy, Stanisław Konopka, with signs of a herb wreath (presumably common rue and mugwort) with a diameter of 8 cm on his right temple (Grupa *et al.* 2014, 67, 102). Brown spots of deformed circles, registered on grave textile relics, sometimes indicate signs of wreaths made of natural flowers and herbs (author's observations during textile conservation treatments; Grupa *et al.* 2015, 121).

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Irene Skals

Exploring a Medieval Patterned Silk Weaving in Honour of its Master Designer

Introduction

The Church of St. Bendt in the town of Ringsted, Denmark, dates back to about 1170 and was the preferred royal burial place until about the middle of the 14th century. During a renovation in 1858 of the floors of the church, some of these royal burials were examined by the National Museum of Denmark (NM) in Copenhagen and fragments of monochrome tabby woven silk textiles were found in several of them. From one grave, however, the fragments were of a delicate, double-faced patterned silk which, when it was received for conservation, initiated an interest in the elaboration of the patterning of silk weavings and the various creators of the fabrics who remain unknown. While the people who used these fabrics are often known by their names and through their deeds, we have to study the preserved fragments of the textiles to get acquainted with their unknown designers and reveal their ingenuity.

The fragments of the patterned silk were found in the grave of King Valdemar II, whose reign lasted from 1202 to his death in 1241. Denmark was at the time a great nation and King Valdemar II would have had access to precious fabrics through his political, ecclesiastical and marital connections with many areas south and east of Denmark. He had favoured the German King Otto of Brunswick against Philip of Swabin (King Otto became Emperor of the Holy Roman Empire in 1209) and he conquered Lübeck and Holstein in 1217. He engaged in a crusade against

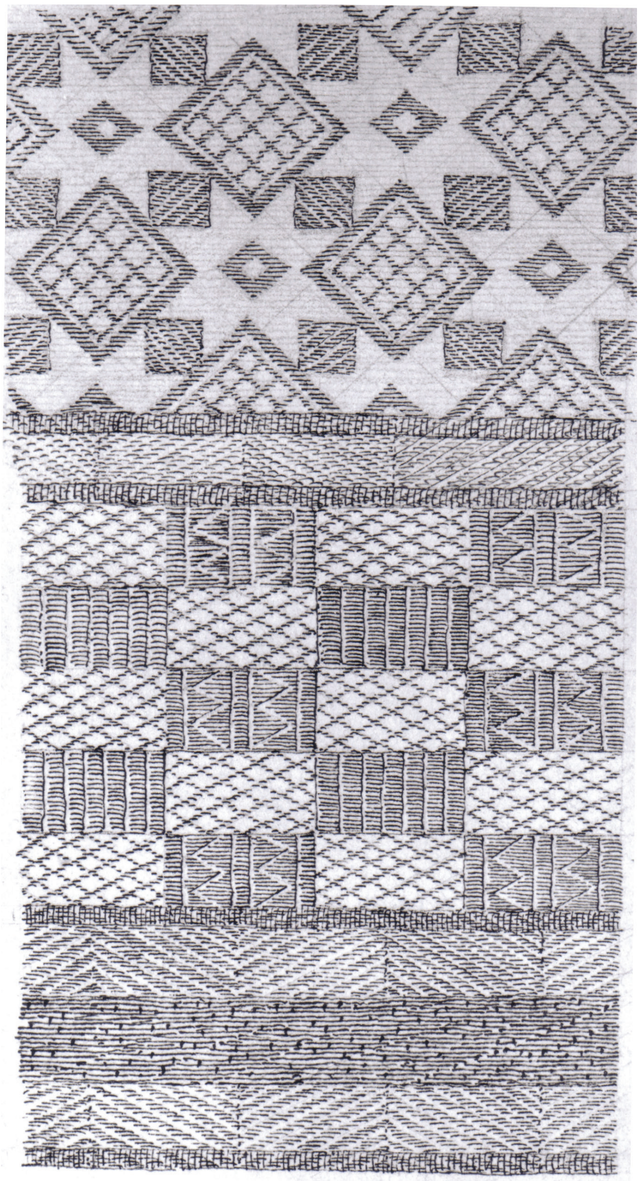

Fig. 1. A drawing was made at the time of excavation showing the different elements of the pattern consisting of stars and diamonds followed by different types of stripes, some of which also can be seen as a check pattern (After: Worsaae and Herbst 1855).

Fig. 2. **Detail of a small fragment showing the selvedge. The black outline indicates the three bundles of fibres that have now disappeared (Photo: Irene Skals).**

Fig. 3. One of the largest fragments in the National Museum of Denmark collection with the pattern of stars and diamonds. Along the left side c. 6.5 cm of the selvedge is preserved (Photo: Roberto Fortuna).

the heathen Baltic countries and conquered Estonia in 1219. Through two marriages he had connections to first Bohemia and later Portugal and his six sisters were all married to European princes.

At the time of the excavation in 1885 it was noted that Valdemar's grave had already been disturbed and this had left the silk scattered around, a fact that might very well have been the cause for its rather poor preservation (Worsaae and Herbst 1855). The fragments were after the excavation placed between glass plates and two of these glass mounts containing three fragments measuring 19 x 10.5 cm, 14.5 x 8-15 cm and 7 x 9 cm respectively were kept in the church and can now be seen there, while more than 20 fragments measuring from 0.5 x 2 cm to 18 x 9 cm were brought to NM where they are now stored. Although the silk can be seen from both sides in the glass mounts, the glass is prone to breaking, which is what happened to some of the mounts in NM enabling a thorough investigation of the silk. It is a double-faced weave with a complex geometric pattern of diamonds and eight-pointed stars, alternating with stripes and checks (Fig. 1). The original colours have now disappeared but various shades of light and dark testify to the use of different coloured yarns and tiny traces of a gold thread can be detected in one area of the pattern.

The exquisite play with technique

The weaving has one warp and two wefts per pass. The yarn in the warp has a light colour with a z-twist and the two differently coloured wefts in each pass have no twist. The colour differences are visually determined as different shades of light and dark brown but the textile is very thin – almost transparent – and the silk so fragile that sampling for dye analyses was considered too destructive. The weaving technique is based on a 3/1 twill with different variations such as lozenge twill and chevron twill forming four different elements of patterning. The colours alternate so that the areas that are light on one side are dark on the

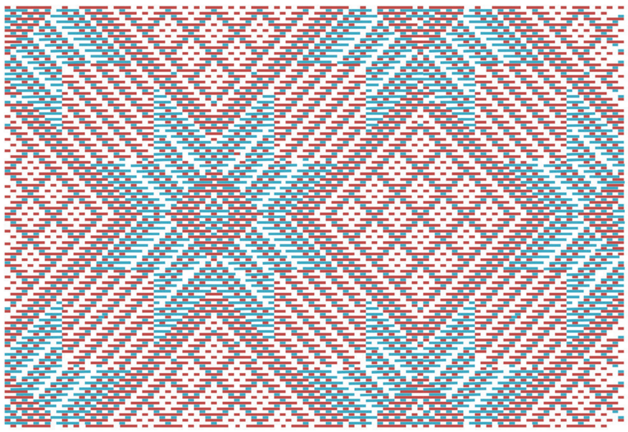

Fig. 4. A schematic drawing of the pattern of stars and diamonds. In this first element of the pattern the colours of the weft alternate so that the stars are light and the diamonds dark on one side and reversed on the other (Drawing: Irene Skals).

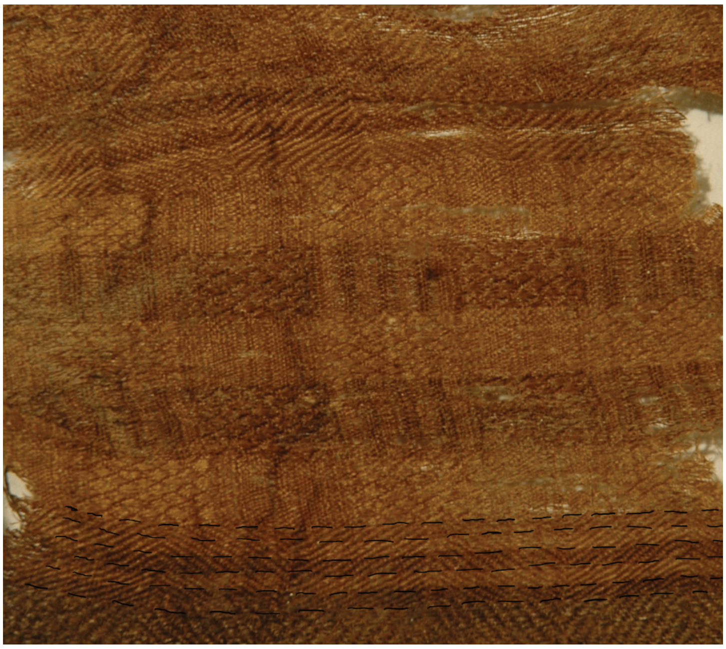

Fig. 5. The second element of the pattern consisting of five narrow stripes of alternating light and dark colours woven in chevron twill are repeated between every shift in the patterning. Each stripe measures c. 7-8 mm. The uppermost stripe appears slightly lighter than the two other dark stripes (Photo: Irene Skals).

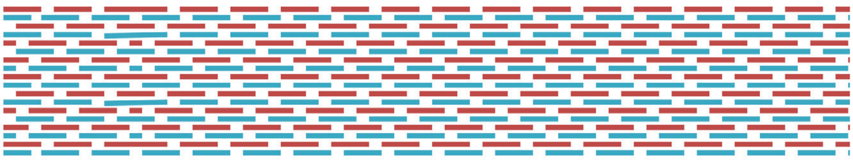

Fig. 6. A schematic drawing of the chevron twill with two wefts of alternating colours. The technique is not influenced by the shift in colours (Drawing: Irene Skals).

other and vice versa. Small parts of the selvedge are preserved making it possible to detect that it consisted of three bundles of yarn which have now disappeared and may therefore have been of plant fibres (Fig. 2).

The pattern of eight-pointed stars and diamonds are seen in most of the preserved fragments and this element might possibly constitute the ground pattern of the textile (Figs 3 and 4). The pattern unit consists of 36 warps measuring *c.* 1.2 cm (width) and 38 passes measuring *c.* 1.7 cm (height). The lighter weft is slightly finer than the darker. This part is followed by a second element consisting of a *c.* 2 cm wide striped pattern woven in chevron twill. This element is repeated between each shift in the pattern and appears to constitute a form of transition. The colour differences here are subtle and alternate to form two light and three dark stripes on both sides of the fabric, each of these being *c.* 7-8 mm wide (Figs 5 and 6). It has not been possible to discern whether the light and dark colours of the wefts are similar to the ones in the preceding pattern and one of the three dark stripes appears to be of a lighter shade, giving this pattern three different colours. The colour differences outlined above were not detected when the first drawing of the pattern was made (see Fig. 1).

The third element following the stripes consists of rows of checks, although in fact, depending on which side of the fabric is facing, it looks either checkered or striped (Fig. 7). Altogether, this part of the weaving measures 3.5 cm and consists of five rows of rectangles each measuring 7-8 mm by 11-14 mm. The pattern is nicely reproduced as rows of checks in the drawing from the time of the excavation (see Fig. 1) and is preserved in two of the fragments that can be seen in the church. These two fragments are mounted in the same frame with different sides facing making it possible to see the two different effects of the colour shifts. In a few tiny fragments in the NM collection, enough of these patterns remain to discern the course of the yarns. In three of the stripes the rectangles alternate between lozenge twill and chevron twill and the two wefts differ in colour but are both in light nuances (Fig. 8). In the remaining two stripes the rectangles alternate between lozenge twill and faced tabby and the wefts are clearly a light and a dark colour (Fig. 9).

The element of the narrow light and dark stripes in chevron twill are repeated again followed by the last element of the patterning consisting of yet another stripe, also woven in chevron twill (Fig. 10). This stripe measures 7-8 mm and has a gold thread as one of the wefts in the pass. The gold has now disappeared,

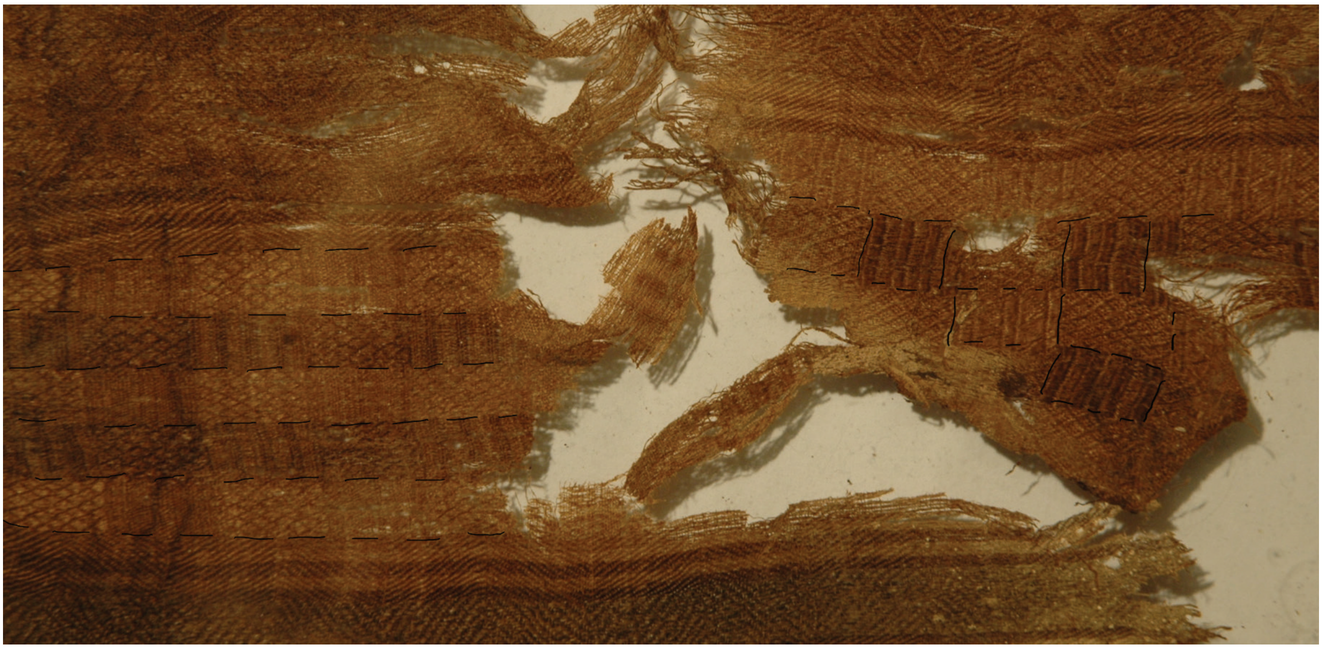

Fig. 7. Two fragments are placed side by side in one glass mount with opposite sides of the textile facing. Due to the colour shifts the stripes are accentuated on one side and the checks on the other side as indicated on the photograph (Photo: Irene Skals).

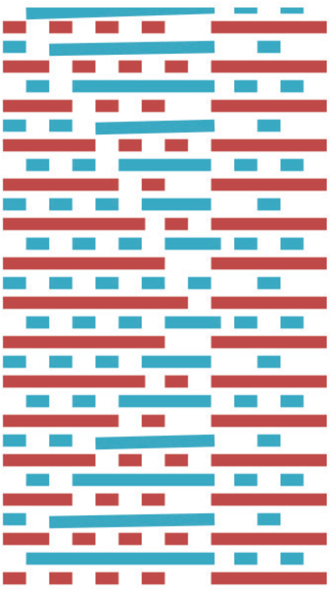

Fig. 8. A schematic drawing of the pattern unit for three of the stripes in the third element of the pattern. It is woven in lozenge twill alternating with chevron twill and the wefts consist of two different light colours that appear as light stripes on one side and as two differently light-coloured rectangles on the other side (Drawing: Irene Skals).

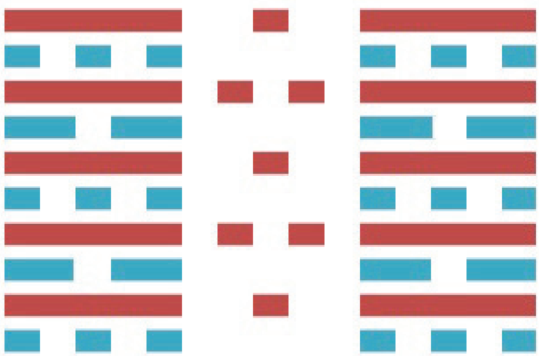

Fig. 9. A schematic drawing of the pattern unit of the two remaining stripes in the third element of patterning. They are woven in lozenge twill and faced tabby with a light and a dark weft. They appear as dark stripes on one side and as alternating light and dark rectangles on the other (Drawing: Irene Skals).

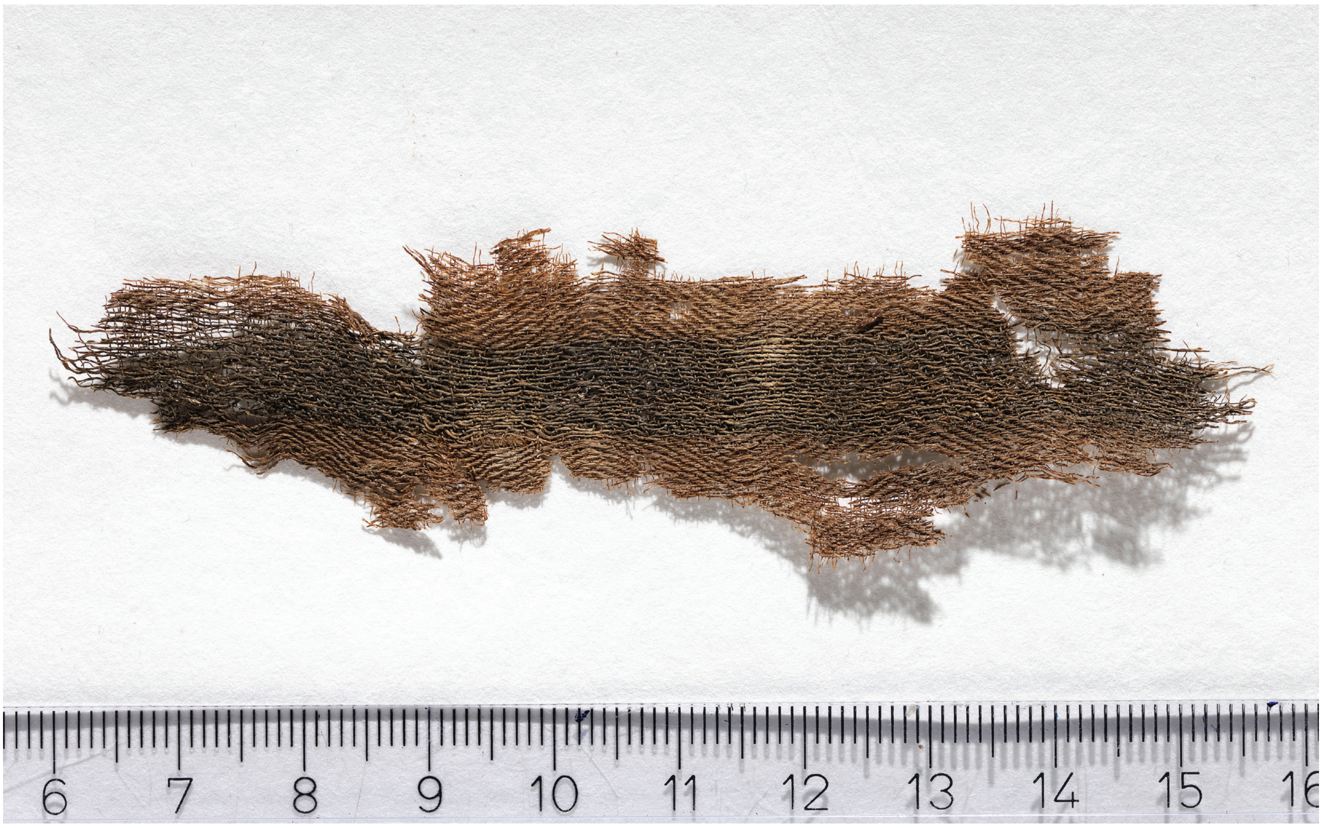

Fig. 10. The stripe with the gold thread is preserved in one small fragment and appears dark because silver corrosion has discoloured the silk yarns (Photo: Roberto Fortuna).

but traces of it are visible on the silk threads as discolouration from silver corrosion. Additionally, traces of membrane can be discerned which indicates that the thread was membrane gold, a type of gold thread consisting of strips of gilt animal gut wound around a core of silk thread. Further, an s-twist can be deduced in the silk core (Fig. 11). The second weft in each pass is silk with no twist indicating that the gold was only visible on one side. Possibly the silk weft was yellow and appeared golden.

After the gold stripe the light and dark chevron stripes are repeated again but unfortunately the continuation of the pattern from there is lost.

Conclusion: Where was the anonymous master from?

Due to the double-faced geometric pattern of diamonds and eight-pointed stars and the combination of a ground pattern and stripes, this silk was once assumed to be of Spanish/Moorish origin (Geijer 1979). However, after thorough analyses of these textiles, two groups have been distinguished, one to the north and the other to the south of the Pyrenees (Desrosiers 1989; 1994; 1999; Desrosiers and Bedat 1992). In spite of the incomplete pattern, the degraded colours and the very fragmented material, the silk from the grave of Valdemar II shares several technical characteristics with the group created to the north of the Pyrenees. The technique of 3/1 twill and the three cords of plant fibres for the selvedge are standard factors as is the s-twist of the gold thread. The variable factors comprise the number of wefts per pass which can be between two or three and the number of weft passes per cm which may vary from 24 to 40. Colours are preserved in several of the textiles from this group found elsewhere in Europe and are vivid: white, yellow or green contrasted with blue, red or black (Desrosiers 1999) but as dye analyses were not possible in this case one can only guess at the subtlety of the colour shifts from the variations in shades of light and dark.

Textiles with similar characteristics have been preserved as relics or grave textiles in many different places in Europe but none of the ones that were made south of the Pyrenees seems to be preserved outside Spain (Desrosiers 1999). It is therefore not surprising that the textile found in Denmark should belong to the group from north of the Pyrenees and our fragments only form an addition to these. In medieval inventories these textiles are described as cloth 'de Areste', 'de Arista' or 'de Larest', in modern French and English labelled 'Draps d'Areste' and 'Cloth of Aresta' (Desrosiers 1989). Because the Latin term 'Arista' means fish bone the term is thought to be related to the herringbone patterning of many of these weavings (King 1968; Crowfoot *et al.* 1992; Desrosiers 1999). However, it has been suggested that Areste/Arista/Larest are misspellings of 'de Alesto', a term which also appears in medieval inventories, signifying an origin in Alès, which seems a very likely interpretation (Desrosiers 1999). Alès is situated in the south of France and was earlier in its history called Arisitum. It is not unlikely, that our master designer earned his living there. The textiles he created were popular and used as royal burial clothes or wrappings. Through this analysis of a patterned silk weaving it has been possible, in spite of its degradation, to gain an impression of the creativity, skill and ingenuity needed to calculate how the loom should be set up in order to weave this kind of intricate pattern. It cannot be done just by intuition. Aside from detailed knowledge of the properties of the available materials, both artistic and mathematical skills would have been needed to get from the idea of the pattern to the setting up of the loom. These important silk producers were artists unknown to us now and often neglected in favour of the knowledge of the people who ultimately used the textiles. The materials used in silk weavings are so fine that many of the nuances only become apparent when they are viewed through the lenses of a stereo microscope. In the case of this particular weaving it is the colour shifts and the exquisite use of the twill techniques that are especially noteworthy. Numerous other examples can be seen of patterns made by subtle differences in materials such as the thickness or the twist of the yarns, as colour differences in the core of the gold threads or in the tightness of the yarn twist. These details bear witness to a creativity and playfulness on the part of the industrious people behind medieval silk textiles. Although anonymous today, they made their living creating fantastic textiles with subtle effects that were valued by the contemporary elite and this study should be seen as a tribute to their creative genius.

Fig. 11. In this detail traces of the membrane gold is visible in some places as a semi-transparent dark coating of the silk yarn. An s-twist of the silk core is discernible (Photo: Irene Skals).

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Britt Nowak-Böck and Helmut Voß

Standardised Mapping System for the Digital Documentation of Organic Materials on Metal Finds and In-Situ-Blocs

Introduction: Necessity for and development of the standardised mapping system

The corrosive layers on archaeological metal finds often contain remains of organic materials such as textiles, leather, fur, wood and feathers. These substances are usually severely decomposed and difficult to identify. Due, however, to the information they may reveal, they are important primary sources for archaeological research (Figs 1 and 2). Using suitable investigation methods, it is possible to establish manufacturing and processing techniques once used. Based on the sequential arrangement of the layers, it is even possible to reconstruct various details of clothing. Due to the severe fragility of these organic remains and due to the fact that any handling of the objects is a threat to the structural stability, thorough documentation throughout all steps of handling, from excavation to analysis, is of utmost importance. In order to ensure that all information relevant for research is preserved, it is necessary to record the position, orientation and context of each individual find during excavation (*e.g.* colour point marking on the upper side). This has particular significance for subsequent analysis, particularly with regard to grave context. Moreover, it is important that documentation of mineralised structures occurs during all conservation and restoration processes, to ensure continuous data collection of the organic remains. Conservation procedures include the cautious preparation of in-situ blocks, the stabilising of metal objects (*e.g.* desalination, consolidation), investigative conservation (*e.g.* partial exposure of metal surfaces) and the actual restoration of objects. The data can only be considered in its entirety during the later scientific analysis if the exact organic makeup has been documented within its stratigraphy (Nowak-Böck 2010, 174-180; Nowak-Böck 2013, 131-143).

The necessity of systemising the form and content of the descriptive documentation has been mentioned in various publications (*e.g.* Walton-Eastwood 1983; Mitschke 2001; Gillis and Nosch 2007; Peek 2013a, 183-198; Peek 2013b, 37-44). Such methods are especially significant when dealing with sites rich in finds, when planning projects involving many parties and experts and when relaying scientific results to other disciplines. Loss of information and lacking data quality can be avoided by implementing a consistent approach. Furthermore, labour-intensive data collection alleviates work in the subsequent scientific evaluation and publication of the results.

In order to utilise the above-mentioned benefits also when mapping organic substances within metal finds, a digital mapping system has recently been developed at the Bavarian State Department for the Protection of Historical Monuments and Sites (BLfD) as part of a pilot project on early medieval finds from Unterhaching near Munich (Nowak-Böck *et al.* 2013, 156-185; 258-300). The system is based on the image processing software Adobe Photoshop® Version CS3. Consequently, this “prototype” has been further developed, employed in other projects, and could even be adjusted for a much wider range of applications (see *e.g.* Nowak-Böck *et al.* 2014, 98-110). The goal was to create an easily comprehensible, implementable

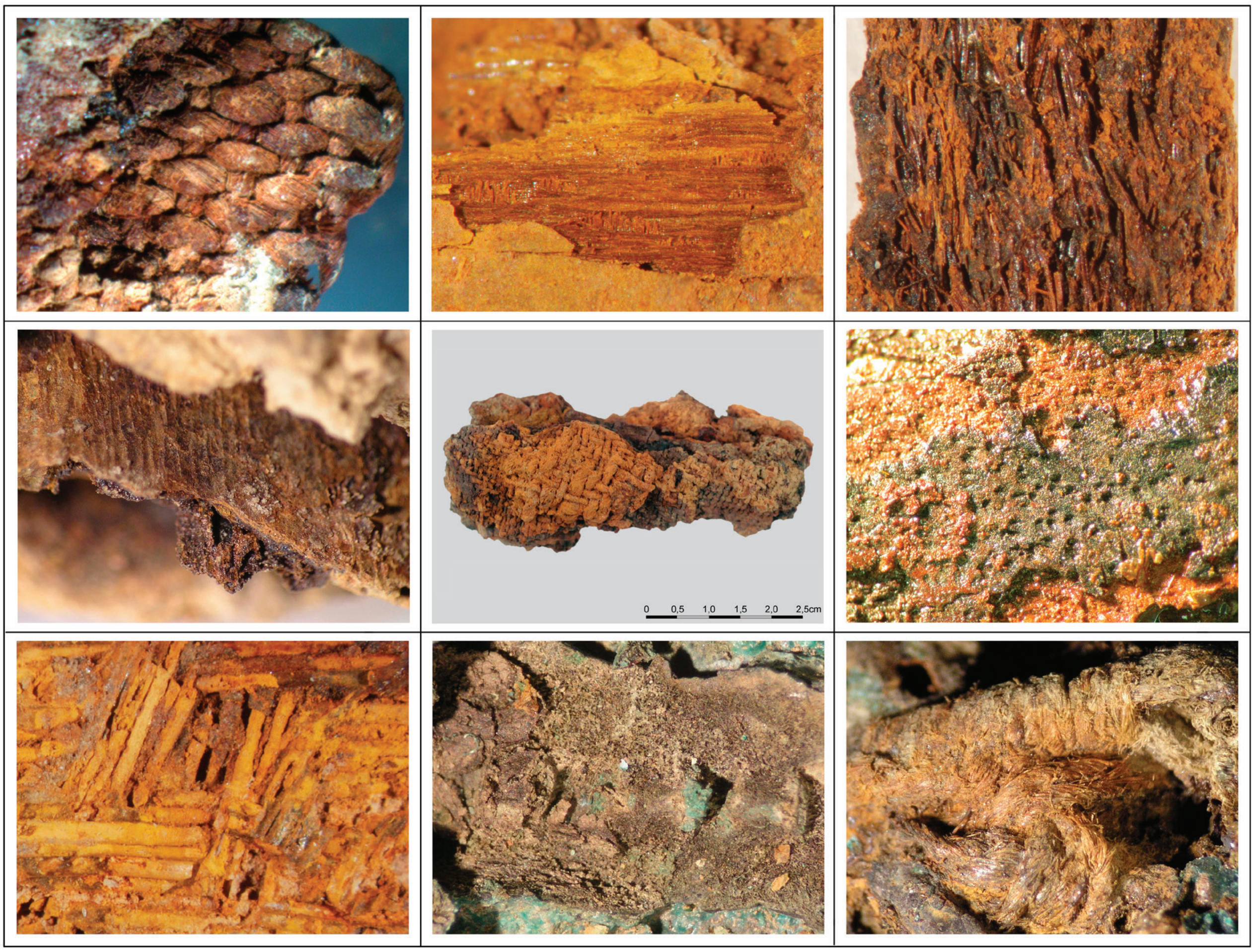

Fig. 1. Different organic materials on metal finds (from left to right): Textile, wood, fur, horn, multilayered textiles, leather, botanical residues, leather and loop (© Helmut Voß, Britt Nowak-Böck, Bavarian State Department for the Protection of Historical Monuments and Sites).

Fig. 2. Dürrlauingen, Lkr. GZ, grave 42: Front and back side of two strap-ends with organic residues (42.5f and 42.5e) (© Helmut Voß, Britt Nowak-Böck, BLfD).

Fig. 3. Example of use: Mapping of all organic remains on the metal finds of grave 42 from Dürrlauingen, Lkr. GZ: Iron buckles (42.3a, 42.5d), fittings (42.2, 42.3b, 42.5g, 42.5h, 42.5i) and strap-ends (42.2, 42.5e, 42.5f) of the belt 42.3 and the sword belt 42.5. Due to the fact that the fibre materials of the textile structures have not yet been analysed, the remains are depicted using the bright "extra" colour red (© Helmut Voß, Britt Nowak-Böck, BLfD).

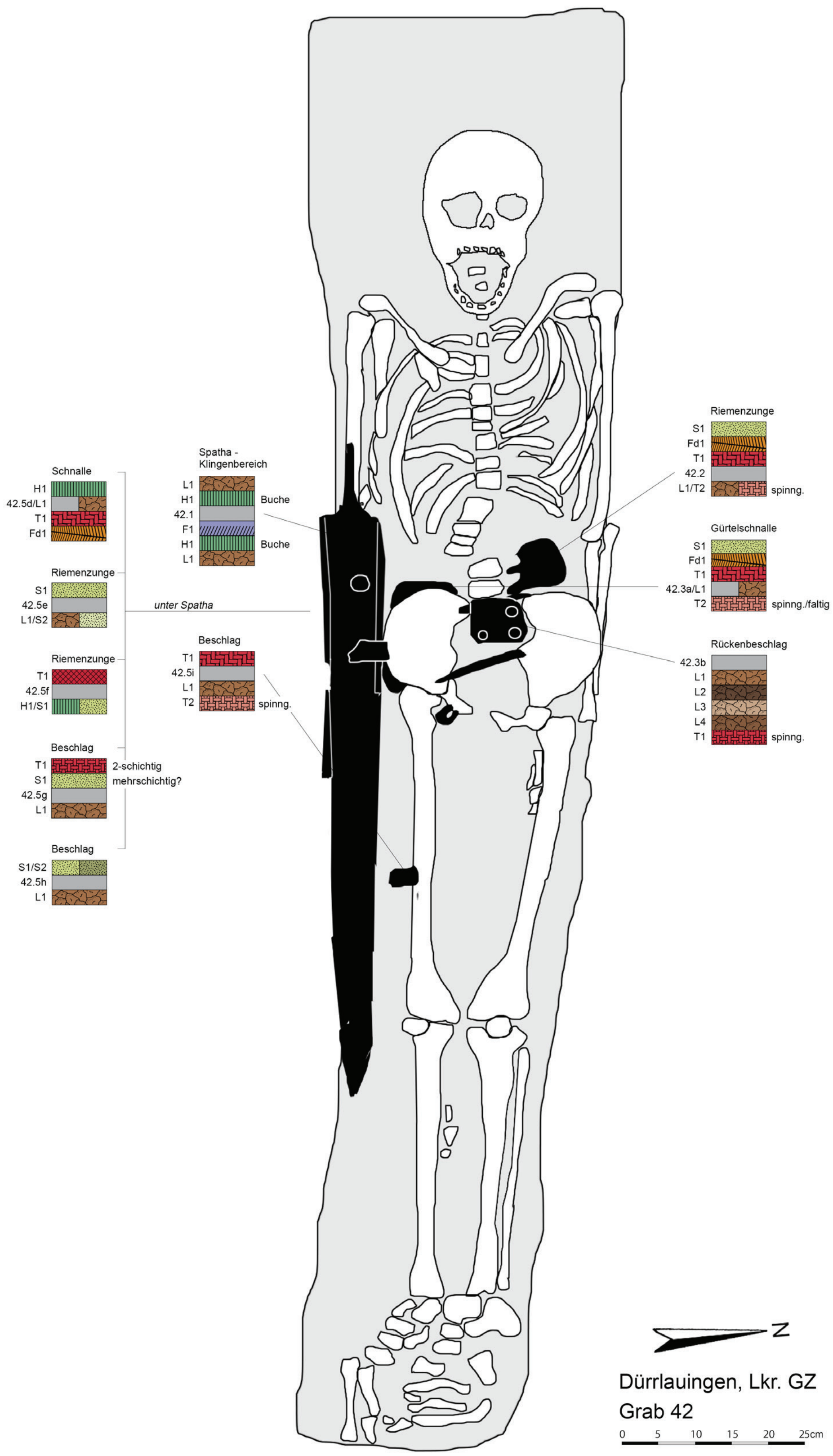

Fig. 4. Situation of grave 42 from Dürrlauingen, Lkr. GZ with all stratigraphic layer bars (for more information on the archaeological context see Neupert 2009). Here is also illustrated the sword (42.1) with the remains of the scabbard made of beech wood, leather and one-sided fur inlay (© Helmut Voß, Britt Nowak-Böck, BLfD).

and uniform mapping system for organic substances applicable to single finds and to in-situ blocks across various time periods. A standardised depiction with predefined colours, pictograms and acronyms enables easier understanding and optical comparison of pieces and complexes. Further reasons for the development were the adaptability of the standardised system to individual cases, and the possibility of recording and making easier amendments to detailed information gained during processing.

The application of the digital mapping system

The system consists of a planar map with a set colour code and a stratigraphic presentation by means of coloured pictograms. Schematically determined acronyms are used to identify the substances that are to be mapped (Figs 3 and 4).

Planar mapping with defined colours

To create a foundation for mapping organic substances, the objects must be depicted from the front and back, and if necessary also from the side. Rectified photos or drawings with clear outlines can be used for this purpose. These must be scaled according to actual size (for small finds usually 1:1). The find is depicted in grey. Should two or more objects be joined together, these can be illustrated using various shades of grey. All organic residues are shown in their entirety and the different materials are mapped according to a standardised colour code. The most common mineralised structures are distinguished using nine different colours, each with one lighter and one darker shade (opacity is always 100%). The ranging shades of one colour are to show materials layered on top of each other. The colour values are complementary to each other and are within the colour range of Adobe-RGB and CMYK. This is very important for working on a computer screen and also for accurate colour printing. Three "extra" colours can be used for rare materials or for depicting substances that are specifically important to a certain project (*e.g.* silk, threads or entomological residues).

The course of organic layers around the edge of an object can be depicted in the planar view using predefined arrows. The direction of warp and weft (system 1 and system 2) in textile structures are identified using small crosses (Fig. 5).

Fig. 5. Defined Colour Code: Predefined colours (middle colour range) for various organic materials, each with a darker and a lighter shade (© Helmut Voß, Britt Nowak-Böck, BLfD).

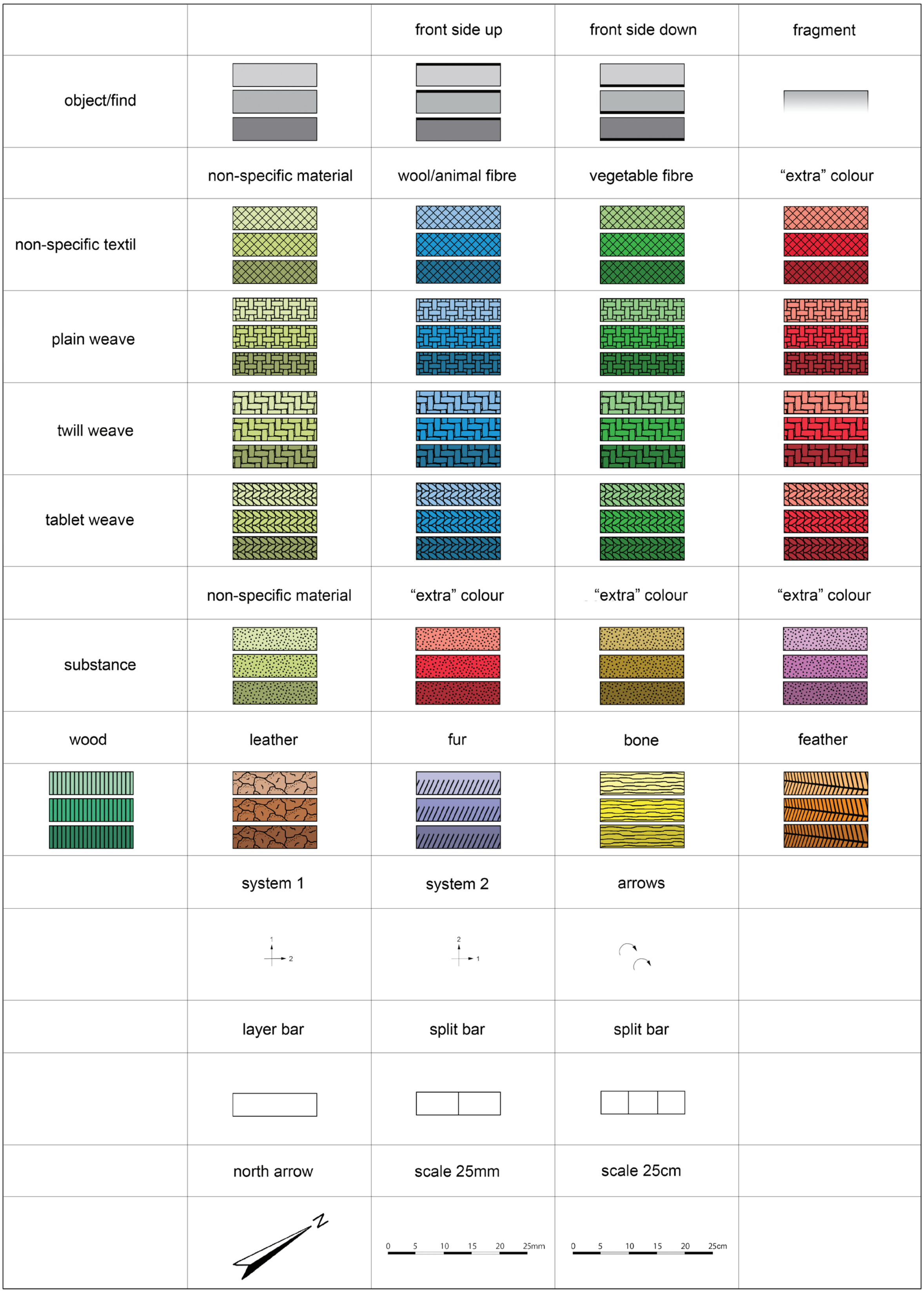

Fig. 6. Table with symbols and coloured pictograms for stratigraphic depiction (© Helmut Voß, Britt Nowak-Böck, BLfD).

Stratigraphic mapping using colours and pictograms
The layers of organic structures contained on both the front and the back of finds are schematically depicted using layer bars when mapping stratigraphically (for more on micro-stratigraphical analysing method, see Hägg 1989, 431-439; for depictions, see *e.g.* Rast-Eicher 2012, 56-77). For finds containing very complex layering or for large objects (*e.g.* swords), depicting the stratigraphy at several different positions and creating additional detailed drawings and descriptions are recommended. The initial starting point is the find, which is represented by a grey bar. If the orientation of the object upon excavation was recorded, this can be shown using a bold line on the grey stratigraphic bar; this information is very useful for subsequent analysis. The bar for organic residues consists of material colour and pictogram. These are standardised for the following materials: leather, fur, bone/horn/antlers, feathers, wood and non-specific substances. To maintain clarity in planar object mapping, the use of pictograms has to be avoided; these areas are often too small to be able to easily recognise the pictograms. The pictogram for non-specific substances can be combined with different colours. For example one can use the neutral substance-colour (beige) when the substance is unidentified, or a bright "extra" colour (red) if a special or rare material needs to be shown for which a pictogram or colour has not been assigned (*e.g.* botanical residues). By using the substance pictogram and "extra" colours to vary combinations, the system can be adapted to suit individual cases.
Specified textile pictograms exist for the most common weaving techniques (especially those of the Middle Ages) such as plain weave, twill weave and tablet weaving. Again, to ensure clarity we have abstained from extra pictograms for derivations of these weaves (*e.g.* diamond twill). More precise information about the weave technique can be expressed using logical abbreviations noted to the right of the stratigraphic bar (*e.g.* in German: Rips – Rp; Panama – Pm; Köper – K 2/1 bzw. K 2/2 bzw. K 3/1; Spitzgratköper – Sgk; Rautenköper – Rak; "Rippenköper" – Rik; "Rosettenköper" – Rok; Fischgratköper – Fgk; Diamantköper – Dik; "Kreuzköper" – Krk; "Blöckchendamast" – Bld). This form of illustration enables not only a clear overview, but also allows the presentation of textile structures with varying degrees of information. Further characteristic details such as spin-pattern, fine, coarse or multilayered can also be noted next to the pictogram.
An unspecific textile symbol can be used for indeterminate or very rare weave techniques (*e.g.* weft-faced compound twill, patterned weaves or combined bindings) or also for other fabric techniques such as sprang or netting. This must be assigned with a material colour and identified using an acronym.
If two substances are contained within the same stratigraphic layer (*e.g.* the sheath and handle residues from a knife), these can be depicted using a split bar. Any "non-planar" substances (*e.g.* single yarns or small leather strips) are not depicted in the stratigraphic view, but solely documented in the planar using the correlating acronym (Fig. 6).

Acronyms for identifying organic layers
Every substance must be assigned an acronym to ensure each of the mapped layers can be uniquely identified in documentation, photos or samples. The acronym consists of a letter for the material (*e.g.* T = textile, L = leather, B = bone, W = wood, F = fur, Ft = feather, S = (non-specific) substance) and a sequential number. The acronym is depicted to the left of the corresponding stratigraphic bar.

Field experience and advice to users
The standardised mapping system has already been implemented in various projects, including tertiary education for thesis research in both conservation/restoration and archaeology. The focus was not only on recently excavated and/or restored finds from the early Middle Ages, but also on prehistoric and post-medieval material.
Based on field experience gained so far, the advantages of a standardised system outlined above have been proven. Documentation quality was improved remarkably, as each researcher was forced to consider each object intensively. Although the preparation and creation of the map initially demanded more time and effort, this method led to a more efficient recording process. This effect became even more apparent when several people worked in different locations, at various times. This was the case, for instance, in projects with many phases, involving several restorers with diverse activities (*e.g.* for recording finds, conservation measurements, investigative conservation, restoration and analysis). A homogenous approach is a major advantage to projects like these that deal with large numbers of finds. It ensures the collected data is concise and greatly eases the subsequent compilation and analysis of the documentation. If aspects such as map documentation, the concluding scientific analysis and the publication of all results are considered from the early stages of a project, most steps of the process can be made easier and more efficient. For example, initial object photos should be taken distortion-free (avoiding wide angle), in focus and with a scale positioned at the height of the object. For analogue sketches it is important to ensure a solid line of

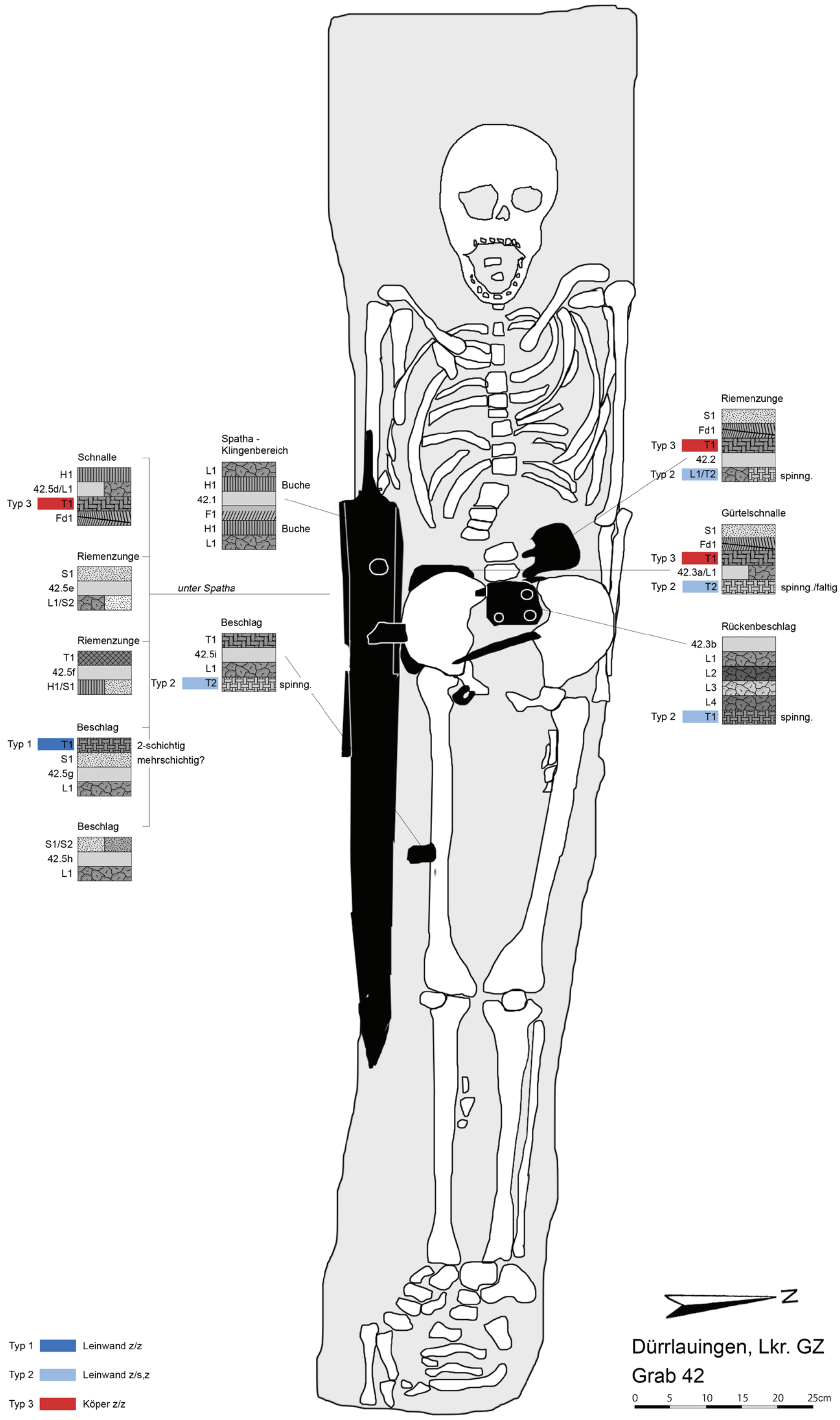

Fig. 7. Interpretation of the textile data and depiction of defined textile types in grave 42 of Dürrlauingen, Lkr. GZ: type 1 (plain weave z/z): located only on the fitting 42.5g, function unclear; type 2 (plain weave z/z,s, spin-patterned): especially preserved on the inner side of the belt (42.3a and 42.3b), maybe residues of a garment worn under the belt (tunic?), type 3 (twill z/z): preservation on the front side of the belt buckle 42.3a (recovered underneath the dead person), the strap-end 42.2 and as well under the sword 43.5d, possibly interpretable as an outer garment worn over the belt or as a relic of the bedding, because documented underneath the body and always in combination with feathers (© Helmut Voß, Britt Nowak-Böck, BLfD).

consistent thickness. These templates can be later used as a map foundation without requiring time-consuming editing. In most cases, digital mapping can replace the need for complex hand sketches. Moreover, the colour and pictogram of a given mapped layer can be added "with one click of the mouse" if new information is gained at a later date during material and textile analysis.
Furthermore, a standardised mapping system for organic materials is a significant aid when communicating and comparing organic finds. Images using colours and symbols allows even readers without expert knowledge to gain a quick understanding of very complex information. In this way, for example, a reader can quickly gain an insight into the distribution of repetitive stratigraphic sequences, the appearance of combined layers or certain substances within a grave. This consequently creates a sound basis for objective discussion of fact-based interpretations (*e.g.* closely related stratigraphic layers within diverse grave goods or the distribution of defined textile types within a site). In a further step these interpretations can also be shown using the mapping system (Fig. 7).
The advantages outlined above have become more apparent the more consistently the system presented has been applied. Necessary project-oriented modifications can be achieved by combining predefined "extra" colours and substance or textile pictograms, so that additions to the system should remain an absolute exception. Detailed "Guidelines for Installation and Implementation of the Mapping System", including helpful Plug-ins for Adobe Photoshop® and all fundamental settings, predefined colours and pictograms have been compiled to make implementation of this system as simple and consistent as possible. Additional automated actions offer even the inexperienced user practical help for planar and stratigraphic depiction (Fig. 8). All files and further information can be accessed free of charge on the BLfD homepage http://www.blfd.bayern.de/bodendenkmalpflege/restaurierung_archaeologie/index.php ("Kartierungssystem für organische Materialien und Kartierungsvorlagen") or requested from the authors. An English version of the guidelines is currently being developed.

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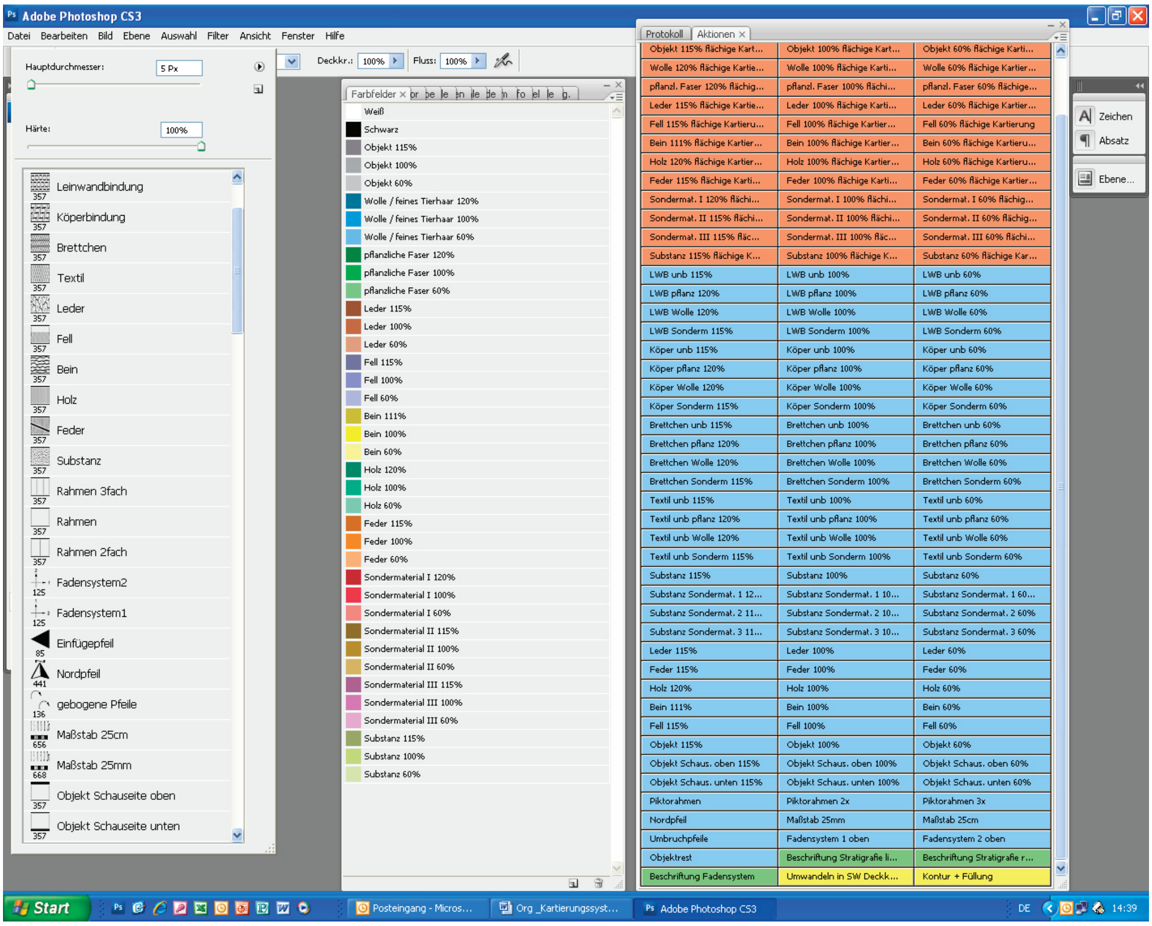

Fig. 8. Adobe Photoshop® CS3 Interface with standardised brushes, colours and automated actions (German version) (© Helmut Voß, Britt Nowak-Böck, BLfD).

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Ulrikka Mokdad

Transparent Textiles

Experiments in Plain Gauze Carried Out on a Small-Frame Loom

Introduction

The weaving experiments conducted in the context of a project trying to better understand the weaving of gauze were partly inspired by an article written by Andersson Strand and Cybulska (2013). The authors advance the hypothesis that a so-called *guz-za* fabric described in a Mesopotamian Ur III text dated to *c.* 2050 BC may have been woven in gauze technique. Only very few preserved textile fragments have been unearthed from this area and period, but in the North Caucasus, wool textiles with twined warp ends were produced as early as the 3rd millennium BC (Shishlina *et al.* 2003, 333).

The gauze or warp-twining technique

Plain gauze has a unique weave structure that differs from all other known weaves (such as the three basic bindings of tabby, twill and satin) in having the warp ends arranged in pairs that twist around each other between each weft. A cloth woven in plain gauze technique is remarkable because the twined warp threads prevent the wefts from being beaten closely together, thus creating a light, airy fabric with a transparent structure (Fig. 1). Although almost the same amount of transparency can be achieved by weaving a very open tabby weave, an open tabby fabric has a tendency to bruise where the threads shift away from their uniformity, disturbing the regular structure of the weave. This is not the case with a gauze fabric where each weft will be kept firmly in place by the twined warp threads, thus securing a much more solid structure. The basic idea of this structure is rather simple and makes the creation of gauze a logical step on even the most primitive loom (Pancake and Baizerman 1980-81, 1).

Plain gauze technique seems to have developed simultaneously in different parts of the world by peoples who had no contact to each other. Ancient gauze fabrics have been excavated at archaeological sites as geographically far apart as China, North Caucasus and Peru. In China, one of the earliest known silk fabrics, found in a child's burial site in Qingtai Village, Yingyang County, Henan, is in fact a fabric with twined warps dating to 3650 BC (Zhao Feng 1999, 39). At the Novosvobodnaya sites in North

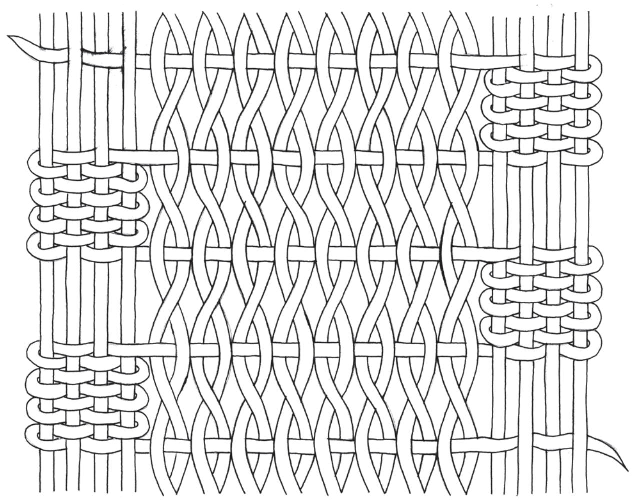

Fig. 1. The course of the threads: the technique of plain gauze with stabilising edges in tabby weave (Drawing: Author).

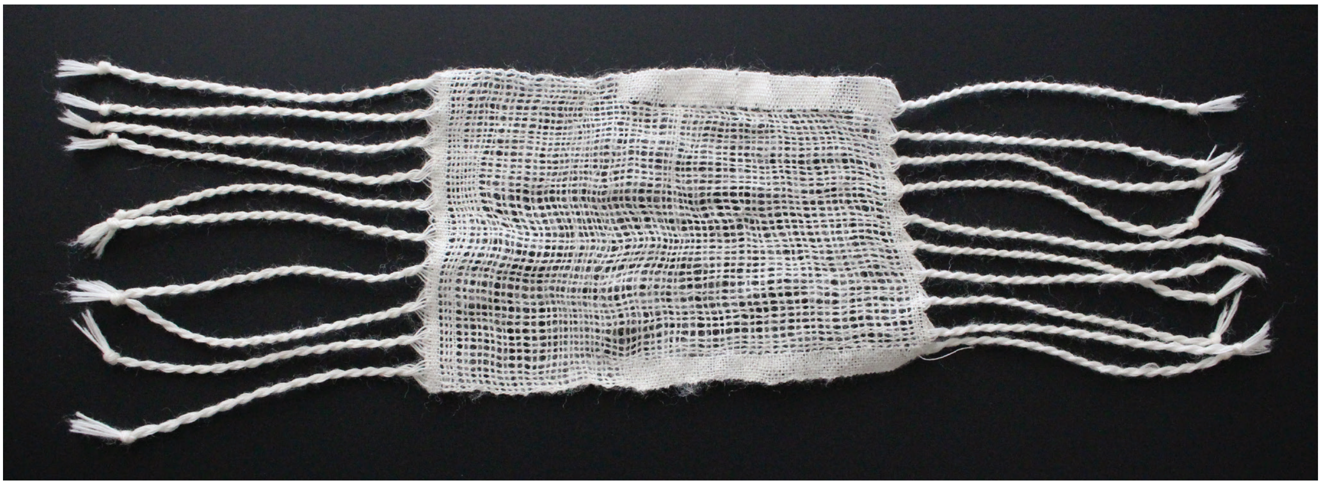

Fig. 2. The wool sample (Photo: Charlotte Rimstad).

Caucasus, fragments of wool cloth attributed to the Majkop culture (3700-3200 BC) were discovered in the late 19th century during the major excavations undertaken by Veselovsky. Recent analyses have revealed that several of these were also woven with twined warps (Shishlina *et al.* 2003, 331-333). In Peru, the translucent cotton textiles found in the Chancay Valley excavations show that the Chancay weavers in around 1300 AD had further developed the relatively simple technique of plain gauze to make complicated ornamental patterns for their headdresses (Fung Pineda 1995, 554). Finally, Barber mentions that tiny bits of gauze weave have been detected among linens from the Middle Kingdom in Egypt, 2000-1700 BC. They do not form part of any decorative pattern, so they most likely served as "weaver's marks" (Barber 1991, 151).

The looms used for warp-twining

Most ancient looms were probably made of perishable materials such as wood, which means that they have disappeared without leaving any trace in the archaeological record, an exception is the warp-weighted loom, which had its warp threads held taut by loom weights such as perforated pebbles or weights made of clay. A large number of clay loom weights from different periods have been unearthed at several sites in the Aegean. They prove that the warp-weighted loom was in use there for textile production from at least the early Bronze Age, *i.e.* mid-3rd millennium (Barber 1991, 93). But the fact that the only preserved evidence of looms point to the use of the warp-weighted loom should not be taken as a proof that this was the only type of loom employed in this area.

In other parts of the world where archaeological textiles have been preserved, analysis of the textiles has revealed that several loom types were in use simultaneously for different purposes.

The remarkable collection of Danish Iron Age textiles that was analysed by Hald in the 1930s has proven that before the warp-weighted loom came into use another large loom, probably a vertical two-beam loom well-suited for tubular weavings, served the inhabitants of the north (Hald 1980). At Akrotiri, loom weights have only been found in four out of 11 excavated houses, according to Tzachili (Tzachili 2007, 191). The author therefore advances the hypothesis that there may have been looms of a different type in the other houses, such as vertical two-beam looms like those known from depictions from New Kingdom Egypt (Tzachili 2007, 192). In pre-Columbian Peru there is evidence that both large vertical two-beam looms as well as the ordinary back-strap looms were in use in the Wari Empire during the Middle Horizon *c.* 700-1100 AD (Engelstad 1985, 8-9).

A small experiment that was carried out at the CTR Loom Laboratory in 2013 by the author showed that the warp-weighted loom was less suited for weaving plain gauze. Technically, it requires the possibility of opening and closing both the tabby shed and the warp-twining shed. However, the fact that the warp-weighted loom has the warp threads permanently divided into two layers, forming a natural shed that is practically always open, makes the task of warp-twining difficult on this type of loom. Weaving gauze

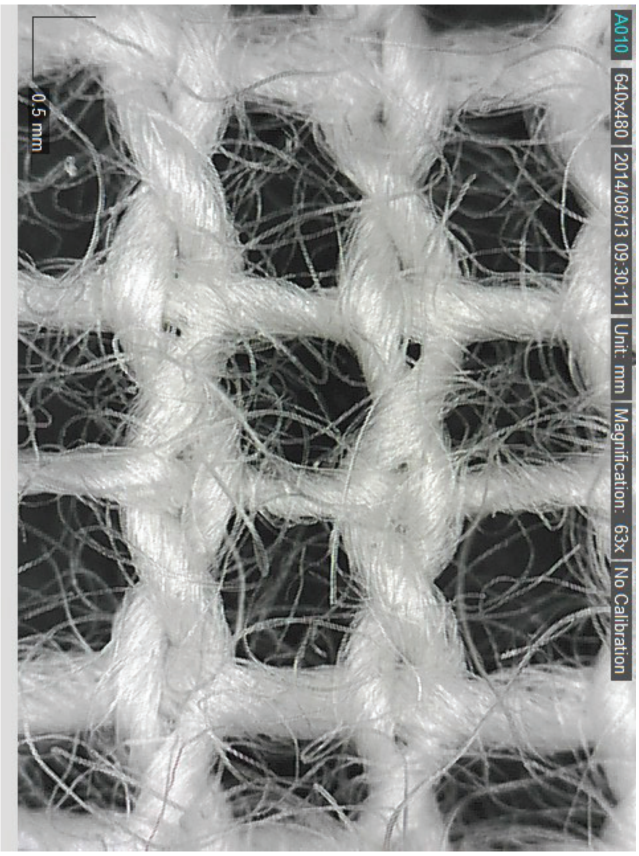

Fig. 3. Detail of the open plain gauze structure of the wool sample (Photo: Charlotte Rimstad).

on a back-strap or two-beam loom, in contrast, is much easier. The fact that the warp threads are not divided permanently into two layers as well as the much smaller sheds makes these types of loom better suited for working with warp-twining.

The experiments

The decision to carry out an experiment in plain gauze weaving on a small exercise frame loom was made by Nosch at the Danish National Research Foundation's Centre for Textile Research in early spring 2014. The samples were presented same year at the NESAT XII conference in Hallstatt, Austria. The aim of the experiment was to investigate if and how one could weave very fine gauze textiles on a very simple loom even without the aid of any additional shedding mechanisms like pearls or specially-produced long heddles as known from modern gauze weaving (Paulli Andersen 1971, 181) to open the gauze shed. As the exercise frame loom measured only 20 x 30 cm, it was not well suited for heddles. Furthermore, we cannot be sure whether or not the gauze weaves of the past were all woven with additional shedding.

In their study of Guatemalan gauze weaves, Pancake and Baizerman claim that some of the finds from ancient Peru were most probably executed without any shedding devices (Pancake and Baizerman 1982, 1). However, model-sized back-strap looms, presumably made as tomb offerings, have been found in Central Coast graves of the late Intermediate Period. Some of these little looms were set up with several heddle rods with special heddles in order to create a simple gauze weave (Rowe and Bird 1982, 33).

The first sample was made entirely of wool. I chose a rather thin yarn (nm 12/1 that runs 12 m/g). The exercise frame loom was set up with a tubular warp in order to ensure the warp threads were long enough for warp-twining. The setup was 100 warp threads for a 10 cm wide piece = 10 threads per cm. A natural tabby shed was made by inserting a flat stick between the warp threads at the far end of the frame. Turning this flat stick upright would open the tabby shed allowing the weft to be carried through by a very thin, pointed tapestry bobbin. The second shed, the one for warp-twining, was picked up by hand each time with the help of the pointed end of a bobbin before the weft was carried through. At first, the weaving was carried out without a stabilising selvedge, but after approximately 4 cm it turned out that the sample became narrower for each weft. In order to stabilise the width, 10 warp threads in weft-faced tabby weave were employed as selvedges on both sides. After having shrunk to 9 cm, the sample started to widen again, and finally the width was stabilised at 9.3 cm. About six passes of weft-faced tabby at the edges were made for every weft passing from selvedge to selvedge. The sample reached 14 cm before the warp threads began to break because of wear from the passing of the bobbin (Figs 2 and 3). A modern commercial yarn is generally less suitable for this kind of work than a hand-spun yarn with a high twist. The solution to this problem may be to use a warp made of a more hard-spun wool yarn, a single-ply worsted wool thread or a two-ply wool yarn.

As can be seen from the drawing in Figure 1 the four warp threads in the selvedge stabilises the edges. When the weft-faced tabby edges are beaten closely together, they tend to stretch out the weft in the gauze area, thus preventing the textile from shrinking during work. Further, it is shown that the paired warp threads are not twisted around each other in a continuing spiral, such as in a tablet weave where all the tablets are turned in the same direction. On the contrary, one of the two threads in a pair is always lying on top of the other, the one on the top passing under the weft and the underlying warp thread of the pair passing over the weft. This means that every time the weft has passed through the gauze shed, the warps will go back

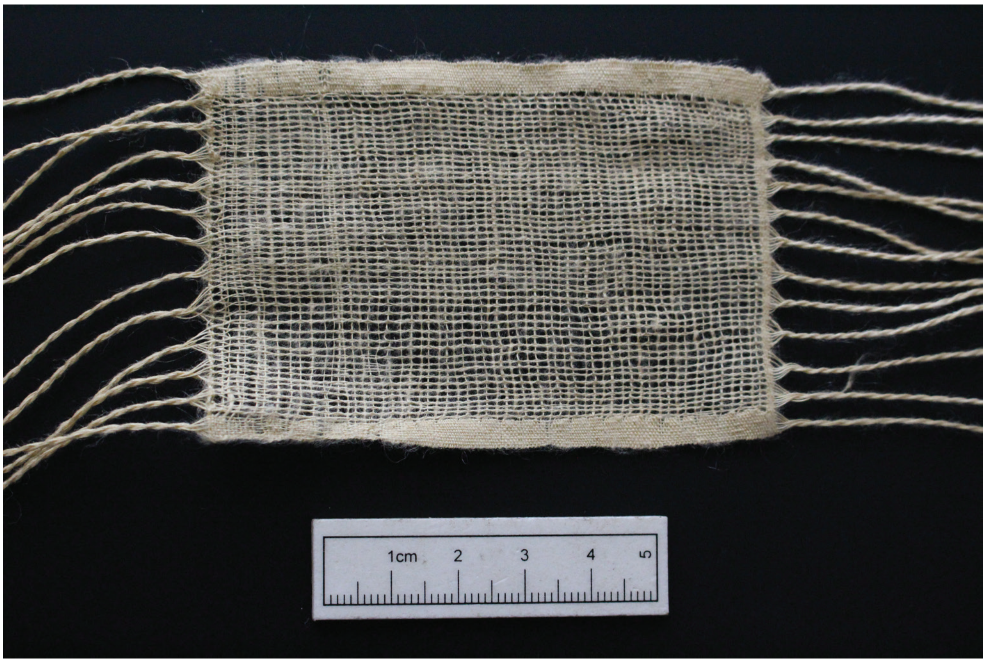

Fig. 5. The linen sample in plain gauze with tabby edges (Photo: Charlotte Rimstad).

to their normal position as the tabby weft is passed through the natural shed. This prevents the warp threads from becoming over-spun or under-spun.

The second sample was made of linen 60/1, a very thin thread that runs approximately 36.2 m/g. The method of weaving was the same as in the first sample, though from the beginning, the sample was set up with 10 warp threads on each side employed as stabilising selvedges, woven in weft-faced tabby with 10-12 wefts between every weft passing from selvedge to selvedge (Fig. 4). This sample reached 8.5 cm before it was cut off. It did not shrink and the warp threads did not break despite their thin quality (Fig. 5). This method of weaving gauze is quite slow due to the fact that every second shed has to be picked up by hand. The wool sample took 10 hours to weave, *i.e.* 1.4 cm/hour. The linen sample took 16 hours, *i.e.* less than 0.5 cm/hour. On a larger loom, it would be reasonable to tie heddles to lift the gauze shed.

Conclusion

The aim of the gauze experiment was to investigate if and how one can weave fine gauze textiles on a loom without special heddles. As the warp-weighted loom had proven difficult to work with for this task, my focus was on using a weaving frame as a substitute for a large, two-beam loom. The work pace was very slow, but despite this, it can be concluded that it was possible for trained weavers in the 4th millennium

Fig. 4. Detail showing the stabilizing tabby edge of the linen sample (Photo: Charlotte Rimstad).

BC to produce fine lace-like textiles on either a two-beam loom or a large frame using the warp-twining technique. However, due to the very slow pace, it is likely that they employed a special set of heddles for the twining shed. The next logical step would be to try to weave larger samples in wool and linen on the upright two-beam loom and include a natural shed as well as one or two heddle sheds.

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Émeline Retournard

Archaeological Textiles from an Ore-Washing Workshop in the French Alps

Introduction

This article provides a summary of Master's research conducted at the University of Burgundy (Dijon, France), consisting of the study of more than 400 textile fragments dated from the 12th to the 14th century, from Brandes-en-Oisans, Isère, France. Stefan Wirth (UMR 6298, ARTeHIS, Dijon) and Christophe Moulhérat (Musée du quai Branly, Paris) were the supervisors. Several questions were raised during the project. The most important of them were to know the function of the textiles found within a specific area (the B102 zone) and whether the textiles from this zone were objects of reuse. The zone was a place dedicated to ore-washing.

Main context

Brandes-en-Oisans (Fig. 1) was a medieval village located approximately 60 km from Grenoble. It was built at an altitude of 1800 m and divided into several parts: a church, its graveyard, a fortified house, villagers' houses and industrial districts (Fig. 2). Silver and lead mines were located both in and around the village. A steady archaeological presence has been maintained here since 1977, with excavations directed by Marie-Christine Bailly-Maître (UMR 7298, LA3M, University of Aix-Marseilles/CNRS). These allowed for the discovery of more than 80 buildings over an area of five ha. A rich collection of artefacts has been found: pottery, stone and metal objects, glass, animal and human bones and organic material including wood, leather and textiles. These discoveries and their contexts allowed researchers to date the site between the 12th and the 14th century.

Villagers lived in half-buried stone houses composed of a single room covered by a thatched roof. Domestic pottery, wooden dishes, lighting, cosmetic and clothing elements, as well as games were discovered in the houses. A church was built in the south of the village, on the Rock of Saint Nicolas (*rocher Saint-Nicolas*). In the graveyard next to the building 250 skeletons were found. An equal percentage of children, women and men were discovered. This represents a society based on a familial pattern where the average age was 34

Fig. 1. Localisation of Brandes-en-Oisans (Map: Émeline Retournard).

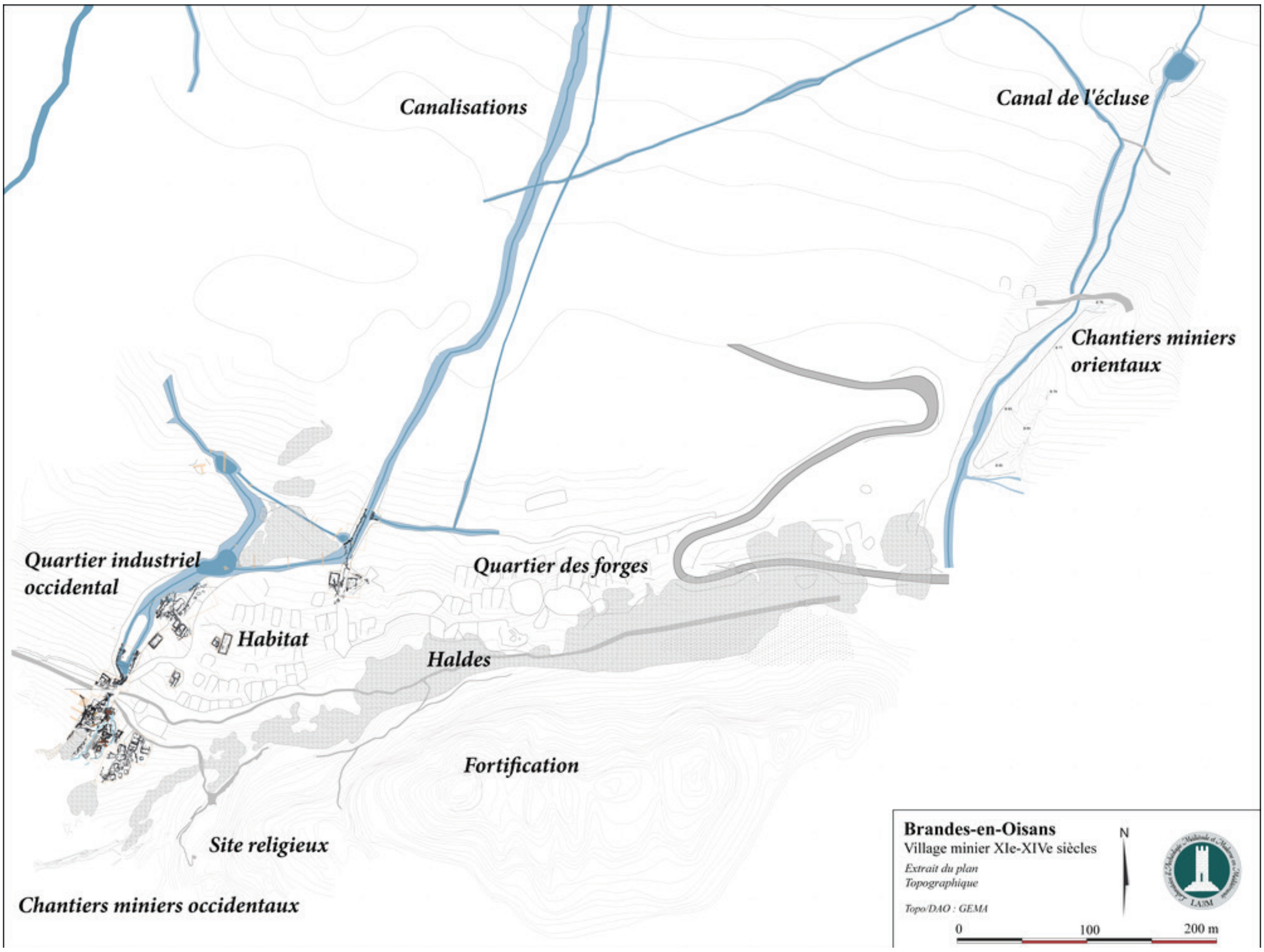


Fig. 2. Plan of Brandes-en-Oisans (up to down, left to right): pipes (*canalisations*), canal of the lock (*canal de l'écluse*), eastern mines (*chantiers miniers orientaux*), western industrial district (*quartier industriel occidental*), forge district (*quartier des forges*), housing (*habitat*), spoil heaps (*haldes*), fortification *(fortification)*, religious site *(site religieux)*, western mines *(chantiers miniers occidentaux)* (Map: Marie-Christine Bailly-Maître).

years, though some individuals reached 60 years of age. No objects were found within the tombs besides funeral material, such as hairpins, glass and amber pearls, iron belt buckles and scallop shells.

On top of the rock, a fortified circular house was built called a 'shell-keep'. It was composed of a circular wall with a central courtyard and surrounding rooms. A ditch was dug to protect the shell-keep. The function of the building was probably to guard the surroundings.

Brandes-en-Oisans is located on a silver and lead vein. At first, miners worked in open-air mines and dug the subsoil with iron tools or fire. Ancient floor levels and ladders were found within at least two galleries. Dendrochronological analysis indicates that the wood used for these elements grew at an altitude between 800 and 1500 m. And it is suggested that local varieties of wood were used for these elements. This also allows us to date the beginning of mining activity between the 11th and the 13th century.

Mines were first mentioned in a text dated to 1236 AD, while the first mention of the village dates to 1261 AD. '*Brandes*' means 'burned earth' in Occitan (a dialect from the south-east of France): it perhaps derives from a mining method where walls were burned with fire to break the stone. At the same time, the medieval name of the village (*L'Argenteria de la Branda* or *L'Argenteria de Brandis*) expresses its main activity: the extraction and treatment of silver ore. Silver was transported to Grenoble as powder for coin mints (Bailly-Maître 2002, 167; Bailly-Maître 2008, 10-56).

Area	Type or location	Number of textiles
B116	Various workshops	583
B102	Ore-washing workshop	445
B21b	Ore-washing workshop	122
B72	House	72
B70	Forges district	30
B54	Ore-crushing workshop	18
B39	Buildings	14
B42	Spring district	12
B71	Forges district	10
B21	Ore-crushing workshop	9
B111	Mining zone	4
B63	Blacksmith's house	3
B3b	House	2
B67	Forges district	2
B34	Ore-washing workshop	2
B12	House	1
B28	House	1
B29	House	1
B105	Pipe	1
B118	Trench	1

Table 1. Localisation of textiles in Brandes-en-Oisans.

Diversity of the corpus

Presently, a total of 1335 textile fragments (fabrics and threads) have been found in 22 of the archaeological areas. Among these areas, two demonstrated a remarkable quantity of discoveries: B116 with 583 fragments and B102 with 445. These were industrial districts dedicated to the treatment of silver and lead ore. Other areas with houses and industrial districts also delivered textiles (Table 1). Some pieces of textiles were restored by Véronique De Buhren (Museum of Textiles, Lyon), as well as by some of her students. One of them, Audrey Éberlé, studied some samples for her Master's degree at the University of Burgundy. The rest of the corpus is neither washed nor restored, and as a result is stored in plastic re-sealable bags.

One of the aims of the research was to study textiles discovered in zone B102. A workshop for silver and lead ore washing was discovered in this area. Several structures of stone buildings along with several washing basins inside and outside of the structure were brought to light. After the technical analysis it was possible to classify some of the discoveries (Table 2). Tabby weaves are divided into three types: balanced, weft-faced and undefined. Twills are represented with 2/1 warp-faced, 2/1 weft-faced, 2/2 warp-faced, unproven 2/2 warp-faced and undefined. Threads are also represented in the corpus in simple and twisted form.

Initially appearing as a uniform mass, the study of the 372 fabrics and 73 threads from zone B102 reveals a diversity of weaves, colours and decoration: Twill is the most common weave in the corpus with 343 samples. 2/2 twill is the most common with 277 fragments. 2/1 twill was also found during the study but in lower quantity: three samples of 2/1 warp-faced twill and two of 2/1 weft-faced twill. Twenty-four textiles are considered as 2/2 twills but the state of conservation does not allow confirmation of this information. Thirty-seven fragments remain undefined, but 35 others are possibly 2/2 twills.

The weaving quality is medium for the 2/1 weft-faced twills and one piece of 2/1 warp-faced twill: the number of threads per centimetre (thread count) is between eight and 12. In the case of the two other 2/1 warp-faced twills, the thread count reveals a finer quality with more than 13 threads per cm. In the case of the 2/2 twills, the quality is more various: four textiles have a thread count lower than seven threads per cm (Fig. 3), 222 are considered as medium quality (8-12 threads per cm: Fig. 4) and 18 are classified as fine textiles through 13 or more threads per cm (Fig. 5). Three samples can be considered as mid-rough and four as mid-fine. Finally, there is no possible thread count for 26 fragments, as they are enveloped in dirt. Two groups of tabby were found in a total of 23 fragments: balanced tabby (with the same number of warp and weft threads) and weft-faced tabby.

Threads are also present in the corpus in bags that have a combination of textiles or alone. In total, 73 threads mostly simple were analysed. Only four twisted threads were discovered. They are composed

<table>
<tr><td colspan="15">Textiles</td><td colspan="2">Fibres</td></tr>
<tr><td colspan="11">Fabric</td><td colspan="4">Thread</td><td>Animal</td><td>Plant</td></tr>
<tr><td colspan="3">Plain tabby</td><td colspan="8">Twill</td><td colspan="2">Simple</td><td colspan="2">Twisted</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>Balanced</td><td>Not balanced</td><td>Undefined</td><td>2/1 weft-faced</td><td>2/1 warp-faced</td><td colspan="3">2/2 warp-faced</td><td>2/2 warp-faced?</td><td>Unproven</td><td>Undefined</td><td>S</td><td>Z</td><td>S(zz)</td><td>(Zss)</td></tr>
<tr><td colspan="3"></td><td>Medium (8-12 threads/ cm)</td><td>Fine (13 and more threads/ cm)</td><td>Rough (7 and less threads/ cm)</td><td>Medium (8-12 threads/ cm)</td><td>Fine (13 and more threads/ cm)</td><td colspan="7"></td></tr>
</table>

Table 2. Typology of textiles discovered in a workshop (B102) in Brandes-en-Oisans.

Fig. 3. Example of rough textile quality: *B102, zone2, D136, n°1* (Photo: Émeline Retournard).

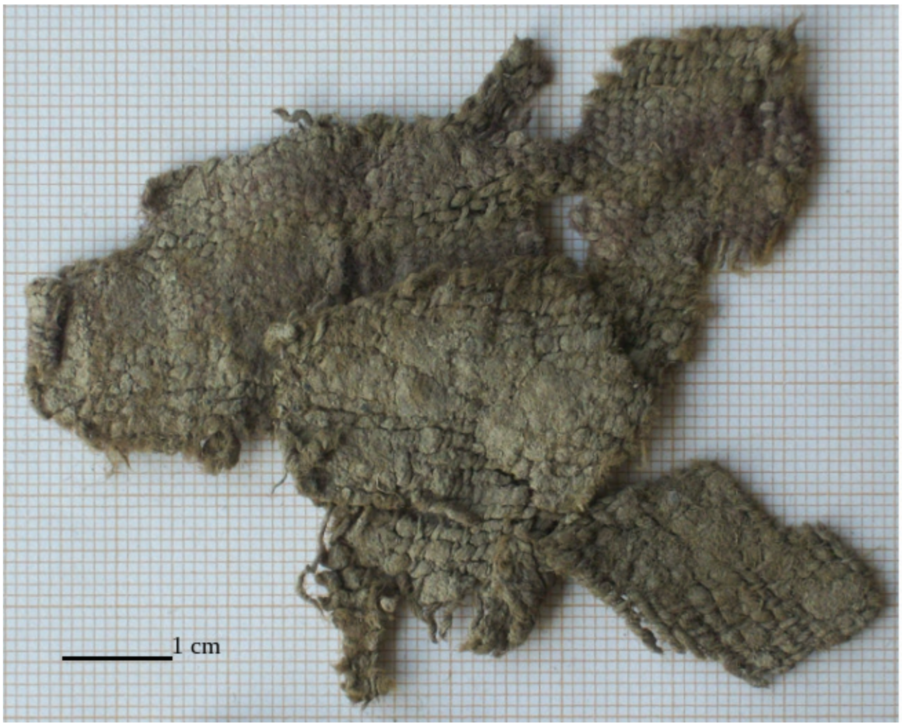
Fig. 4. Example of medium textile quality: *B102, G10, c.78, n°1* (Photo: Émeline Retournard).

Fig. 5. Example of fine textile quality: *B102, +B+12, US68* (Photo: Émeline Retournard).

of two simple threads twisted together. Three samples are twisted in 'S' with two 'z' threads and one sample is built with a 'Z' twist with two 's' threads. One bunch of fibres was identified as human hair (cf. Christophe Moulhérat, Musée du quai Branly, Paris). On the other hand, all the textiles are made of wool. The colours are various: beige, light brown, dark brown, black and several natural colours. Several of these can be present in one piece of textile.

Decoration

Sixteen textile fragments in zone B102 contain dyed visible threads. Twelve tabbies and one 2/2 twill (?) were decorated with reddish bands, one beige tabby has a bluish band and two 2/1 weft-faced twill have a bluish background and beige tabby bands (Fig. 6 and Table 3). Concerning the tabby with the red weft-faced bands, the thread counts in the bands are higher in some samples because of a higher beating of the weft. This process allows for a double visual effect with colours and weaving. For the samples from square *B102, +H+19, c. 100*, bands measure five mm high and five mm separate the two bands. A fragment contains at most two bands. The other tabby has a beige background and a blue weft-faced band. Concerning the textiles from square *B102, +F+20, c. 120* and *B102, F6, c. 44*, measurements are more difficult to describe because of the bad state of conservation. A double decorative effect is seen on other dyed fragments (*B102, +C+6, c.44, n°1-2)*. These textiles have a main weave in 2/1 weft-faced twill and two tabby bands are inserted on the weft (Fig. 7). Twill is dyed in blue while the tabby is beige. One of the fragments has a weaving mistake, probably because of the incompatibility of the weaves. At the transition between the background and the decoration, the weaver lifted the second thread of the 2/1 weft-faced twill and not the third (Fig. 8). This



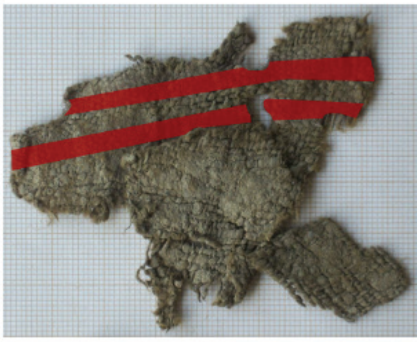


Fig. 6. Example of a decorated textile with reddish bands: *B102, +H+19, c.100, n°1* (Photo: Émeline Retournard).

inattention contributed to a wrong beginning for the tabby. The weaver continued to weave and inserted more weft threads into the second band of decoration to correct his mistake. The bands measure between four and five mm and are separated by two mm. This pattern is reproduced approximately every five cm.

Among the 445 textiles, only seven selvedges were identified on 2/2 twills (Table 4). All the selvedges can be considered as basic (Fig. 9, A). Any preparation of the warp was seen. One of them differs, however: the sample. Even if the construction stayed simple, two threads were taken in the return of the weft during a new passage, instead of one for the other selvedges (Fig. 9, B).

Traces of sewing and/or embroidery were discovered on 17 textiles (Table 5). Holes are lined up vertically and/or horizontally. Warp and weft threads are open, not ripped. Holes are empty or full of a sewing/embroidery thread. The size of the related textiles varies. Bigger samples present more holes than the smaller ones (possible previous placement for embroidery: Fig. 10). Unfortunately, it is quite impossible to see a clear drawing in the layout of the holes, as a hole could be used several times. One fragment of 2/2 twill is remarkable in its selvedge embroidery (Fig. 11). Two threads pass into holes every side of the textile in overcast steam. The z-twisted threads are slightly lighter than the brown wool and have a diameter of one mm.

Cutting marks were also discovered during the technical analysis: several textiles have one or many straight sides. Finally, some textiles present a twisted form: they are s- or z-twisted on themselves. The biggest twisted fragment is 30 cm long.

Textile ID	Main weave	Weft-faced Bands
B102, +F+20, c. 120, no. 1	Beige tabby	Reddish tabby
B102, +F+20, c. 120, no. 2	Beige tabby	Reddish tabby
B102, +F+20, c. 120, no. 3	Beige tabby	Reddish tabby
B102, +F+20, c. 120, no. 4	Beige tabby	Reddish tabby
B102, +F+20, c. 120, no. 5	Beige tabby	Reddish tabby
B102, +H+19, c. 100, no. 1	Beige tabby	Reddish tabby
B102, +H+19, c. 100, no. 2	Beige tabby	Reddish tabby
B102, +H+19, c. 100, no. 3	Beige tabby	Reddish tabby
B102, +H+19, c. 100, no. 4	Beige tabby	Reddish tabby
B102, +H+19, c. 100, no. 5	Beige tabby	Reddish tabby
B102, +H+19, c. 100, no. 6	Beige tabby	Reddish tabby
B102, +H+19, c. 100, no. 7	Beige tabby	Reddish tabby
B102, F6, c. 44, no. 1	Beige tabby	Reddish tabby
B102, F6, c. 44, no. 4	Beige 2/2 twill(?)	Reddish 2/2 twill(?)
B102, +C+6, c. 44, no. 1	Blueish 2/1 twill	Beige tabby
B102, +C+6, c. 44, no. 2	Blueish 2/1 twill	Beige tabby
B102, E7, 38	Beige tabby	Bluish tabby

Table 3. List of textiles with weft-faced bands.

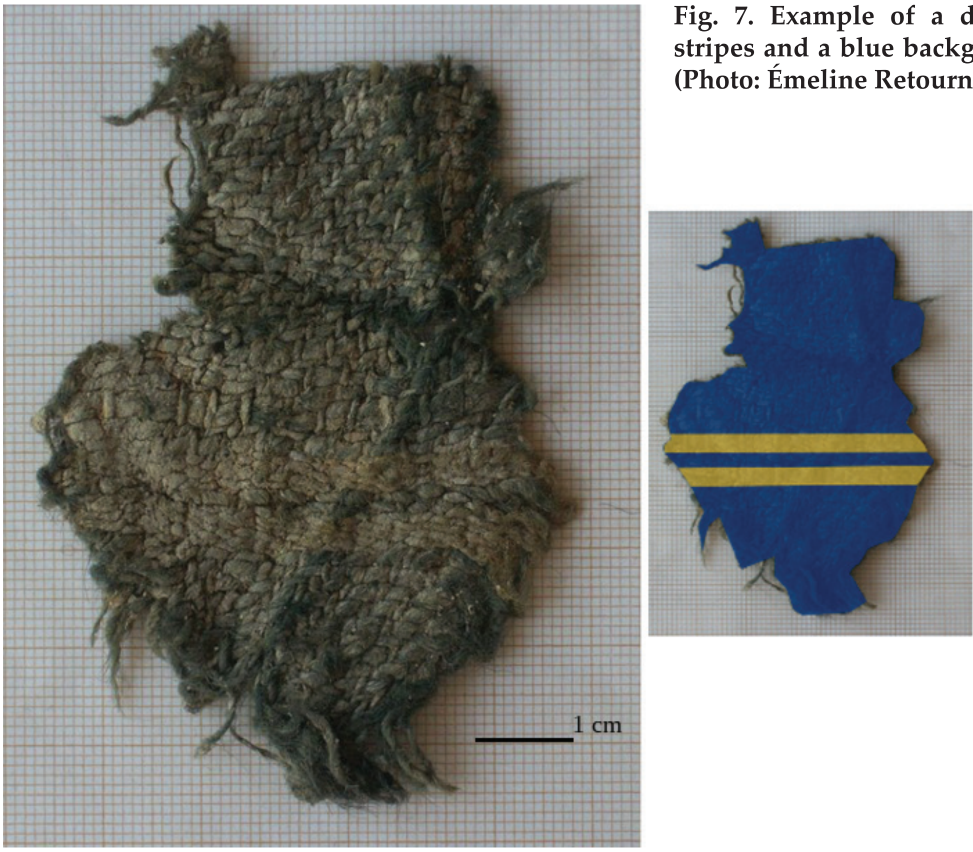


Fig. 7. Example of a decorated fabric with beige stripes and a blue background: *B102, +C+6, c. 44, n°2* (Photo: Émeline Retournard).

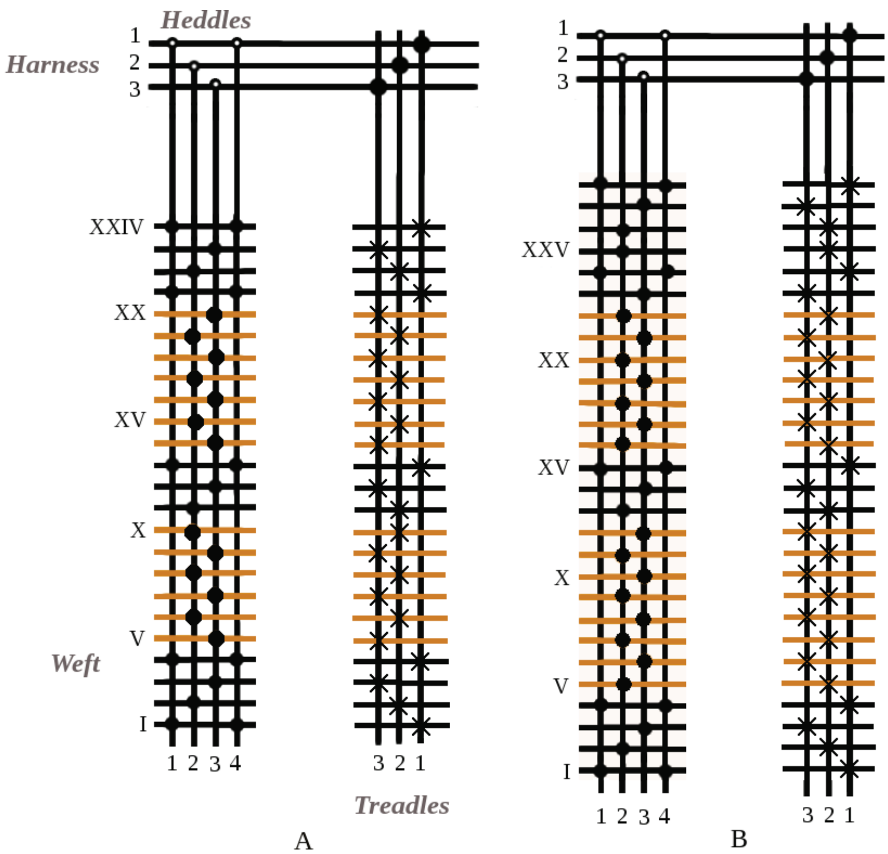


Fig. 8. Weaving schemes of decorated 2/1 weft-faced twills. A: *B102, +C+6, c. 44, n°1*. B: *B102, +C+6, c. 44, n°2*. Point: warp thread up. Cross: Working treadle (Drawing: Émeline Retournard).

Interpretation
The textiles from zone B102 were found in garbage dumps, in and around washing basins, inside and outside buildings, near pipes and in barite sand (Fig. 12). Seventeen samples were discovered near a domestic hearth inside a construction identified as a shelter for workers. Does the presence of textiles within this ore-washing workshop correspond to a precise technique? Why was this organic material here? Were textiles abandoned or buried purposefully? The study of 445 archaeological textiles highlights both diversity and homogeneity in a corpus found within an industrial context. Were these fragments produced in the village? Was there a commercial network with Brandes-en-Oisans? Who made them: villagers or professionals?
Many details of the textiles from zone B120 allow for hypothesising a domestic textile production for local distribution (medium quality of textiles, weaves, simple selvedges and decorations, natural wool colours). Raw material was within range of the villagers. Indeed, a study of the animal bones carried out during the 1990s by C. Olive highlights the presence of *caprinae* in the area (Bailly-Maître and Bruno-Dupraz 1994, 122). These animals could have supplied the village with meat, wool and skins. Villagers could even have selected animals to obtain different coloured fleeces. The discovery of a sheepfold and tools (spindle whorl and thimble) accentuate the hypothesis of a specific farm and a domestic textile production (Bailly-Maître 2008, 46).

Chemical analyses
Laboratory analyses were conducted by Christophe Moulhérat at the Musée du quai Branly in Paris. These consisted of an observation of fibres with an SEM (Scanning Electron Microscope) and a microscope and were performed in order to observe which chemical elements touch these fibres (Table 6). The SEM confirmed the use of wool, even if the scales of wool were difficult or, in some cases, impossible to detect because of a layer of sediment around the fibres. The surface of fibres was very damaged (Fig. 13). Diameters of fibres were between 18 and 30 microns. These measurements correspond to a fine to medium quality of wool according to Moulhérat. Sample *B102, +A+B 5+6, c.2, n°12* differs by having bigger fibres than the others. It may be coarse hair mixed with wool, expressing in this way a medium quality of wool. The analysis of sample *B102, +K+33, US 249, 2010-102-69* revealed the presence of human hair. Indeed, even if sediment prevents one from seeing the medulla, the thickness of fibres indicates the result. The low pigmentation shows that although now black, the

Textile ID	Selvedge
B102, +H+20, c. 117, no. 1	Simple
B102, +N+37, c. 403, no. 1	Simple
B102, Bassin sud, c. 43	Simple
B102, A2, c. 53, no. 1	Simple
B102, E7, c. 38, no. 1	Simple
B102, Fosse 112 sud, no.2	Simple
B102, +F+6, c. 44, no. 5	Simple
B102, +F+6, c. 44, no. 5	Two threads taken in the return of the weft

Table 4. List of selvedges.

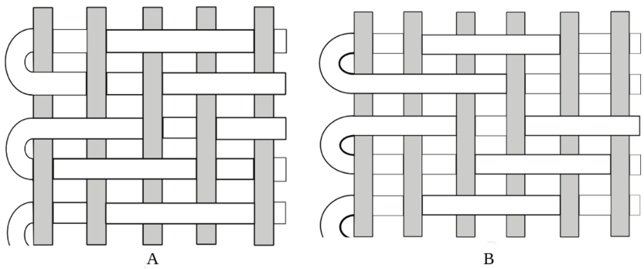


Fig. 9. Schemes of selvedges of zone B102. A: simple selvedge. B: simple selvedge with two threads (Drawing: Émeline Retournard).

Textile ID	Embroidery
B102, +G+10, US 96, no. 1	Hole (and a thread remains into another hole?)
B102, Tranchée sondage 96, no. 1	Holes and threads remains
B102, +I+10, US 91, no. 1	Holes (?)
B102, +I+10, US 91, no. 2	Holes and a thread remains
B102, +I+10, US 91, no. 3	Holes
B102, +I+10, US 91, no. 4	Hole (?)
B102, fosse 112 sud, c. 2, no. 11	Holes and threads remains
B102, fosse 112 sud, c. 2, no. 12	Holes and threads remains
B102, fosse 112 sud, c. 2, no. 13	Holes
B102, fosse 112 sud, c. 2, no. 14	Holes (and threads remains into another hole?)
B102, fosse 112 sud, c. 2, no. 15	Holes
B102, fosse 112 sud, c. 2, no. 2	Holes and threads remains (border decoration)
B102, +J+33, US 249, no. 1	Holes
B102, E3, c. 61, no. 1	Holes
B102, E3, c. 61, no. 2	Holes
B102, E3, c. 61, no. 3	Holes
B102, entre mur 277 et 336	Holes

Table 5. List of embroideries.

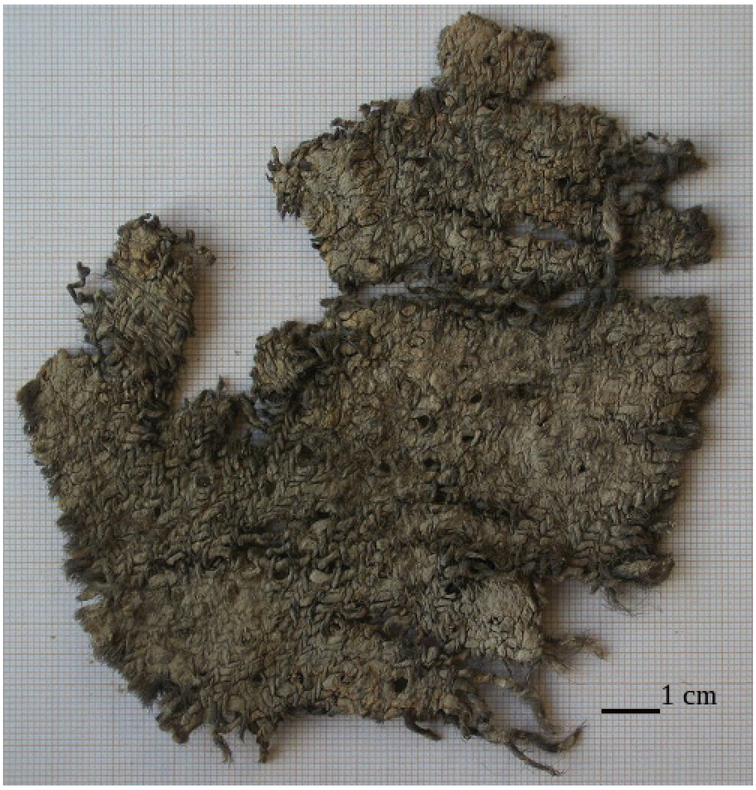


Fig. 10. Example of embroideries: ***B102, Fosse 112 sud, n°12*** **(Photo: Émeline Retournard).**

Fig. 11. Example of a selvedge embroidery: ***B102, Fosse 112_sud, n°2***
(Photo: Émeline Retournard).

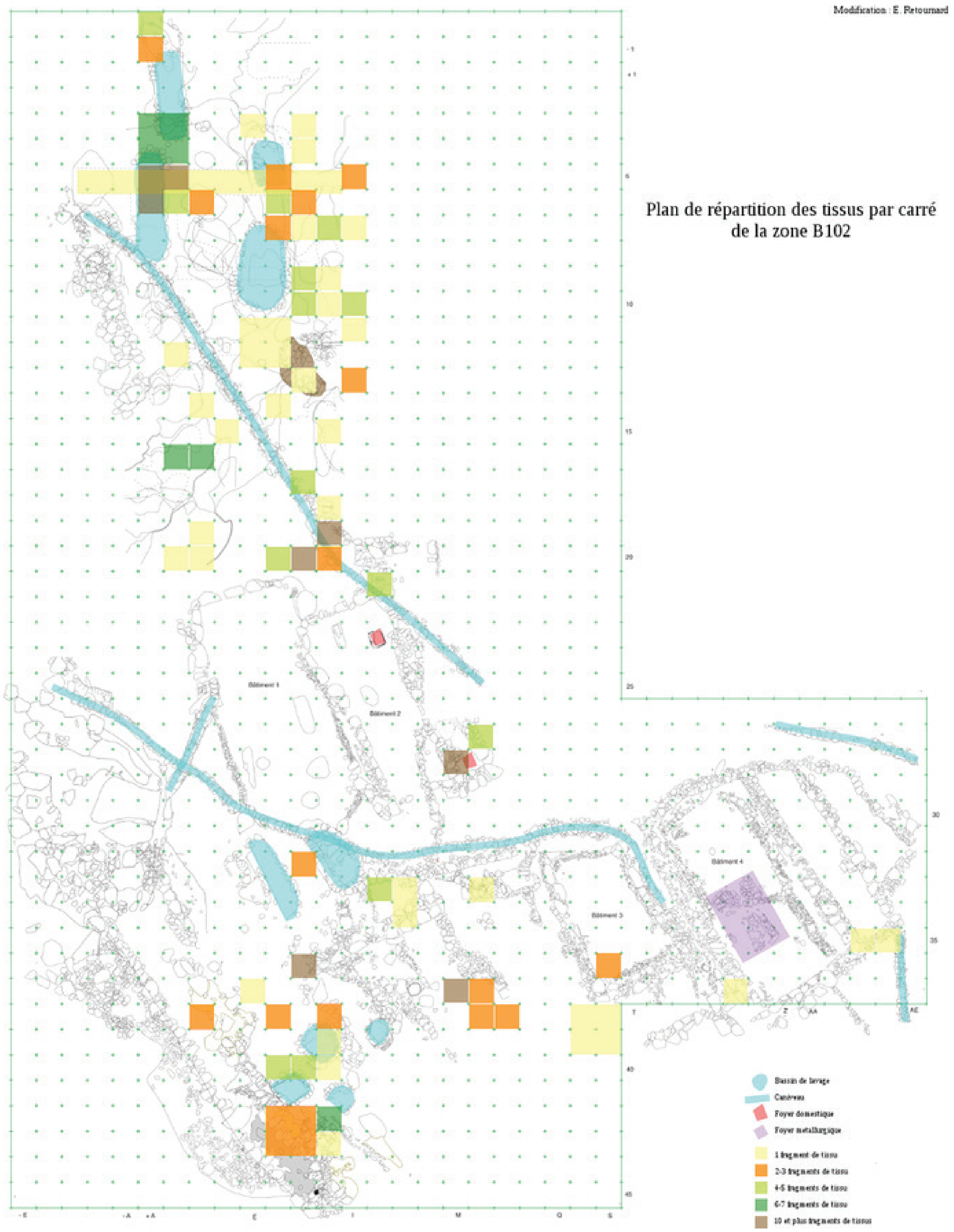


Fig. 12. Plan of zone B102 with localisations of textiles by square. Yellow square: one textile, orange square: two-three textiles, light green square: four-five textiles, dark green square: six-seven textiles, brown: ten or more textiles. Basins and pipes are blue (Drawing: Marie-Christine Bailly-Maître. Modifications: Émeline Retournard).

Textile ID	Samples
B102, +A+B 5+6, c. 2, no. 12	Warp thread
B102, +C+6, c. 44, no. 1	Warp Weft Decoration threads
B102, +H+19, c. 100, no. 1	Warp Weft Decoration threads
B102, +K+33, US 249, 2010-102-69	Animal material
B102, +M+21, US 134, z. 183	Plant material
B102, tranchée sondage 96	Plant material and fabric

Table 6. List of samples for the SEM.

hairs were blond or light before burial. A strange plant material was also analysed (*B102, +M+21, US134, z.183* and *B102, Tranchée sondage 96*). In macroscopic view, this material appears white and bast while *alveolae* and knots are visible in microscopic view. The plant is neither flax nor hemp.

Several chemical elements were detected on the surface of the fibres. Lead is the most common at 4-48 % according to the samples and the points of analysis. Barium and silicon have a huge percentage too. The other components include carbon, oxygen, magnesium, sulphur, iron, copper, phosphorus, arsenic, chlorine, potassium, bromine, aluminium, titanium and antimony. Barium is a component of barite sand, the main component of the veined ore rock of Brandes-en-Oisans. Silicon is a chemical element of quartz. Sometimes, veined ore barite rock is found melted with quartz (Bailly-Maîre 2008, 64). Silver appeared on the screen for just a moment, but the concentration was too weak to be incorporated in the scale.

The observation of the dyed fibres indicated that none of the fibres were dyed inside and the colours did not soak in the same way everywhere. Fibres were spun and dyed before they were woven. Red and blue were observed under the microscope (Fig. 14). Madder and woad were perhaps used to dye the threads of samples *B102, +C+6, c. 44, n°1* and *B102, +H+19, c. 100, n°1* because of the rural context and large-scale trade of these plants in Medieval Europe (Pastoureau 2000, 63). But it cannot be confirmed without chemical analysis.

Origins and uses of textiles

Raw material, dyes and embroideries permitted us to postulate that a part of the corpus from zone B102 were fragments of clothing. Because of the cold weather, the villagers of Brandes-en-Oisans needed wool to protect themselves. Twill, the most common weave, is longer and involves a more physical weaving process than tabby does, but it has more positive features. It retains physical heat because of longer floats and it is more resistant than tabby (Guyard-Commien 2011, 13).

According to Dominique Cardon, 2/1 twill is more common in the wool and drapery industry of the Middle Ages (Cardon 1999, 482). Consequently, is the presence of a huge quantity of 2/2 twills in Brandes-en-Oisans a result of local speciality and production? Textiles presenting dying and embroidery highlight the clothing taste of the villagers: an aesthetic view created with simple and varying materials. The quest for beautiful clothing must be linked to various bodily ornamentations and cosmetic practices discovered in

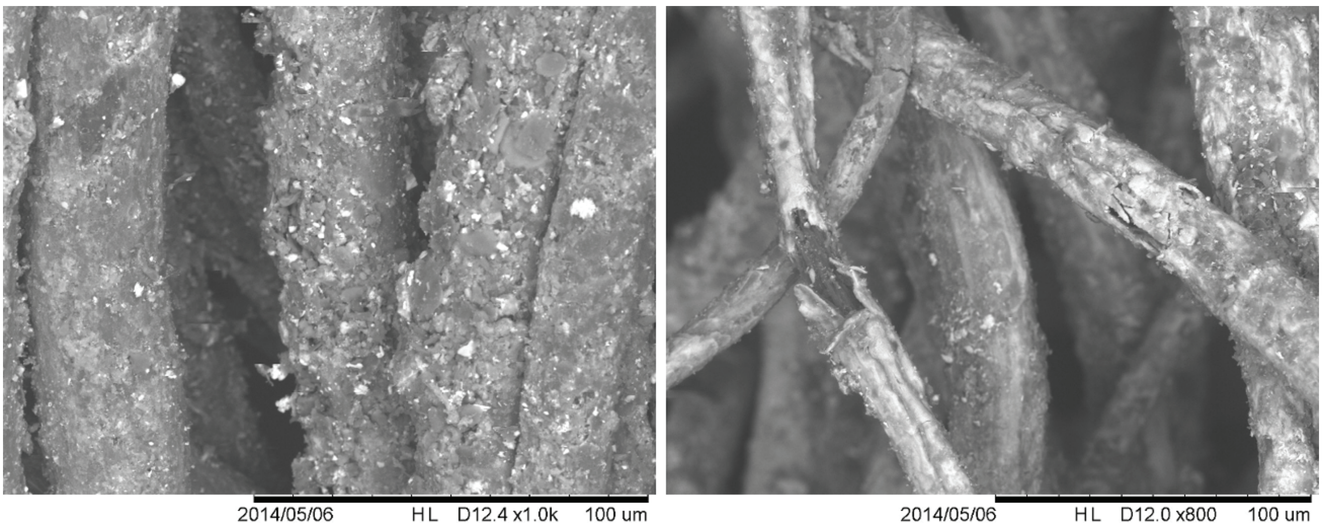


Fig. 13. Detail of fibres of the warp (left) and weft (right) threads of sample *B102, +C+6, c. 44, n°1* with a SEM (Photo: Émeline Retournard).

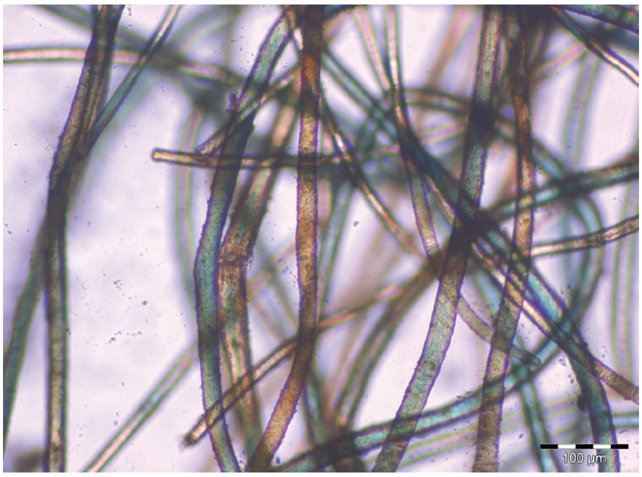


Fig. 14. Observation of coloured fibres under the microscope: *B102, +C+6, c. 44, n°1*, decoration thread, weft (Photo: Émeline Retournard).

the church, the houses and garbage dumps, including belt buckles, brooches, glass pearls, hair pins, tweezers et make-up palettes. Bodily appearance and care were obviously a matter of interest. Leather material reinforced this hypothesis with the types of shoes retrieved, such as a low-cut shoe with a decorated sole and an ankle shoe luxurious slipper (Bailly-Maître and Bruno-Dupraz 1994, 128-132; Bailly-Maître 2008, 50-53).

Zone B102 was a place dedicated to ore washing. Most of the textiles were found in or near washing basins and pipes (Fig. 12). Consequently, a theory suggests that some textiles could have been used for ore-washing. The scales of wool are ideal for use in the catching of specks on the surface of the textile. This method is called *sluice* in French and was already used in antiquity for the washing of gold ore. Georgius Agricola published in 1530 *De re metallica*, a book about mines and metallurgy where this method is illustrated. The process uses a wooden table at a slight angle. Ore powder and water are poured together on the installation. Specks grip onto the surface while the veined ore rocks and water fall down to the table. In *De re metallica*, several etchings depict the recovery of the ore. It could be made using punched or striped smooth wooden tables, subdivided wooden tables or even wooden frames with railings. We also have evidence for methods used in Thuringia, Germany, where workers used smooth as well as rough wooden tables. They may have put fabrics, animal skins, rags and lawn on the tables: fibres, hairs and grass catch particles of ore. Others used sheep and horse skins. Skins and textiles were then washed to recover the specks. Agricola writes about the myth of the Golden Fleece. He explains that people of Colchis put fleeces into the spring puddles and recovered them covered by specks of gold, inspiring at the same time poets for the Golden Fleece. A picture illustrates this with soldiers dressed in the manner of the 16th century in front of a spring waiting for the fleece of a ram in water. It represents Jason and the Argonauts (Fig. 15). These methods can also be used for silver and gems. Concerning the use of textiles, etchings illustrate the *sluice* with fabrics inside (Fig. 16) or outside (Fig. 17) a building. Other methods consist of attaching textiles to a tip-up table (Fig. 18) or the use of nets made of horse hair instead fabrics (Fig. 19; Agricola 1530, 254-265).

Latin is the language of the original text. Textiles are mentioned using words such as *lintea*, *linteis* and *panno*, *pannos*. These words are ambiguous because *lintea* and *linteis* can be interpreted simultaneously as 'fabric', 'plain tabby' and 'flax'. Likewise, *pannos* refers to 'a piece of fabric' or 'rags'. In this way, it is more complicated to know exactly which sort of textiles were being used for the recovery of ore. It is possible that twill, with its longer threads, would catch more silver powder than tabby. Cutting marks indicate a reuse of textile or a transformation. Are these marks proof of an adjustment of textiles for the *sluice* and do the smaller samples represent losses of fabrics? Were the textiles discovered in zone B102 made specifically for ore washing or were they reused for this particular tecnique? Can decorated fragments be interpreted as portions of reused clothing? Was the dark colour of

Fig. 15. Etching from *De re metallica*, illustrating Jason and the Argonauts. A: Spring, B: Skin, C: Argonauts (After: Agricola 1530, 263).

some of the wools useful to differentiate the textile background from specks or is it a deterioration due to time? Agricola explains in *De re metallica* that many workers used a green fabric to more easily distinguish the ore particles on the textile.

As previously mentioned, the textiles of zone B102 were discovered in pipes and in and around basins dug into the ground. That is why the first interpretation of these textiles was that they were used for the washing of silver and lead ore. Microscope analyses revealed significant erosion of the fibres and the presence of lead, barite and silicon, components of the veined ore rock found in mines around Brandes-en-Oisans. Combined action of water and these elements could have caused the erosion of the fibres. Thus, the hypothesis of using some of the textiles for ore washing is strengthened. Nevertheless, should the better-quality textiles be regarded as reused?

A third hypothesis consists in considering that some of the textile fragments were abandoned. Indeed, some fabrics were even found in what came to be understood as garbage heaps. But, to throw away textiles was not conventional and against ancient popular customs: a cloth was typically used until it was worn out (Piponnier and Mane 1995, 28). Were the twisted fabrics used to proof the bottom of the washing basins? Could they have been used as hand and knee protection for workers breaking, sieving and washing ore or was safety dress only in leather? Could these textiles be remains of workers' clothes (coat, cloak, hat) to protect themselves from the cold winter weather?

Comparisons

Comparisons between the corpus of zone B102 in Brandes-en-Oisans and other European archaeological textiles are possible and similarities were discovered with a few other medieval textiles. As yet there is no other example of an ore-washing site with textiles.

Excavations in London revealed an important concentration of fabrics as tabbies and twills. As in Brandes-en-Oisans, decorated tabbies with weft-faced bands from the 14th century were found. Bands were monochrome or contained up to three different colours. Red was identified, as well as blue, purple and brown. These fabrics, called 'rays', were woven in England, Flanders, Brabant and northern France. They were discovered in excavations in Amsterdam and Dordrecht (Nederlands), Lübeck (Germany), Novgorod (Russia) and York (England: Crowfoot *et al.* 2001, 52-54). Tabbies with weft-faced bands were also found in Lödöse (Sweden), as a beige tabby with red weft-faced bands or tabbies with several colours in the bands. Twills with weft-faced bands are also visible: 2/1 twills with weft-faced tabby bands or 2/1 twills with weft-faced twill bands (Vestergård Pedersen 2009,

Fig. 16. Etching from *De re metallica,* illustrating the sluice. A: Table, B: Textile, C: Top of the table, D: Pipes, E: Settling tank, F: Rake, G: Tank (After: Agricola 1530, 242).

Fig. 17. Etching from *De re metallica*, illustrating the sluice. A: Top of the table, B: Table, C: Rag (textile), D: Pipes, E: Collection tank for rubbish, F: Tank for textile washing (After: Agricola 1530, 264).

140-145). Are these 'rays' a style of the late Middle Ages and evidence of the distribution of ideas across Europe at this time? In this case, it would suggest that the village in the French Alps was connected with a much larger network.

Brandes-en-Oisans and its archaeological textiles can be compared with other medieval silver mining sites such as Altenberg (Siegerland, Germany). There, silver mines were exploited from the Middle Ages to 1914. The mines were within the territory of four villages and the city of Siegen. Some buildings were found near the mines (including houses and caves). Organic material was also discovered, including wood, leather and textiles. Textiles were found mainly in two mine wells, inside and around the building above. They can be classified into three groups: fabrics, needleworks and felt. Sheep wool was the only raw material recovered. Tabbies, 2/2 twills and 2/1 twills are present in smaller quantities as Brandes-en-Oisans and 2/1 twill is the most common weave. The colours were black, white, beige, deep orange and brown. Dye analyses highlight the presence of madder, lichen, weld, broom, woad and tannins (barks and galls). Tabby weft-faced bands are visible on tabbies and twills. Weft threads are monochrome or two-coloured and more beaten than the background (Vierck 1998, 1-7; 1998, 113-133).

Conclusion

The study of more than 400 fragments of medieval fabrics from an ore-washing workshop at Brandes-en-Oisans (Isère, France) shows the site's huge potential. The discovery of this organic matter is exceptional because of its typically perishable nature. The localisation of textiles on excavations permitted us to hypothesise about a use of textiles in an antique method to catch ore specks. Laboratory analyses reinforced this hypothesis demonstrating a significant erosion of the surface of fibres and the presence of an important quantities of lead, barite and silicon upon contact with samples. Traces of dyes and embroideries on fabrics led to think about a reuse of clothes for the process of washing. Finally, comparisons with other contexts put Brandes-en-Oisans into a medieval European network. In every instance, the study of these textiles indicates that the people of this little village in the mountains were concerned with their appearance and moved with the times.

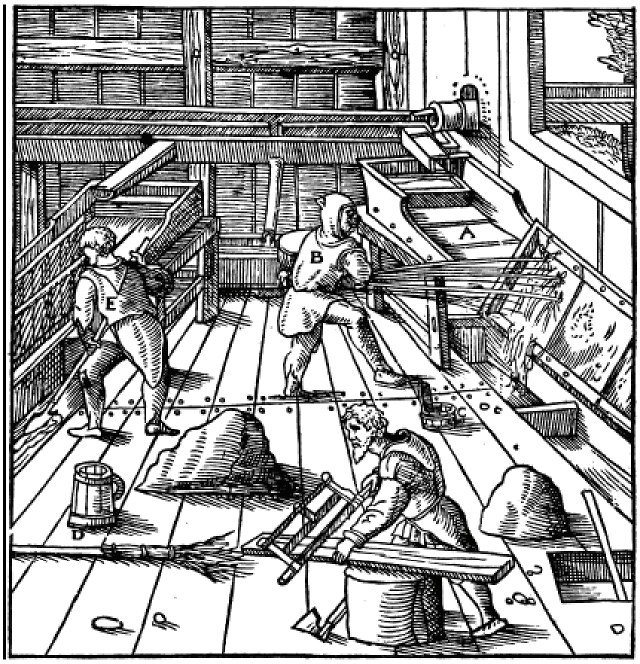


Fig. 18. Etching from *De re metallica*, illustrating the sluice. A: Table, B: Wet textiles, C: Bucket, D: Other type of bucket, E: Remains of veined ore rock (After: Agricola 1530, 243).

Fig. 19. Etching from *De re metallica*, illustrating the sluice. A: Taut net, B: Net, C: Tank for textile washing (After: Agricola 1530, 265).

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Preliminary Approaches for the Identification and Classification of Mediterranean Murex Dye Production Sites

Introduction

Murex snails were used as early as the Bronze Age in the Mediterranean to produce an expensive, reddish-purple dye. By the Roman period, murex-dyed fabrics were well-established symbols of high status, power, and wealth (Jensen 1963). Because the product was used by the Phoenicians, Minoans, Greeks and Romans, Mediterranean history is littered with textual and archaeological evidence of the dye and textile making process. Influenced by the available data, current research leans toward recreating the recipe: determining how many murex snails were needed, the application and utility of additives, and the type of facilities or equipment used. While significant progress has been made in this regard (Koren 1999; Cardon *et al.* 2004; Koren 2005; Ruscillo 2005; Ruscillo 2006; Koren 2007; Cooksey 2009; Hoffman *et al.* 2010; Cardon *et al.* 2011; Cooksey 2013; Karapanagiotis *et al.* 2013; Margariti *et al.* 2013), inaccurate presentations and problematic methodologies of the evidence still exist when attempting to identify the actual locations of dye production.

The first step towards recognising the variations in the archaeological record is to realise that all available data must be considered equally. While Pliny is arguably the ancient authority on dye production, if we only relied on his descriptions to verify archaeological remains, our results would be biased – experimental studies clarify the intricacies in ingredients and processes, and the areas where his descriptions (and those of other authors) are lacking. On the other hand, the ancient authors' knowledge should not be disregarded, particularly when they mention specific locations in which production occurred. In other words, all available datasets must be utilised and questioned.

Because extensive textual, scientific and archaeological remains are available for the Roman period, this paper will focus on Mediterranean dye manufacture evidence between the 1st century BCE and the 5th century CE. Strengths and weaknesses are presented for textual, scientific and archaeological data in order to qualify the unique evidence each can reveal and to clarify how textual and scientific data can enhance our ability to recognise archaeological remains. Based on this methodological analysis, a catalogue of Roman-period sites which are 'definitively' or 'probably' linked to murex dye production are presented.

Some scholars might argue that earlier production should be considered as well. While there is extensive scientific and archaeological scholarship available on Bronze Age dye production sites, contemporary textual references are not readily available. Our understanding of Bronze Age dyeing is affected by later evidence – there was a (perhaps intentional) lack of record keeping prior to the Roman period, especially with regard to the exact ingredients, recipes and techniques used (Ziderman 1987, 51). Roman authors, on the other hand, recorded detailed accounts of snail harvesting and manufacturing processes

(Stieglitz 1994; Ruscillo 2005; Schneider 2012). I do not intend to argue that there is no plausible relationship between Bronze Age and later-period manufacturing techniques. Because of the amount of skewed evidence and misidentification, however, I am intentionally limiting this case study in order to link the appropriate textual evidence to whatever material evidence is available.

Ultimately, this paper proposes a 'clean up' of the evidence, which could lead to informed decisions when handling the archaeological evidence. By systematically addressing the diversity of the existing evidence, it will become much easier to identify the material evidence. Future research could lead to site-type classification schemes and the ability to compare production facilities on a regional level. By clarifying what exactly constitutes evidence for a murex dye production site, we will be able to understand why variations in the record might be present and how the methodologies for dye manufacture would have varied over time and space.

The past and present of murex dye studies

Thanks to the detailed descriptions made by the ancient sources, the social significance of murex dye is well attested. Social positions were displayed in the ability to wear the dye in various Mediterranean cultures and periods, the Roman period included (Jensen 1963, 115). Roman literature is littered with references to powerful and privileged individuals possessing the cloth. Romulus' mantle, for example, was described as being adorned with purple stripes. Subsequently, togas representing various social and political positions were dyed in purple as well (Pliny, *Hist. Nat.* 9.71 ff.). The *toga praetexta*, *toga picta*, *paludamentum* and *tunica palmata*, for example, were regulated garments adorned with varying amounts of purple (Elliot 2008, 181; Livy, *Ab urbe con.* 10.7 ff.).

In later periods, purple was restricted to specific state officials, regardless of whether one was wealthy enough to purchase the product. Julius Caesar (Suetonius, *Caes.* 43) restricted purple-dyed fabrics to certain individuals and events. Nero actually employed police to close wholesalers and strip individuals of their purple-dyed clothing if seen in public (Suetonius, *Nero* 32.4). Scholars have linked these restrictions with efforts to preserve imperial power (Reinhold 1970). Indeed, in the midst of imperial struggle, Diocletian restricted the finest-quality dyes to the imperial household and court. Various qualities of cloth were under scrutiny, and in the *Edict on Maximum Prices*, Diocletian set the price of purple wool at 50,000 *denarii* a pound and purple silk at 150,000 *denarii* a pound, while high-quality, undyed wool was only 175 *denarii* a pound (Reinhold 1970, 58-59). Despite the arguable care that ancient authors, Pliny primarily, took to record the actual dye production process, it is at this point that the literature becomes complicated.

Intrigued by these descriptions, scholars have been eager to identify the ingredients used, the ways they were collected and the methods by which the dye was processed and the cloth dipped. Unfortunately, our understanding of these processes is hindered not only by the archaeological record, but also by the limited application of interdisciplinary study and comparative datasets. All too often, mention of murex dye production is found in excavation site reports (*e.g.* Reese 1980, 2007, 2010; Wilson 1999, 2001, 2002, 2004; Alfaro Giner and Costas Ribas 2008), meaning the location is presented as an isolated entity. Detail of the dye production facilities is often limited – middens are often unmeasured, vats and pits are described as 'large' or 'small'. Particular sources of evidence that could indicate dye manufacture, such as crushing tools, residue or ash, are often not mentioned, leaving scholars to wonder if sites were not used for dye production, or if excavation techniques need to improve in dye-related contexts.

One exception is Alberti (2008, 75), who carefully considers the variable forms of evidence (heating sources, vats, residue, and murex shells) and classifies sites into three categories: 'direct', 'indirect' by means of waste material, and 'indirect' by means of recycled debris. While this study is invaluable for its attempt to categorise forms of evidence, many points are left unaddressed. There is little mention of the textual sources or experimental projects which could aid our understanding of production methodologies, and in turn, the identification of archaeological remains. Furthermore, the typology is applied to sites ranging from the Bronze Age through to the Roman periods, with no discernible pattern of available evidence per period or per location (Alberti 2008, 82). With such a long-standing interdependent relationship through space, time and with other modes of production, limiting studies to a smaller span of time or a specified geography could provide a greater understanding of the dye production process and, ultimately, regional variability.

A proposal for interdisciplinary, multi-data analyses

In the following I will put forth an alternative methodology: to analyse the separate datasets available within a specific period of time, identify the various forms of evidence they can each yield, and therefore realise the strengths and weaknesses of each dataset before actualising them as a larger unit of information. Dye production evidence will be discussed according to dataset type: textual data, experimental/scientific data and evidence yielded from excavations. Within these dataset types, the various forms of evidence which can be found are discussed, and are identified as follows:

Necessary: Evidence without which a dye production site could not be definitively identified.
Corroborating: Evidence which can assist in the identification of dye activities, but cannot easily be used to identify the location of a dye production site.

Dataset types are first discussed in isolation, in order to highlight the specific forms of evidence that can be extracted, and how they will manifest themselves individually. Connections are mentioned in order to highlight the benefits of a multidisciplinary and multi-data approach to murex dye production studies, and can also be observed by comparing Tables 1-3. This methodology importantly highlights our ability to understand which dataset is most appropriately going to provide evidence for various aspects of the industry. Some data cannot be feasibly retrieved from the archaeological record; textual sources mentioning particular methods or ingredients and experiments attempting to recreate dye according to these descriptions can help us fill in the gaps. Alternatively, textual and experimental data can clarify which types of ingredients or equipment were needed, but cannot always offer an accurate picture of the retrievable archaeological remains.

While datasets may generally reveal the same form of evidence, the ways in which this evidence manifests itself can vary significantly, and in turn the identification of a production site can be problematic. These variations should be expected, even at sites where a 'definitive' label is applied. This dye was vastly popular across time and space, and variations in methodology are inevitable. Like the 'necessary' and 'corroborating' evidence categories, variations in evidence can best be understood only when all forms of data are considered.

Literary references

Necessary textual evidence for dye production

Roman textual descriptions refer to murex dye in any number of circumstances; the most useful for the purposes of identifying dye production sites are descriptions of snail collection, dye production, and variations in recipe and final product. This section will describe the snail collection process, how the dye was produced, and the relationship between snail species,

Necessary Evidence for Dye Production	Textual Data	Experimental/Scientific Studies	Archaeological Evidence
Snails			
Large amounts of shells in a midden/concentrated context			x
Confirmation of *Murex* snail species	x	x	x
Dye Production Process			
Vein extraction	x	x	
Dye mixing	x	x	
Heating	x	x	x
Specific production location (reference to location or particular environment)	x	x	x
Evidence of residue	x	x	F
Dye Production Equipment			
Pits, vats, and channels	x	x	x
Extraction tools	x	x	F
Light and oxygen controls	x	x	x

Table 1. This table summarises the necessary evidence for dye production facilities, and which of the three datasets can yield evidence for these categories. Tools and residue are marked as 'F', meaning they are forms of evidence which could be argued as necessary proof for a dye production facility, but are not always feasible to recover during excavation, or while revisiting previously excavated materials. Extraction tools are misunderstood due to a misinterpretation of dye production facilities; in the case of residue, excavation and preservation methods can often prevent retrieval. Arguably, even if there is a lack of evidence for either of these features, but the other six forms of archaeological evidence are present, a dye production site can feasibly be identified.

Corroborating Evidence for Dye Production	Textual Data	Experimental/Scientific Studies	Archaeological Evidence
Snails			
Catching Snails	x	x	
Shells in a non-dye related context			x
Shell treatment (crushed, holes)	x	x	x
Dye Production Equipment			
Metal vessel	x	x	
Clay vessels/pottery	x	x	x

Table 2. This table summarises corroborating evidence for dye production. In this analysis, sites which possess primarily corroborating forms of evidence are identified as 'possible' dye production sites until further investigations can be made.

Variable ("Problematic") Evidence for Dye Production	Textual Data	Experimental/Scientific Studies	Archaeological Evidence
Snails			
Variations in species	x	x	x
Variations in final product colour	x	x	
Dye Production Equipment			
Evidence of non-mollusk ingredients	x		x

Table 3. This table summarises problematic evidence for identifying dye production. This evidence is considered problematic because it highlights the enormous degree of variation that can be found in various texts, in experiments or at sites – problematic evidence should not be interpreted as a reason for disregarding the possibility that dye production occurred at any given location. In the case of "variations of final product colour," this form of evidence is confirmed in both textual and experimental studies. Archaeologically, this evidence is difficult to find, with the exception of textiles. These artefacts, however, have not been included in the catalogue because their find spots are more likely linked to consumption of goods, not production.

colour and region – arguably the most complex piece of textual evidence.

According to Pliny (*Hist. Nat.* 9.61 ff.), the carnivorous snails were caught in baited baskets. Because the dye would dry out when the snail died, dye extraction needed to occur within a 50-day period, during which the snails could stay alive using their own saliva. No descriptions of storage facilities are offered, however. The hypobranchial vein was then removed from the snail. No clarification is given by Pliny as to whether the snail was pulled from the shell or the shell was crushed. Vitruvius (17.3.2) suggests that the snails were crushed with iron (*ferramentis*) tools. We do not know how it was extracted, but the vein was then soaked in salted water for three days at the most. Alkaline-based boiling proceeded in lead[1] vessels over a moderate heat: "[the dye] is heated by means of moderate heat and brought to a separate kiln via a pipe" (Pliny, *Hist. Nat.* 9.70).[2]

After a maximum of ten days (or until the colour of the dye had reached a satisfactory shade), cloth (for the Romans, most likely wool) was dipped into the dye. The cloth had to be soaked for five days at least, the length of time dependent on the type of mixtures used with the murex.[3] The dyed cloth would then be exposed to sunlight to trigger the dyeing colour (Pliny, *Hist. Nat.* 9.70; Vitruvius 17.3.2 ff.).

Corroborating and problematic textual evidence for dye production

From the ancient sources we have an excellent understanding of how intricate the dyeing process was. Changes to the recipe could result in any number of variations of colour; these intricacies are simultaneously the value and the quandary of this particular dataset.

Interpreting murex dye production evidence is inevitably linked to an understanding of the dye's social value – the social value was linked to its colour. According to Vitruvius (17.3.2 ff.), the various shades of dye produced were a result of regional variations in sun exposure. Eastern and western regions of the Mediterranean would have blueish hues, while the south would have had a reddish tint. The northern regions like Pontis and Gallia would be *atrum*, or black. Because Tyrian purple was the most valued type, we infer it was recognisable by its shade – this was actually a deep blood-red colour (Pliny, *Hist. Nat.* 9.62.38), and not our modern idea of purple.

Variations in colour could be a result of sun exposure, but snail species were a major factor as well. Pliny refers to *Purpura, Buccinum* and *Pelagia* snails being used throughout his text (Pliny, *Hist. Nat.* 9.68). If *Buccinum* was the only dyeing agent employed, the fabric would be an inferior quality because it is not colourfast. In order to resolve this issue, he claims that the ideal mixture was 50 pounds of wool, 200 pounds of *Buccinum* juice, and 111 pounds of *Pelagio*. By adding the *Pelagio*, the dye became colourfast, and it added a crimson-like hue. The coveted Tyrian colour was also made with these ingredients, but it was double-dipped – the wool was first soaked in the *Pelagio* and then the *Buccinum* (Pliny, *Hist. Nat.* 9.70 ff.).

Link these snail types to modern species is problematic, in part because of inconsistencies in Pliny's text, in addition to a lack of detail by other ancient authors (Bostock and Riley 1855, 9.70 note 1). The variable relationships between colour and the snail species used will be discussed more thoroughly in the next section, which presents contemporary experimental attempts to recreate the dye.

Experimental and scientific evidence

Necessary experimental/scientific evidence for dye production

Scholars who have attempted to recreate the dye have made great strides in demonstrating which portions of the ancient sources are accurate or inaccurate, and have made clarifications of the dye manufacturing environment. This can help to clarify the physical evidence that archaeologists have identified. As a result, it is more effective to discuss experimental recreations of dye prior to describing presently-known archaeological remains of the industry.

Ruscillo (2006, 811-815) tested several methods of snail collection and dye creation in order to verify and better understand the recipes mentioned in textual accounts. As a result of these studies, valuable data is available describing the number of snails needed to make the dye. Baited baskets were left in shallow water, and managed to both trap snails and attract others for hand collection. Without baited baskets, hand collection reduces the collection rate of 100 snails per hour by 70 %. Dropping baskets off a boat was also less efficient, yielding about 30-50 snails, though the length of time this took was not specified.

A 125 cm^2 piece of wool textile was tested using dye made from the snail collection. In order to achieve a full coverage of dye, 200 murex snails were needed; it was estimated that 5000 snails would be needed to dye a single cloak. Koren (2005, 138-143) recorded similar data, determining that one gram of unwoven wool could be dyed with only three snails, though it was commented that the colour was quite light, and was not a reflection of the dye qualities mentioned by Pliny.

Gland extraction was also tested during these experiments because textual descriptions are limited. Koren (2005, 140) intentionally crushed the snails with a hammer in order to puncture the gland, and placed the snail and shell in a jar to collect the dye. Ruscillo (2006, 813) used a brass pointed tool and a hard stone to break open the shells. When a hammer and the pointed tool were used to make a hole in the shell beforehand, the process was much easier, and also enabled a controlled break to be made and prevent the gland from being broken.

Environmental regulations were necessary during the process. Ruscillo (2005, 104-105) tested several heating methods, and found that boiling actually damaged the dye. She tested several forms of water (salt, fresh, mixed with various additives, *etc.*) and found that maintaining an eight-degree Celsius temperature for three days helped to steep the dye and made sieving much easier.

Modern experiments have demonstrated how sensitive the mixture was to light exposure and oxidation; too much light or oxygen during the dyeing process could severely alter the final shade. When cloth is initially dipped into murex dye, it turns green; not until intentional and regulated exposure to light and oxygen does the dyed cloth turn from green to purple. Cooksey (2009, 176-177) showed that overexposure of the dye mixture *prior* to the cloth being dipped creates a purple hue that is very different from the blood-red goal described. Modern Tekhelet cloth, for example, is very different from the 'Tyrian ideal' indicated in texts; this murex-based dye is blue-purple. The difference in colouration is a result of intentional exposure to light and oxygen for a lengthy period of time (Hoffman *et al.* 2010, 89) (Fig. 1).

Corroborating and problematic experimental/scientific evidence for dye production

While the textual and experimental data confirm the importance of heating the mixture, it is difficult to determine whether metal or clay vessels were used. One of the most popular translations of Pliny's "*fevere in plumbo*" refers to being "boiled in lead" (Bostock and Riley 1855, 9.70). Experimental studies focused on recreating the dye have attempted to decipher what 'lead' actually refers to, and whether the material was a necessary chemical component. Doumet (1980, 47) explained that Pliny might have been referring to 'white lead' or Roman tin.

Koren (2005, 139-142) recognised the necessity for an alkaline reaction, but questioned whether the alkaline needed to be supplied by the vessel itself. His experiments proved that the addition of sodium carbonate, plant/wood ash or lime into a clay pot achieved the same reduction process as would a metal vessel. Many sites listed in the following catalogue indicate evidence for pottery, but confirming whether this pottery was used specifically for dye production would necessitate residue analysis. As for the lack of metal vessels, it is entirely possible these were melted and reused. While these experiments are able to confirm whether the recipes were accurately recorded, they also highlight the huge range of possible shades, and in turn, how difficult these variations can be to identify in the archaeological record.

As mentioned, Pliny references a variety of snail species (murex included), which could produce a purple hue. According to the texts, we can confirm that murex species, specifically *Hexaplex trunculus* L., *Bolinus brandaris* L. and *Stramonita haemastoma* L. were used to create a dye which could be considered real 'Tyrian Purple' (Koren 2005, 137). Kenrick (1855, 239) argues that *Pelagia* is *Murex trunculus,* and *Buccinum* is likely *Nucella lapillus* or 'Dog Whelk' (called *Buccinum lapillus* by Linnaeus). *Pelagia* could also be referring to *Murex brandaris* or *Murex tribulus* (Struck 2009). According to Ziderman (2008, 40), *Pelagia* could be a general reference for murex species that bore purple. Rawlinson (1889, 46) argues that Pliny's *Buccinum* could be referring to any number of snails: *Murex trunculus, Murex/Bolinus brandaris* or *Helix ianthina*. The *trunculus* and *brandaris* species are closely related; the *brandaris* is more common on the Phoenician coast. Despite its commonality, he argues that "it is unlikely that the ancients regarded it as a different shell from *Murex trunculus*."

Alternative, non-murex species should also be mentioned. These snails could produce similar shades, but were not colourfast, and therefore made an inferior product. *Helix janthina* L. is an example. It produced violet dye and is believed to have been used in the eastern Mediterranean. Evidence of its usage has been found at Beirut and Tyre (Jensen 1963, 105).

Chemical analysis, particularly High Performance Liquid Chromatography (HPLC), performed on the dye and paint pigments found can help to identify the ingredients used. Realising the variation that could occur, Koren (2007) analysed the pigment secretions from several *Hexaplex trunculus* L. snails from Israel, Spain and Italy. Isolating the different chemical signatures of these snails demonstrated that variation in composition as well as hue was possible across the same species; they ranged from reddish purple to violet. These variations are due to differing amounts of red or blue colourants in the pigment itself; these observations were made prior to any dye process being implemented (Koren 2007, 388).

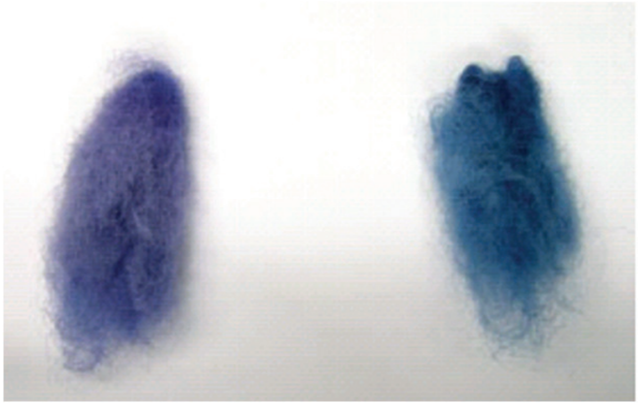

Fig. 1. Wool dyed with Murex trunculus, demonstrating that lengthened exposure to light will result in a bluer shade (After: Hoffman *et al.* 2010, 893).

Bolinus brandaris L. and *Stramonita haemastoma* L. are nearly indistinguishable from one another via HPLC analysis. The 6,6' –dibromoindigotin levels of both species will peak at about 60%, and unlike *Hexaplex trunculus* L., both have high levels of 6-bromoisatin (Koren 2007, 388-389). Another study (Karapanagiotis *et al.* 2013, 78) describes similar results, but was unable to distinguish *Bolinus brandaris* L. and *Stramonita haemastoma* L. from one another using both Principal Component Analysis and HPLC. In other words, though we have textual references to types of snail species used to create the dye, and though it is possible to isolate species types via residue analysis, there is still a huge lack of understanding about exactly which snail types would have been used, in what amounts, and in what regions.

Additives could be incorporated to alter the colour of the dye, including urine and a variety of plants and berries (Jensen 1963, 108-111). Kermes was also popular for its red-coloured shade, though thousands of these insects were needed, and they were nearly as expensive as murex (Cardon *et al.* 2011, 202-203).

Currently, the incorporation of these additives is a popular topic of debate in studies that chemically analyse ancient dyes, with questions as to how the additives may have reduced or increased the value of the product, as well as possible other snail species that could have been used. While analyses of residues and textiles are contributing to our understanding of how the dye was made, they simultaneously complicate our understanding by highlighting the intricacies and possible variety (Koren 1999, 2005; Cardon *et al.* 2011).

Archaeological evidence

Necessary archaeological evidence for dye production

Textual evidence highlights the types of equipment, materials and environments necessary to create purple dye; the experimental evidence confirms these features' utility. These datasets also demonstrate the variations possible, which can therefore lead to misunderstandings of the archaeological record. In this section, the archaeological evidence which is confirmed as 'necessary' will be discussed, in addition to corroborating and problematic evidence.

Murex dye facilities were often constructed away from residential areas because of the noted unpleasant smell, confirmed by contemporary experimental projects as well as nearly every ancient text mentioning dye manufacture (Cooksey 2013, 178). Facility features include vats, water sources and cisterns in open courtyards, in addition to associated burned contexts. Aforementioned sensitivities to oxygen and light exposure mean that the Roman period dyeing facilities and equipment would have needed mechanisms to protect against overexposure. Excavations have been able to confirm equipment similar to what Pliny describes, specifically sites with vats of varying sizes at the mouth, connected with channels and holes. According to Sagona (1999, 39), "while the channels obviously imply the flow of fluids into the vat, the smaller holes to the side might be to vent gases from the vat without allowing too much light or air into the chamber." She also argues that more awareness should be given to the possibility for overhead roofing systems and walls, which could have helped to monitor the oxygen exposure.

Corroborating and problematic archaeological evidence for dye production

While these features are *necessary* for murex dye production, they should be considered cautiously and in conjunction with all other available evidence. Cuicul (present day Wilaya, Algeria) demonstrates the difficulty in identifying murex production in the archaeological record. At Cuicul, heating sources and vats were found, which are confirmed in this study as 'necessary' evidence, on the basis of textual and scientific data. The archaeologists also identified a yellow liquid deposit found in context with these vats as secretions of murex snails prior to processing. Despite these features, there are many problems with identifying Cuicul as a dye production site. The residue was never chemically analysed, and the 'dyeing facilities' (found in an altered bath house) have no traces of murex shells. According to Wilson (2004, 158) the vats and heating systems could be evidence of plant-based dye manufacture.

Wilson's caution that a lack of murex shells at Cuicul means that no murex dye installation can be *definitively* identified is valid. His argument can be countered, however: could the shells have been moved? Should the site be identified as a production site using 'indirect evidence', according to the typology presented by Alberti (2008, 75), or should it be dismissed, as Wilson suggests? Some scholars have attested that shells are *required* evidence (Spanier and Karmon 1987, 171-191); or "the most important" evidence (Alberti 2008, 74). While these are reasonable assumptions, particularly on the basis of the data published by Koren (2006) and Ruscillo (2005), we should investigate all available possibilities.

Murex shells found in large numbers should be considered necessary for confirming production occurred there, but careful consideration should be given to why there may be a small cache of shells, or none at all. Smaller amounts of shells could be evidence for the variations in recipes implemented at any given location. As demonstrated by Koren (2005, 138-143), a small number of snails *could* dye a piece of wool, but the final product would be a light colour. Small amounts of shells are also possibly an indication for non-dyeing activities (Alfaro Giner and Costa Ribas 2008, 198). For example, the 17 murex snail shells found at the gardens in the Villa Livia at Rome were likely used to decorate the garden wall niches, not to dye fabric (Pinto-Guillaume 2002, 44). The snails are also edible – they are discussed in contemporary recipes (Lovell 1867, 134), in archaeological cooking contexts (Jensen 1963, 106; Marzano 2013, 148) and in ancient texts. Macrobius (3.13.12), for example, describes a dinner hosted by Caesar that included murex snails.

Thinking back to our Cuicul example, a lack of shells could be proof of recycling for lime plaster (Dix 1982, 331). The large murex middens at Meninx (Djerba), for example, were cut into, likely to harvest shells for plaster production (Wilson 2004, 161). Such a site demonstrates that the number of shells found in a context, even if related to dye production, could change. Much like the process of understanding dye production, placing lime manufacture necessitates finding the materials and the facilities. Berenice (Libya) is an excellent example. Large murex middens are found outside of the city walls. Although poor-quality kilns and ovens were found within the city, archaeologists believe that they were used for lime production using recycled murex shells. Murex dye manufacture facilities would likely not be so close to a residential area, and would have needed better-quality equipment (Reese 1980, 89).

A lack of murex shells still means that a 'definitive' label is problematic. Without the shells physically present in conjunction with features related to dye production, the vats, pits and heating sources could be evidence for another form of production. Similarly, a large pile of murex shells found in isolation could be indirect evidence for production (Alberti 2008, 76), but we cannot apply a 'definitive' label – the shells could have been moved.

Catalogue of (possible) Roman-period dye sites

According to the above-mentioned criteria, evidence for murex dye production can be identified as 'necessary' or 'corroborating', and grouped according to what datasets most likely reveal such evidence. Archaeological studies can therefore confirm six of the ten evidence types necessary for murex dye production:

1. Large amounts of shells in a midden or concentrated context
2. Confirmation of murex snail species
3. Evidence of heating
4. A specified production area
5. Pits, vats and channels
6. Sunlight and oxygen controls

In consideration of the identified 'necessary' (Table 1) and 'corroborating' (Table 2) evidence categories, several sites previously related to murex dye production were studied. Eighteen sites are included here (Fig. 2), grouped into 'definitive' and 'possible' sites. The 'definitive' sites have examples of each of the six forms of evidence; 'possible' sites do not have all

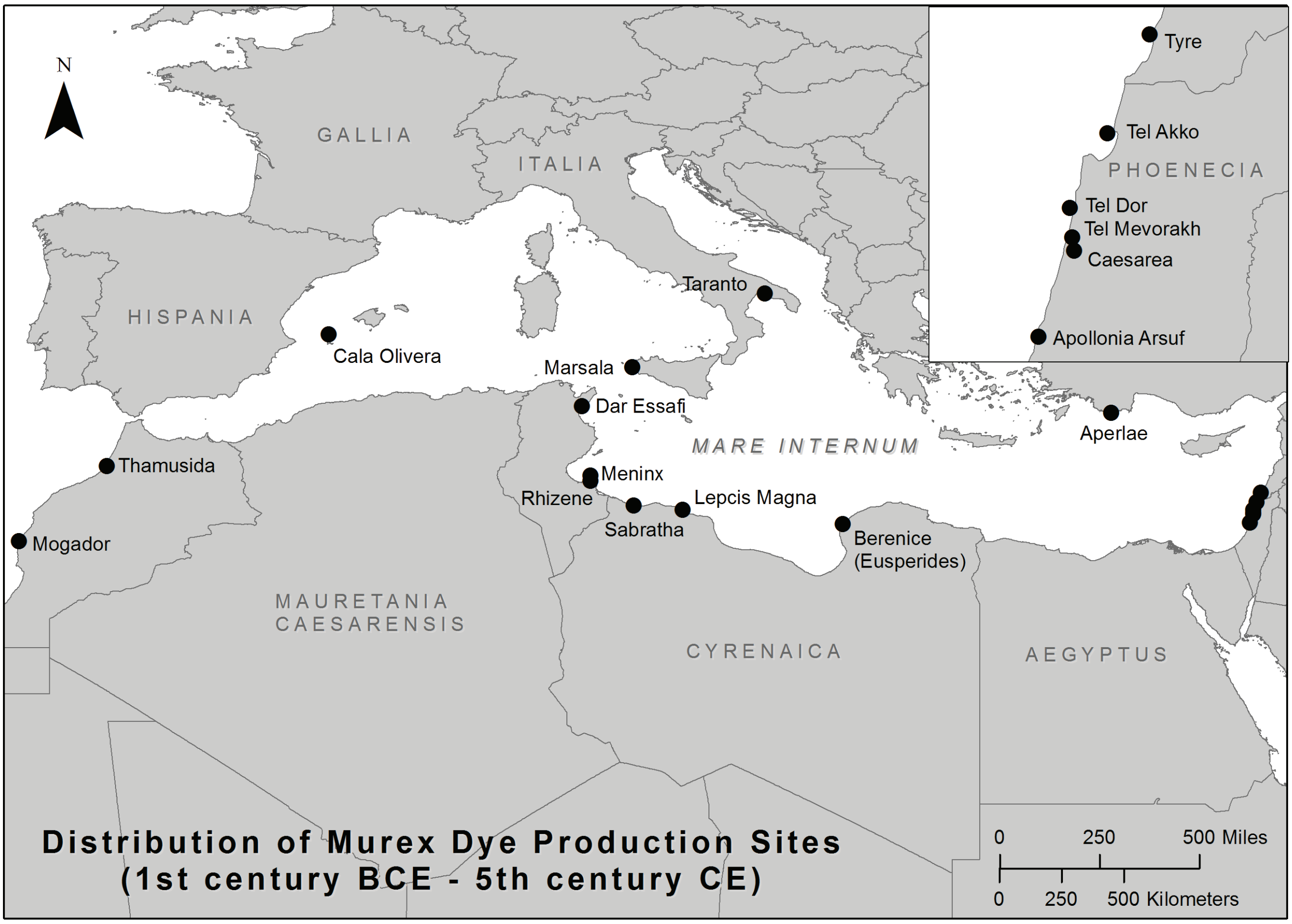

Fig. 2. Map of murex dye production sites (Map: Natalie Susmann).

evidence types, but demonstrate enough promise that further study could prove otherwise.

Using this catalogue in conjunction with the multi-data analysis proposed here, the extreme degree of variability becomes clear – while the evidence for snails, dye production processes or dye production equipment may be present, they manifest themselves in very different ways. The possible dye production sites that are presented here are limited to the constraints of my own research, the complexities of stratigraphy and the dating of materials, and the available details of published excavation reports. As more sites are identified, either via retroactive investigation or through further excavation, additions to the catalogue are to be expected.

Definitive production sites:

1.1 Apollonia Arsuf, Israel (32.17364, 34.803485)
Date: Mid 5th century BCE - late 1st century BCE
(RO[4]: mid – late 1st century BCE)
Source: Karmon 1999
Snails: Murex concentrations are found within the ancient urban city, in areas H and D, dating to the 4th century BCE - 1st century BCE. Roman occupation indicates that loci 1514, 1515, and 1517 were areas of dye manufacture.
Evidence for dye production processes and equipment: Large pits were also found near the shells in these areas. Crushed shells were found together with burnt ash and other burnt organic materials, as well as pottery sherds (Karmon 1999, 278).

1.2 Cala Olivera, Ibiza (38.988268, 1.411908)
Date: 2nd century BCE – first half of 3rd century CE
Source: Alfaro Giner and Costa Ribas 2008
Snails: There is a large shell mound measuring 8 x 4 m, protected by a now-collapsed rock shelter with roof. At least 62% of the snail species present were *Murex trunculus.* Many other uncrushed snails were found in the mound, which were hypothesised as being used for bait for fishing for the carnivorous murex (Alfaro Giner and Costa Ribas 2008, 204-205).
Evidence for Dye Production Processes and Equipment: There appears to be a retaining wall constructed for the shell dump after its initial development. Heating evidence is mixed with the sherds associated with the retaining wall. It is believed that the fire was kept consistently burning for dye production. This workshop is seen as a small-scale operation with portable containers, not permanent vats (Alfaro Giner and Costa Ribas 2008, 202-203).

1.3 Tel Dor, Israel (32.64131, 34.918620)
Date: Late 4th century BCE – mid 1st century CE
(RO: mid 1st century BCE – mid 1st century CE)
Source: Reese 2010
Snails: Murex shells were found in dye contexts, as well as in a construction fill dated to the late 1st century BCE.
Evidence for dye production processes and equipment: A pit was found in area A, completely filled with crushed murex shells. The top of the pit was lined with stones. It was connected to another pit via a 2 m long channel. This second pit was located near a third, as well as a small, square, plaster and stone-lined basin. Purple material was found in the channel, the basin, and the second pit, as was the surrounding soil. Evidence of heating was also found in the area (Reese 2010, 134-135).

Possible production sites:

2.1 Tel Akko, Israel (32.91154, 35.053753)
Date: Late 2nd century BCE – mid 1st century CE
(RO: mid 1st century BCE – mid 1st century CE)
Source: Spanier and Karmon 1987; Reese 2010
Snails: Large amounts of crushed murex were found together with waterproofed, thickened wall vessels.
Evidence for dye production processes and equipment: The vessels, dating in the period from the 13th to the early 12th century BCE, were found with only murex crushed shells and their residues, and are therefore believed to have been used to create the dye. Later occupation layers are thick, mixed with ash and shells, and as such are possibly evidence for heating dye. Roman-period murex activities are identified by large amounts of crushed shells in area H and a plastered basin (Reese 2010, 121). There is no Roman evidence for heating, therefore justifying the designation as a 'Type 2' site. Karmon and Spanier (1987, 153) comment that the lack of decorative pottery in this area could be evidence of industrial work occurring here.

2.2 Aperlae, Turkey (36.15861, 29.783611)
Date: Late 3rd/early 4th century CE – ?
Source: Hohlfelder and Vann 2000
Snails: The town has large middens of crushed murex shells covering a total area of 1600 square metres. A 'conservative estimate' of the number of shells would surpass hundreds of thousands.
Evidence for dye production processes and equipment: Possible holding tanks are also present, likely for keeping the snails alive before dye was harvested. The holding tanks are quite clearly Roman in construction, and bricks, a hydraulic mortar enclosing a ceramic tile floor, and cobblestones date to the 4th century CE (Hohlfelder and Vann 2000, 132).

2.3 Caesarea, Israel (32.48573, 34.34123)
Date: Late 3rd/early 4th century CE – ?
Source: Levine 1975
Snails: The *Targum Jonathan* references murex at Caesarea. Levine (1975, 52) translates the passage thus: "they shall take joy in the *Murex* and from its blood they will dye their fabrics a purple color." The Caesarean Talmud and *Expositio* mention the industry in the city as well. Levine (1975, 53) claims that "special pools for the preparation process existed in Caesarea, and regulations were enforced to keep them sufficiently removed from other buildings because of their stench."

2.4 Dar Essafi, Tunisia (36.39439, 10.621752)
Date: Mid 2nd century BCE – late 2nd century BCE
Source: Sagona 1999; Wilson 2004
Snails: Several large crushed murex middens were located near the town's small harbour (Wilson 2004, 162).
Additional notes: There are also sites nearby which have earlier evidence of dye production, suggesting possible murex production in the so-called 'prehistoric' period. Tas-Silg, two kilometres away, has large middens of crushed shells (Sagona 1999, 35).

2.5 Euesperides/Berenice, Libya [Sidi Khrebish, Benghazi] (32.12485, 20.063571)
Date: Late 4th/early 3rd century BCE – mid 5th century CE (RO mid 1st century BCE – mid 5th century CE)
Source: Reese 1980; Wilson 2002, 2004
Snails: At Euesperides (Berenice's predecessor town), large spreads and dumps of shells were found in the southern part of the city. The location of the dumps varies; some were found in a burnt state in the courtyard of a building with dye-specific architecture; others were found across the city, suggesting the shells were recycled for street surfacing (Wilson 2004, 161). About 95 % of the spreads were confirmed to be murex-specific, and the presence of other types of species in the midden is arguably accidental. The shells were completely crushed, suggesting that the gland would not have been removed intact from the snail. Instead, it is likely that the crushed snail body and shell were heated together (Megías and Wilson 2008, 57-58). At Berenice, Euesperides' Roman successor, Wilson (2004, 162) confirms there are large middens of murex shells present in unexcavated areas, so numerous that it suggests murex dye production continued to play a major economic role.
Evidence for dye production processes and equipment: Archaeologists argue that the magnetometric evidence of burning at Euesperides is an indication for furnaces and hearths (Megías and Wilson 2008, 57), which are necessary for murex dye manufacture. Yellow staining is further evidence for snails having been dumped there (Wilson 2004, 161). Archaeologists agree that murex dye production would have occurred at Berenice as a result of the clear evidence for earlier production activities at Euesperides. That being said, no production facilities have been found that can clearly be associated with the Roman period (Wilson 2002, 255). Until confirmed Roman-period architectural evidence for production is found, the site remains 'possible.'

2.6 Lepcis Magna, Libya (32.64972, 14.264444)
Date: Late 1st/early 2nd century CE – late 3rd/early 4th century CE
Source: Wilson 2002
Snails: Crushed murex shells are mixed into the mortar of structures dating to the 2nd and 3rd centuries CE, including the foundations of the cistern and *castellum* adjoining the Chalcidicum fountain, in the external mortar of the large cisterns located behind the Hadrianic bath latrines, and in the ground near the Arch of Tiberius. It is assumed that the significant amount of crushed shells is direct evidence for a dyeing industry, one which recycled the byproducts for construction material. Architectural features or equipment relating to dye processing have yet to be found (Wilson 2002, 255).

2.7 Marsala, Italy (37.79908, 12.434233)
Date: Mid 3rd century BCE – ?
Source: Cassiodorus; Gleba 2008
Textual: The ancient site (Hydron) was referenced in Cassiodorus' *Variae* as the Italian equivalent of Tyre for its flourishing textile and dye production: "If the Hydruntum diver had searched for the crushed conches of sea at a suitable time, that Neptunian harvest, always generating a flourishing purple harvest, mixed with copious amounts of water, would have released the flaming liquid which showers the princely robes adorning the thrones" (Cassiodorus 1.2.2).
Roman coins depicting *Muricidae* have been interpreted as evidence that the region was engaged in murex dye industries in some way, either by way of supplying the snails, or in manufacture of the dye (Gleba 2008, 81).

2.8 Meninx [Jerba], Tunisia (33.68582, 10.922214)
Date: Early 5th century BCE – late 1st/early 2nd century CE (RO: mid 2nd century BCE – late 1st/ early 2nd century CE)
Source: Strabo; Wilson 2002, 2004
Snails: The large midden is 540 m long, 340 m wide

and 3 m high, with later evidence of quarrying for lime mortar. Mau wine vessels dated to the 1st/2nd centuries CE were found broken in the midden.

Evidence for dye production processes and equipment: Early mentions of purple dye manufacturing at Meninx were made by Strabo (17.3-18), who refers specifically to purple and salting factories found at Syrtis, a small city. Archaeological evidence for Roman-period dye production is indicated by the mixture of crushed murex and large ash dumps (Wilson 2004, 161). Previous research has identified cisterns near the ash dumps (Wilson 2002, 249).

Although these cisterns are large enough to accommodate murex dye production, they are identical in design to domestic rainwater cisterns found in other sectors of the site, as well as in North Africa generally. Additionally, Wilson (2004, 161) is hesitant to link the cisterns to dye production because of the lack of "durable or permanent" dye-related structures or vats. Still, it is unlikely that such a large murex dump accumulated just for lime manufacture. The location of the dye manufacture is unknown, but the byproducts are a strong indicator of dye production somewhere in the vicinity.

2.9 Tel Mevorakh, Israel (32.53381, 34.926831)
Date: Late 4th/early 3rd century BCE – ? (RO: mid 1st century BCE – ?)
Source: Stern 1978
Snails: Large middens of murex shells
Evidence for dye production processes and equipment: A 4th/3rd-century BCE vat made from a hollowed-out block of limestone is assumed to be evidence of dyeing installations. The vat has a chiseled groove running along approximately two thirds of its rim. Three holes are evenly spaced between the groove and the inner basin. This vat is similar in design to those found at other clear dye production sites: Judah and Ain Shems in Palestine, and Tell Beit Mirsim, Tell en-Nasbeh, Bethel and Gezer in Israel. However, these earlier vats are closed at the top. No evidence of heating was found (Stern 1978, 24).

2.10 Mogador [Cerne], Morocco (31.512501, 9.770005)
Date: Late 1st century BCE – early 1st century CE
Source: Euzennat 1976; Edens 1999
Snails: Many large middens have been found near Essaouira (modern Mogador) with murex shells, as well as with *Purpura haemostoma* (a species mixed with murex dye to create cheaper imitations) (Euzennat 1976). There was a mixture of crushed and whole shells. Many of the whole shells have a single puncture mark in them (Edens 1999, 83).[5]

2.11 Rhizene, Tunisia (33.874943, 10.926486)
Date: Mid 2nd century BCE – late 1st/early 1st century CE
Source: Slim *et al*. 2004
Snails: Murex shells have been found in massive quantities at the site, near the coastline (Slim *et al.* 2004, 101).

2.12 Sabratha, Libya (32.79194, 12.484722)
Date: Mid 2nd century BCE – early 4th century CE
Source: Wilson 1999, 2002
Snails: The town has several large buildings with floors covered in murex shells dating to the 2nd-3rd century CE. These buildings include the House of Leda, the House of the Swan, the floor near the Seaward Baths, and the floor north of the theatre. The shells are believed to be an indication recycling after dye production took place elsewhere. Wilson states that the dye industry ended in around 300 CE, proven by the fill in a well near Mausoleum A. A number of murex shells were found in the fill, which appeared to have artificial holes (Wilson 1999, 42-44).
Evidence for dye production processes and equipment: A series of vats have been found at the site, 1-2 m wide and 1 m deep. The smaller, circular vats at the site could have been used for dye production because they are lined with waterproof mortar (Wilson 2002, 242). Because of the cost of murex dye, it is possible that the small size of these vats is appropriate, as they could have been used for "An expensive dyestuff or color not normally used for dyeing whole garments" (Wilson 1999, 46). Larger vats at Sabratha have been disregarded as dye vats because of their size, and were likely used for fish salting. It has also been suggested that the small vats mentioned above were used for *garum* production (Wilson 2002, 242).

2.13 Taranto [Tarentum], Italy (40.46923, 17.24000)
Date: Late 3rd century BCE – early 4th century CE
Source: Silver 1997; Gleba 2008; Pliny, *Hist. Nat.*
Snails: Dye workshops are believed to have been located on the coast, as indicated by the large middens of murex shells (Gleba 2008, 197) now referred to as 'Monte Testacea' (Silver 1997, 254).
Additional notes: Pliny's account of Cornelius Nepos' youth confirms production here: "During my youth, he said, violet purple flourished, whose scale weighed 100 denarii, and not long after, the ruddy Tarentine (color). From here entered the double dyed Tyrian, which was not able to be freely purchased for 1000 denarii per pound" (Pliny, 9.63.39). Tarentine coinage designs depict shells, further emphasising the importance of the industry (Gleba 2008, 81).

2.14 Thamusida, Morocco (34.21854, -6.592132)
Date: Mid 1st century CE – mid 3rd century CE
Source: Wilson 2002, 2004
Snails: Large spreads of murex shells are present. The distance between the site and the ocean implies a substantial amount of manpower was necessary for this location to operate successfully. The snails would have been brought from the ocean and down the Oued Sebou River for processing at Thamusida (Wilson 2004, 162).
Evidence for dye production processes and equipment: Magnetometer surveys have revealed furnace/hearth areas beneath the shell spreads (Wilson 2002, 253).

2.15 Tyre, Lebanon (33.26985, 35.206942)
Date: Late 15th/early 14th century BCE – late 1st/early 2nd century CE (RO: mid 1st century BCE – late 1st/early 2nd century CE)
Source: Karmon and Spanier 1987; Reese 2007
Snails: Bronze Age dyeing occurred, demonstrated by the murex middens and round sandstone pits along the coast with crushed murex shells inside. Similar evidence has yet to be found associated with the Roman period.
Additional notes: Diocletian's Edict on Maximum Prices has direct references to the imperial manufacture at Tyre, which was a state monopoly in CE 383 (Reese 2007, 237). The edict also confirms that Tyre was exporting murex purple and imitations of the product (Karmon and Spanier 1987, 158). Other literary evidence includes the account in Strabo's *Geography* (16.2.23) that "the purple of Tyre was the best. The great number of dye works made the city smell unpleasant. Nevertheless, Tyre was rich and prosperous ..." (Hamilton *et al.* 1903).
Coins dating to the 1st century CE from Tyre have depictions of murex shells (Reese 2007, 237).

Discussion

In order to decipher the production and consumption trends of murex dye, scholars need to be certain that the possible production sites should in fact be included in the sample set. In this particular catalogue, the 18 sites were identified because they possessed certain archaeological indicators for dye production: murex shells covering large concentrated areas, particular forms of equipment and evidence for heating. Via the discussions of textual and scientific data this study has clearly articulated the foremost difficulty in identifying production locations. Murex dye was a popular product used across the Mediterranean, which resulted in regional and temporal variations in ingredients used and methodologies applied. No single dataset can properly highlight these variations; murex dye production studies should therefore be approached in an interdisciplinary manner.

It is for this reason that I have focused only on Roman-period production. Roman-period dye manufacture has associated textual and archaeological data, in addition to scientific studies attempting to recreate these environments. Despite this advantage over, for example, Bronze Age manufacture, complications are clearly present. Certain ancient authors provide specifics for certain points: Pliny makes no mention of crushing tools used, but Vitruvius does, emphasising the range of minutiae that can be considered.

For studies focusing on earlier periods where texts are not available, scholars have a greater challenge. They can only rely on the features that are manifest in the archaeological record, and the types of equipment and environment that have been confirmed to be necessary through experiments. No contemporary textual data is available, but like the Roman examples, evidence linked to dye production could also be related to other industries. At the Thessaloniki *toumba*, for example, while Bronze Age dye production evidence has been found (hearths and kilns, spindle whorls, and crushed murex shells), scholars caution this could be evidence for other activities. Specifically, it is difficult to identify production locations within the site. During the middle Bronze Age, the murex could have been used for cooking, and in later periods, dye production could have occurred in the house (Veropoulidou *et al.* 2008, 175-176). Classification of the evidence is therefore necessary and could help in discerning period- and region-specific production evidence.

Thinking about this Bronze Age example, the methodology presented here can be used as a stepping stone for future murex dye studies. The limitations imposed on the study provide immense value, in that they actualise intricacies in the process, a well as weaknesses and strengths of the dataset. By isolating the locations of production centres, future studies can focus on placing the economy in actual space: understanding regional variations in selecting snail species types and how this would affect the dye production process and product value, as well as how other production facilities, like lime factories, were linked to these locations (Alfaro Giner and Costa Ribas 2008, 198). A catalogue which organises and qualifies potential evidence of dye manufacture enables scholars to identify patterns and trends, and the locations can begin to be analysed as a collective unit, not merely as a scatter of isolated occurrences. Typological analysis of dye production, like that of any other product, will reveal the intricacies of the ancient Mediterranean economies.

Notes

1. This translation is often debated. The phrase *fevere in plumbo* (Pliny, *Hist. Nat.* 9.70) has been translated as "boiled in lead" by Bostock (1855), but *plumbo* could also be a reference to tin (Bostock and Riley 1855, 9.70; Doumet 1980, 47; Koren 2005, 139-142).
2. All Latin translations are my own.
3. The process was extremely odorous. Strabo (6.10) comments that Tyre, despite being rich as a result of its superior skill in dye production, was an extremely unpleasant city to live in.
4. Some sites have evidence of murex production prior to Roman occupation. The first date range encompasses earliest to latest activity, and the 'RO' indicates Roman-specific usage.
5. Whether murex shells are found whole or crushed varies, though the catalogue yields primarily crushed shells. Shells in middens are also often pierced with small holes. These holes could be evidence for an alternative vein extraction method, in which the vein was removed without crushing the shell. The holes could also be evidence of eating one another while being held in a tank prior to dyeing: by drilling a small hole into one via their radula, after which they push their proboscis through the hole to feed on flesh (Armstrong 2004, 1250). Recent excavations at Mount Zion have also revealed a large amount of murex snails associated with a mansion likely used by the elite priests. James Tabor argues that the punctures in the shells are an indication that they were strung and tied around vessel necks – this could have been a way of marking dye types or quality. Note that this site has not been included in the catalogue because Tabor believes there are too few shells to indicate production (Ngo 2013).

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Further Textile Artefacts from the Royal Crypt at Prague Castle (CZ)

A Tablet-Woven Silk Band and Fragments of a Child's Funeral Tunic

Introduction
A unique collection of medieval textiles recovered from archaeological excavations is housed in Prague Castle. It consists principally of the remains of funerary garments and accessories belonging to Czech rulers, their relatives, church dignitaries and patrons. Two textile fragments have recently been the subject of study: a child's funeral tunic in which one of Charles IV's children was buried, and a tablet-woven silk band with gold and silk pattern wefts, likely to have been part of the bodice of a dress belonging to Queen Anna Falcká (†1353).

The tablet-woven band
Find context
Four wives of the Czech king and Holy Roman Emperor Charles IV – Blanka z Valois (†1348), Anna Falcká (†1353), Anna Svídnická (†1362) and Eliška Pomořanská († 1393) – were buried in the Old Royal Crypt situated in the choir of St. Vitus at Prague Castle. Their remains, together with the remains of other Czech rulers, were transferred in 1590 to the newly-built Renaissance New Royal Crypt. The Czech queens named above originally had single coffins, but in the 17th century their remains were collected together in a common coffin. In 1928 the funerary equipment was removed from the crypt, and since then it has gradually been conserved and studied (Bravermanová and Lutovský 2007). The remains of a woman's dress, made from silk lampas decorated with birds and trifoliate leaves was conserved in 2009. Only the front and back pieces of the bodice survive; the sleeves and the skirt have not been preserved (Fig. 1). The dress is thought to have belonged to the second wife, Anna Falcká, although this attribution is not certain. Based on the evaluation of archival sources, a tablet-woven band that was also found could also have belonged to the dress. Most likely it was originally attached to the shoulder.

Description
One large and three smaller fragments of the tablet-woven band are preserved. The fragments are 2.4-2.5 cm wide, with a length of 31.5, 23, 29, and 4 cm respectively (Fig. 2). All the fragments have selvedges on both sides. Neither the beginning nor the end of the band is preserved, rendering a determination of the original length and the finishing method impossible. The band was produced using 45 four-hole tablets.
Its basic structure consists of 180 warp yarns and a heavy and regularly interwoven weft, decorated on the front side with two types of added pattern wefts – a gold weft covering the entire surface of the band and a silk weft, originally of a different colour, used to create a geometric pattern. The gold weft is preserved in the form of small black particles visible on the surface of the band (Fig. 3), and was originally created by narrow strips of gilded leather: several very tiny fragments with a width of 400 μm are preserved among the threads of the silk pattern weft. The remains of the pattern created by the gold weft can be discerned by looking at the fabric sideways

Fig. 1. Bodice of the dress which was probably originally decorated with a band. Condition after conservation (Photo: Prague Castle Administration , J. Gloc).

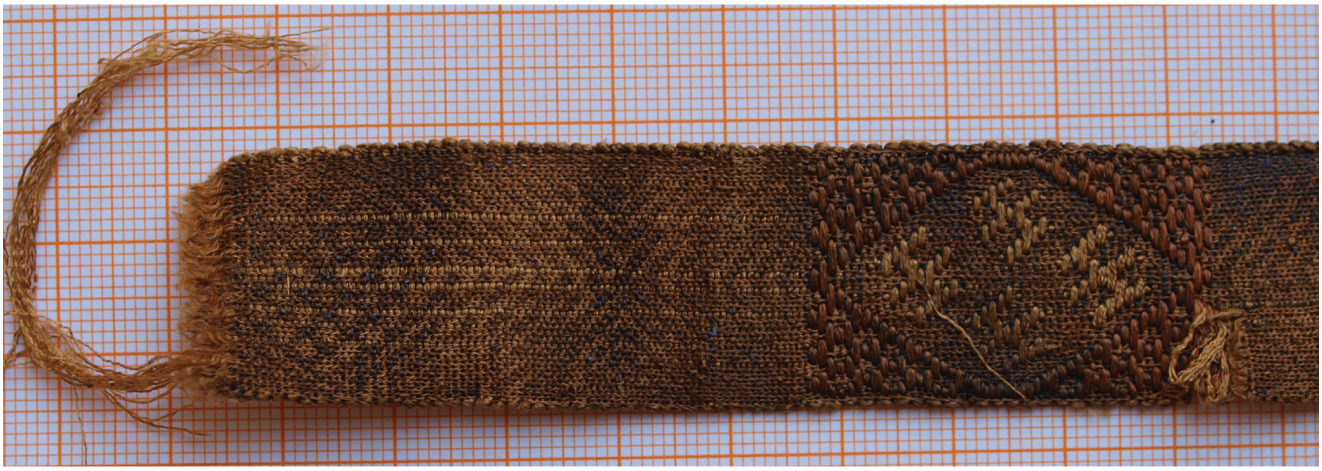

Fig. 2. Detail of the largest band fragment with a width of 2.4 cm and a length of 31.5 cm. (Photo: Helena Březinová).

Fig. 3. Small black particles, remnants of the gold pattern weft, on the obverse of the band (Photo: Helena Březinová).

Fig. 4. Detail of the basic structure of the copy of the band with added polychrome silk wefts (Photo: Helena Březinová).

as an imprint on the ground weft. The pattern is a combination of a regularly repeated broken lines and diamonds.

The silk weft consists of four strands of threads which are not twisted. The geometric pattern consists of a diamond within a rectangle (the rectangle is 3.6 cm in length). Four small motifs reminiscent of a swastika are woven within the diamond. The area of the rectangle outside of the diamond is filled by parallel lines of short stitches. The pattern wefts do not run through the shed like the ground weft, but pass from the front to the back, where they float freely until they are needed for the pattern, and brought to the front again. Two techniques were used for the interlacing of the pattern forming silk wefts: *lancé* and brocade. The diamond within a rectangle is created using the *lancé* technique – the pattern wefts run from one selvedge to the other. The small motifs resembling swastikas inside the diamond are created by the brocade technique – the wefts are only used locally to create the motifs, they do not run the entire width of the band.

Dating, provenance and other finds

The fact that the band was found in the Royal Crypt in St. Vitus Cathedral in the coffin with remains of four Czech queens and probably belonged to a woman's dress dating to about 1350 indicates that it should also be dated to this period. However, it is possible that it might be a little older, perhaps going back to the end of the 13th century. In this case, it is likely to have been added to the dress when the funerary clothing of Anna Falcká was hastily assembled. Based on parallels, it is assumed that the band was made in western Europe.

Tablet-woven bands with added pattern wefts are relatively frequently preserved in archaeological and historical collections both within and outside Europe (Spies 2000). They are interpreted as accessories for luxurious robes for the elite (both secular and ecclesiastical). In the Czech Republic they have only been found at Prague Castle, in the graves of church dignitaries (Bravermanová and Otavská 2003, 506-507; Bravermanová 2004, 603) and rulers (Konservierungsbericht 1992). There are many finds documenting the use of similar bands in other European contexts (Spies 2000).

Experimental reconstruction

In addition to studying the band under the microscope to ascertain its structure, a copy of the band was woven in order to try out possible methods of production. The results were then compared to the original. The aim was not to make an exact replica of the band with identical technical parameters, but to confirm that the

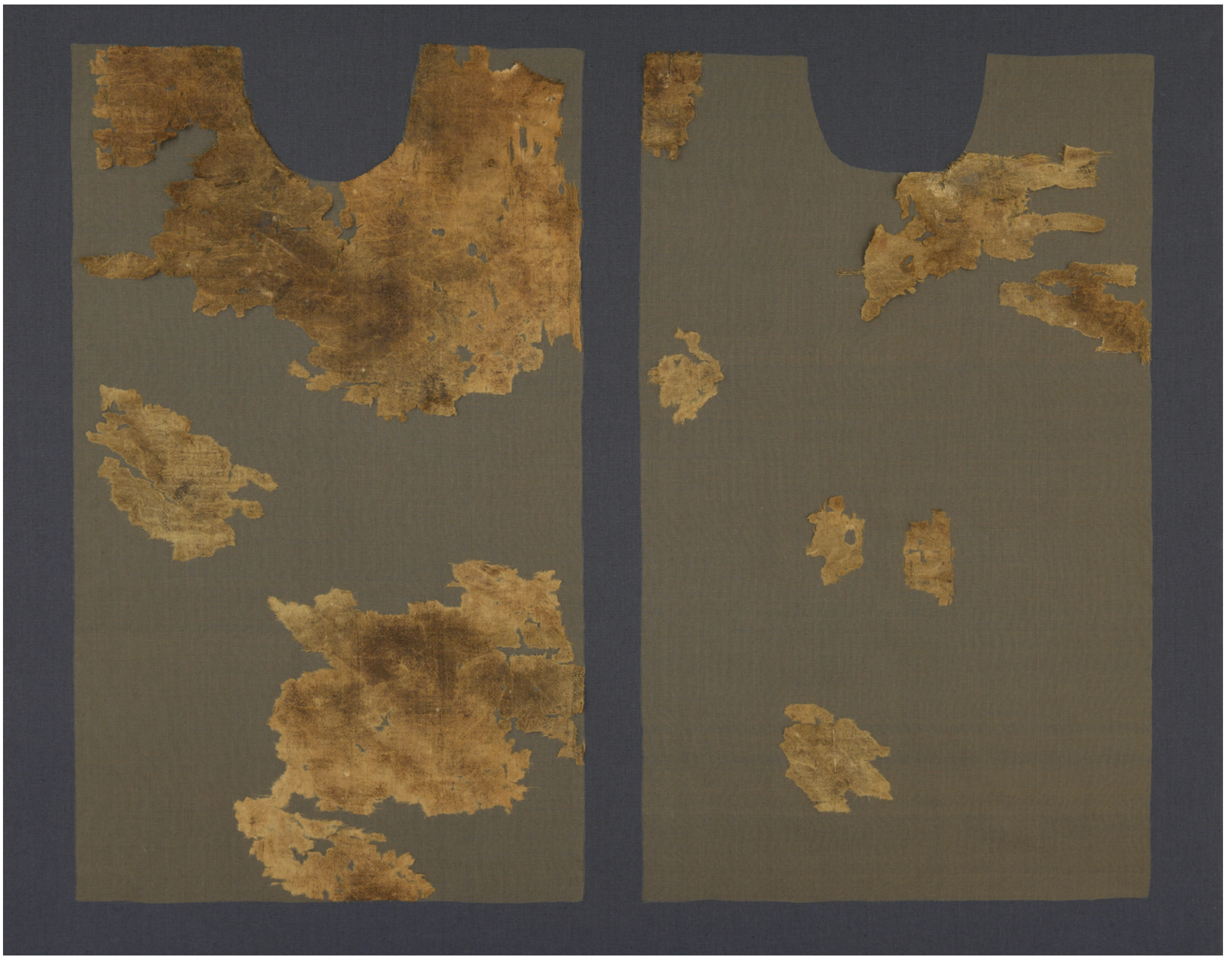

Fig. 5. Child's tunic following restoration (Photo: Prague Castle Administration, J. Gloc).

weaving technique was tablet weaving and to test the possibilities of making patterns with various types of wefts (Fig. 4).

The child's tunic

Find context

Several children's graves were identified in the Royal Crypt. These are connected with the children of the Holy Roman Emperor Charles IV: Wenceslaus (†1351), Charles (†1373), Heinrich (†1378) and a neonate of unknown name (? †1362). The fate of their remains is complicated as they were relocated several times after their interment, without appropriate identification and with a gradual separation of the funerary equipment. Thus, it is not possible today to assign the textile remains to clothes worn by a particular individual (Bravermanová and Lutovský 2007; Bravermanová 2012).

Description

In total, eight fragments of various shapes and sizes are preserved from the tunic (Fig. 5). Most important for the reconstruction of this item is a fragment with the distinct shape of an upper neck part. Around the neck are holes from stitches and traces of turning; the right side ends in a selvedge, while the left side is cut straight off. Part of the second half of the neck was also identified, again with punctures and traces of fitting. The sleeves of the tunic are not preserved.

Following the reconstruction of the shape of the tunic, its dimensions are: length 61 cm, width of front and back piece 35.5 cm, shoulder length 12 cm, width of neck opening 9.5 cm. The shape is very simple, with a curved neckline and straight front and back pieces that are not divided by means of gussets. Almost no tailoring details are preserved: the holes made by the needle during stitching are visible, but the stitches themselves have not survived.

Fig. 6. Reconstruction of the original appearance of the cloth pattern of the child's tunic. The yellow colour indicates areas created by gold wefts, the grey colour by silver wefts (Drawing: T. Brabcová).

The tunic is made of a 3/1 warp-faced twill made of a silk main warp and a ground weft, which today is ochre in colour. The pattern is created by two different *lancé* wefts. Of the first *lancé* weft almost nothing is preserved; only fragments of gold are visible. This weft was apparently composed of gilded leather wound around a flax core (weft I). The second *lancé* weft, composed of silver-plated leather wound around a silk core, was used as an interrupted weft (*interrompue*) (weft II). Similar textiles have been found among the fabrics of tunicellas and dalmatic tunics at St. Nikolai in Stralsund, Germany dated to the second half of the 14th century (Fircks 2008, 127-133, 137-143)

Fig. 7. Detail of the child's tunic under the microscope, with remnants of gold pattern weft (Photo: Prague Castle Administration, A. Prajzlerová).

where gold threads (gilded leather with a flax core) create the first *lancé* weft in both cases, and a second weft (*interrompue*) is interwoven with silk threads.

Pattern of the fabric

The pattern of the cloth used for the child's tunic is composed of a rider on a lion, facing right toward a sun (Fig. 6). This motif is repeated in rows that are shifted by half a rapport. The rider is wearing a tunic with a fur (?) collar; both the fur and the rider's hair are wavy. The rider has a weapon tied to his belt, and with his hand he is holding the muzzle of the lion, which has a thick mane. The lion is raising its front paw, with a lotus flower located nearby. The sun is covered by a mask and radiates long rays. The individual motifs are executed so that the rider's face, legs and hands and the mask covering the sun are interwoven by a silver thread (weft II) while the rest of the rider, lion, sun and lotus flower are made in a gold thread (weft I, Fig. 7).

Dating and provenance

The cloth of the child's tunic can be dated to the second half of the 14th century, based primarily on the use of the motif with human and animal figures, as well as a sun covered by a mask. The design is randomly compiled and corresponds to those of similar Italian fabrics. We suggest that the sun covered by a mask alludes to Advent, a Christian season celebrated at the same time of year as ancient pagan festivals associated with the winter solstice, when the sun reaches its minimum declination (represented by the mask). During the long winter nights, demons were believed to roam abroad. The motif of the rider taming a lion might symbolise the desire to aid the sun's return. The cloth was clearly very luxurious, notably in the use of a decorative design created with gold and silver threads. It was woven in Italy, probably in Lucca. This interpretation is supported by analogies with figurative patterns on other fabrics believed to be of the same origin.

Although a precise parallel for the cloth used for the child's tunic is not known, similar motifs have been found in cloth of Italian provenance from the second half of the 14th century in various European textile collections. A depiction of a lion with a human half-figure holding its mane is found on a lampas preserved in the Kunstgewerbemuseum in Berlin, Germany which is dated to the second half of the 14th century (Lessing 1900, Pl. 178). Eagles bearing women's heads with wavy hair are seen on another fabric from the same museum (Lessing 1900, Pl. 177), while a half-figure is shown rising out of a rosette on a textile in the Deutsches Textilmuseum in Krefeld, Germany (Tietzel 1984, 304-306). Both textiles are dated to the second half of the 14th century. A figure riding on a lion is seen on a lampas from the Kunstgewerbemuseum also dated to the second half of the 14th century (Lessing 1900, Pl. 156a), and a bird flying by a cloud-covered sun is seen on another textile in the Deutsches Textilmuseum in Krefeld which is dated to the start of the 15th century (Tietzel 1984, 418-419). A sun with beams partly covered by a flower motif is found on a fabric in Museum Kunstpalast in Düsseldorf, Germany dated to the second half of the 14th century (Falke 1913, 746). A mask appears on the roots of a tree on a textile from the Kunstgewerbemuseum dated to the second half of the 14th century (Falke 1913, 380). A fantastical motif is seen on the fabric of a tunic from Stralsund showing a man lifting up a dog, above a band with beams rising up from it. This textile is dated to the end of the 14th century (Fircks 2008, 198-201).

Other finds of children's clothes

The remains of the child's funerary tunic, which can probably be attributed to one of the sons of Charles IV buried in the second half of the 14th century, is one of only a few preserved examples of children's clothing in Europe. A patterned tunic with gold thread was found in the coffin of the four-year old Alonso in Valladolid, Colegio de San Gregorio in Spain (Bertrán 2005, 75-77). A skirt, trousers and surcoat were recovered from the grave of infant Marie (†1235) in Leon, Colegio de San Isidoro, also in Spain (Descalzo 2004). Other examples of children's clothing are fragments of upper garments from the church in Uvdal in Norway dated to the 13th-14th centuries AD (Vedeler 2004, 63) and three upper garments from the burial ground in Herjolfsæs in Greenland dated to the 14th-15th centuries AD (Østergård 2004, 178-179, 192-195). In the Czech Republic, the late Romanesque baptismal suit for a neonate from the Cathedral of St. Vitus is unique, sewn from an extraordinarily soft fabric and consisting of a tunic with a hood, on which is a gold embroidered cross, and trousers. The carefully made suit has a complicated shape achieved by inserted gussets (Bravermanová 2013, 197-200).

Concluding remarks

Research and conservation work on two medieval textiles from the Royal Crypt of St. Vitus at Prague Castle has brought several new discoveries. The tablet-woven band was most probably stitched onto the dress, the bodice of which was conserved earlier. It was trimmed using two types of added pattern wefts, where the gold is visible only in fragments under a microscope. The textile technique used was verified during an experimental reconstruction of the band, giving evidence of the original gold design. The tunic that has been fragmentally preserved belonged to one of the small sons of Charles IV. It was sewed from a lampas and trimmed by a fantastical design with a rider on a lion and a sun covered by a mask. The design suggests Advent, which partly adopted ancient pagan festivals associated with the winter solstice. This funerary garment is very special because medieval children's garments are very rarely preserved.

Acknowledgments

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Romina Laurito

TexSEt

Textile Technology in Central Tyrrhenian Italy from Late Prehistory to the Etruscan Period

Background to the *TexSEt* project

The high quality of Etruscan textiles is well known and testified by the elegant Tarquinian paintings and sculptures as well as the decorative pottery created throughout Etruria (in modern Central Italy). They show the wide variety of fabrics and occasionally the richness and attention to detail that went into creating the clothes that were once worn. Less well known are the spinning and weaving tools that were necessary to create these fabrics. Since March 2014, the Archaeological Superintendency of Lazio and Southern Etruria has been involved in a European project called *Textiles in Southern Etruria* (*TexSEt*). This project funds my presence as a Marie Curie Fellow, at the Centre for Textile Research (CTR) at the University of Copenhagen, Denmark for two years from March 2014 to February 2016.

The *TexSEt* project has two aims that follow two distinct but connected threads. The first, studying the spinning and weaving tools of the Etruscan-Italic world, is connected to analyses of archaeological textiles; the second involves museological research looking at presenting scientific research in innovative and more accessible ways to inform the wider public of the importance of fabric-making activities in the ancient world. The ongoing research investigates the emergence and development of textile technologies and the use of textile fibres in central-western Italy starting from late prehistory (final Bronze Age – 10th century BC) focusing specifically on the Etruscan period (8th-4th century BC). The study includes preserved archaeological textiles, textile implements and their contextualisation, as well as ancient iconographic and literary sources. The research further integrates experimental archaeology combined with an ethnographic approach and new analytical methods for textile analysis developed in recent years to explore what constituted pre-Etruscan and Etruscan textile tool kits and the range of qualities that could be produced by these tools, as well as looking for changes in the chronological and/or geographical record. The aim is to enhance our understanding of a long period of evolution in textile production, before the standardisation of technology and production in the Roman Empire.

The final goal is to combine the archaeological study with museological research to develop new approaches in exhibiting textile artefacts and tools in an archaeological museum context. Specifically, this will look at how best to 'translate' scientific results in new ways. My goal is to find new ways to exhibit specific objects, such as textile tools, in the National Etruscan Museum of Villa Giulia in Rome and in the National Archaeological Museum of Vulci (in the province of Viterbo, north of Rome).

Preliminary results

The first step was to create a wide network bringing together museums including the National Etruscan Museum of Villa Giulia and others under the Archaeological Superintendency for Lazio and Southern Etruria, together with the Centre for Textile Research and the National Museum of Denmark in Copenhagen, the La Sapienza University of Rome, the SAXO Institute at University of Copenhagen, and the Land of Legends, the Experimental Centre at Lejre, Denmark. The scientific analysis of the many fragments of fabric is being done by Margarita Gleba from the University of Cambridge, who also includes data from southern Etruria in her ERC project *Production and Consumption: Textile Economy and Urbanisation in Mediterranean Europe 1000–500 BCE* (*PROCON*) (Gleba *et al*. 2013).

At the beginning of my Marie Curie fellowship in 2014, only very few fragments of textiles from pre-Roman Italy had been identified. However, today, more than 60 textile fragments have been identified in the museums in southern Etruria (Fig. 1). This has been the project's first significant discovery. Now we are working hard to re-examine data from the dozens of fabrics identified in Cerveteri, Tarquinia, Vulci, Grotte di Castro and Narce using SEM analysis. Samples have also been selected for dye analysis (De Lucia Brolli *et al*. in press; Gleba and Laurito 2014). The renewed interest of the Italian scientific community in textile archaeology has resulted in greater attention being paid to the archaeological textile tools which are essentially the only archaeological traces left of textile production in this area of Italy. However, in order to understand textile production in pre-Roman Italy, other related sources, such as texts, iconography, paleozoology, experimental archaeology, archaeobotany, and ethno-archaeology need to be included too (see contributions to Gleba and Laurito 2015).

As the research is still in progress, I can here only present preliminary observations on the spinning and weaving tools from the necropolis in Cerveteri (with material that almost exclusively originates from the 7th century BC), the necropolis at Vulci (9th-8th century BC) and from those at Narce and Falerii (principally from the 8th and 7th centuries BC). The most common tools found in Etruscan funerary contexts are the clay spindle whorls that are found in different shapes with incised or impressed decorations. The presence of only the spindle whorls in the tombs (almost exclusively female) suggests that the spindle itself was made of a perishable material such as wood.

Clear differences in spindle whorl size and shape emerge in southern Etruria. Those from Vulci (the oldest), have a wide variety of weights, ranging from the lightest at 5 g, and those exceeding over 30 g. The majority, however, are concentrated between 10 and 20 g. The spindle whorls from Narce, which are of a similar period to those in Vulci, have similar characteristics, although none exceeds 28 g. The spindle whorls originating from Cerveteri, which are chronologically the youngest, are small and light, weighing between 3 and 21 g, with a concentration between 7 and 12 g. Their forms are conical, spherical and bi-conical, with the latter having two variants: type 1 with the maximum diameter in the centre and type 2 which have the maximum diameter in the upper section. Associations can be identified looking at the relationship between the shape of the spindle whorls and their dimensions. In Cerveteri, where the smaller and lighter spindle whorls are found, only conical and type 2 bi-conical spindle whorls are found (those with the maximum diameter in the upper section). There are no type 1 bi-conical spindle whorls. In the other sites, type 1 bi-conical spindle whorls are more numerous and are heavier. Further, it is important to note that the few spherical-shaped spindle whorls are the only ones made from faïence rather than clay.

On rare occasions spindle whorls have survived with spindles. Iconographical comparisons (particularly scenes of weavers from ancient Greece, which are chronologically from the next time period) and use-wear analysis suggest that the spindle whorls were positioned at the bottom of the shaft. Conversely, many spindle whorls do not offer any traces of their actual use. This is one of the most interesting aspects and clearly indicates that during funerary rites both objects that have had a practical function and objects with only a symbolic value were placed in the tombs to accompany the deceased (Lipkin 2012).

I will also look at other tools such as distaffs in order to see if they represent different social and/or cultural factors. In the Etruscan-Italic world, there are two types of distaff: the long distaff with a forked top and the short hand-held distaff (Gleba 2008, 109-122). The long distaff is typical of the Faliscan area. It is a useful and practical object. The spinner can hold/block it under one arm, or they insert it into a belt at their waist, and feed the fibre through using both hands. The short hand held distaff was more widespread throughout southern Etruria.

It is rare to find loom weights inside the tombs. The examples that have been found have a truncated pyramid shape and weigh between 140 and 330 g. It was not common to deposit loom weights before the 6th century BC. This is also an aspect that will be examined further.

Spools are commonly found in graves. In many tombs only one was found, but just as often they were found in groups of up to around 40, with rare cases of more

Fig. 1. Analysing the textile fragments at the National Etruscan Museum of Villa Giulia, Rome. Margarita Gleba and Romina Laurito at work with the Dino-Lite microscope (Photo: Susanna Harris).

than 100 examples. Chronologically, they are attested from the 10th century BC onward (a few examples have also been found in late Bronze Age contexts). They appear rarely after the 6th century BC. The spools have a standard cylindrical or hour-glass shape with flattened or rounded mushroom-shaped ends. Their sizes are relatively standardised, and sets of spools have been found with restricted size ranges.

The fact that spools were found in the same tombs and share similar weights suggests they were used as weights for the looms (Nosch and Andersson 2015, in press). The Italic spools – which are light (well below 70 g) – have been connected with tablet weaving to create borders and fringes (Gleba 2008, 140-150 with previous bibliography), but their simple form clearly makes them multifunctional. They could also have been used to wind the thread, much like a modern-day bobbins, and tests have shown that a spool could contain between 20 and 30 m of thread (Fig. 2).

Future perspectives

Experimental archaeology can play a central role in helping us to understand these Etruscan objects. I have therefore launched an experimental programme which involves the Lejre Experimental Centre and the technical-functional analysis laboratory headed by Cristina Lemorini (chair of Experimental Archaeology at La Sapienza University of Rome). The aim of this team work is to bridge the northern and southern European experimental methodologies. I think that the opportunity to connect different European research groups and work in an interdisciplinary way will fill gaps in understanding of the long operational chain of textile activities and propose a more comprehensive interpretation of textile tools and technology. Certainly the more detailed understanding we have of these ancient everyday objects, the more useful they will be for outreach and exhibition purposes. The objects have an important story to tell, and it is recounting this story which poses the greatest challenge to many museum workers and archaeologists.

Fig. 2. A phase of the experimental programme at Land of Legends in Lejre, Denmark. A spinner winds the flax thread around a replica of an Etruscan spool (Photo: Romina Laurito).

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Gabriela Ruß-Popa

Leather, Fur and Skin Technology in the Iron Age Salt Mines at Dürrnberg near Hallein, Austria and Chehrābād, Iran

Fig. 1. Dürrnberg, Austria. Excavation in the salt mine (© Deutsches Bergbaumuseum Bochum).

Introduction

Iron Age leather technologies are the focus of this dissertation project, which is based on finds of leather, fur and skin from the Iron Age salt mines at Dürrnberg near Hallein, Austria, and Chehrābād, Iran. Similar taphonomic processes operate at both sites, and the economic backgrounds are directly comparable. Objects made of organic materials, including leather, fur and skin, are a very rare find category in archaeology. Under normal conditions they are exposed to natural decomposition processes. The rare conditions that may favour their preservation include salt, water and ice, aridity and contact with metals (see Geijer 1979, 265-270; Fischer 1997, 1). In prehistoric salt mines, the biocidal and dehydrating properties of NaCl, the prevailing low temperatures and the air-tight embedding in salt rock provide an ideal environment for the preservation of organic finds. Many types of organic material are preserved: leather, fur, skin, hair fibres, textiles, wood, tree bast and bark, as well as botanical remains and excrement. Leather, furs and skins were the raw materials used for producing various objects that could be used in the mine. Footwear, headgear, capes, bags and cases served as personal equipment of the miners. Leather and fur were also employed in technical functions, for instance as raw materials for manufacturing various devices and carrying bags for the transport of salt.

Fig. 2. Dürrnberg, Austria. Archaeological finds embedded in the salt rock "Heidengebirge" (© Deutsches Bergbaumuseum Bochum).

Fig. 3. Dürrnberg, Austria. Knife sheath made of calf skin (Photo: Andreas Rausch, © Deutsches Bergbaumuseum Bochum).

Straps and belts played an important role for many purposes in the context of salt mining and finger cots were used as safety clothing. The PhD project described here aims to conduct a thorough investigation of such finds at the sites of Dürrnberg and Chehrābād.

Dürrnberg near Hallein, Austria

The site of Dürrnberg near Hallein is located in the Salzach valley of the Austrian-Bavarian border area. Salt mining started there in the 6th century BC. The region was connected to important prehistoric trade routes in central Europe: east-west along the Danube and south-north from the Mediterranean across the Alps and further north (*cf.* Penninger 1972, 15-17; Maier 1974, 326-347). The Dürrnberg was the second biggest salt producer in the eastern Alps after Hallstatt. The salt deposit consists of alpine rock salt and is part of the 'Hallstatt Zone' extending from the Viennese Forest to North Tyrol.

Evidence for mining technology at Dürrnberg suggests that the miners possessed considerable skills right from the beginning of operations. The exploitation of the Dürrnberg deposits is assumed to have been initiated by groups of miners from the alpine foothills and the Salzburg basin. In addition to the mining methods, the consistency and efficiency of the miners' tools and personal equipment bear witness to a high level of standardisation within the mining operation. The Dürrnberg was an economic centre of its time and remained so until the late La Tène period, when mining ceased: finds rarely date later than the middle of the 1st century BC (Moser 2008; Stöllner 2008). Settlement areas and related cemeteries have been found directly adjacent to the mining area at Dürrnberg. A total of 227 artefacts (assigned to 151 find numbers) from the 2001 to 2012 excavation campaigns are the objects to be examined in this study. They include parts of shoes, a sheath, numerous straps and belts in differing dimensions, as well as hair bundles and smaller and larger leather, fur and skin fragments whose function is still unclear.

Chehrābād, Iran

The site of Chehrābād (province Zanjan) is situated in the north-western part of Iran, where salt rocks have been mined from antiquity to the present day. The rock salt deposits are characterised by a high level of purity and are embedded in a soft and unstable mix of clay and gypsum. The salt is easily accessible due to tectonic activity and its close proximity to the surface. Archaeological excavations indicate intensive use of the mine during the late Iron Age (*i.e.* Achaemenid period). The situation in the Arsacid period remains unclear until now due to the lack of significant finds for the mining activity itself. Carbon dates also suggest mining activities from the Sassanian period up to early Islamic times (651-1036 AD). The ancient mining operations at Dürrnberg and Chehrābād are contemporaneous and comparable in terms of technology. Both follow salt deposits. Only the absence of wooden scaffolding or supports at Chehrābād represents a significant technological difference.

The lack of supports made the work dangerous: miners who lost their lives in accidents have been preserved as mummies and are evidence of the instability of the pit. A total of six human bodies in various states of preservation have come to light at Chehrābād. In

1994, a first mummy was discovered during modern salt production and was partly destroyed. A further salt mummy was destroyed in 2004, but led to the launch of large-scale rescue excavations. Three other salt men were found during the course of subsequent investigations. Parts of a sixth corpse were recovered during an international research campaign in 2010. The bodies date to the Achaemenid (6th-4th century BC), Arsacid (3rd century BC-3rd century AD) and Sassanid (4th-6th century AD) periods. In addition to the well-preserved and clothed mummies (Mummy 4 from the Achaemenid period, for instance, was found with shoes, woolen trousers and tunic, fur cape and sheath (Aali, Stöllner, Abar, Rühli 2012), there are a large number of different-sized fragments of hide, leather and skin. The latter are similar to contemporary finds from the Dürrnberg. Samples of 14 objects of skin, leather and fur from Chehrābād, the purpose of which is unclear, will be analysed within the scope of the project (Ruß-Popa, 2015).

Fig. 4. Chehrābād, Iran. Rock salt deposit (Photo: Gabriela Ruß-Popa).

Fig. 5. Chehrābād, Iran. Foot of the salt mummy 4 with shoe (Photo: Gabriela Ruß-Popa).

Research questions and aims

The project aims to research the selection and supply strategies of the raw materials at the two sites. In so doing, it hopes to reveal important information on the characteristics of the raw materials and to shed light on some aspects of resource management in prehistoric mining operations. The techniques that were used in the production of the materials and the processing of the hide, leather and skin into objects will also be investigated. Another aspect of the project is the typological classification of the finds, which is ongoing, together with a comparison of the material with similar finds from the Iron Age salt mines of Hallstatt in Upper Austria. The project will also include comparisons with leather, fur and skin objects from other archaeological sites, focussing on similarities and differences in the production and use of such objects. Specific finds such as women's and children's footwear suggest that their owners were working in the mine. With this knowledge, the leather, fur and skin finds from the Dürrnberg can be used to address questions of labour division.

The finds have already been examined with regard to animal species for a first overview of the fur supply chain. Questions include whether the animals were domestic or wild, and if they were local or delivered from further afield. To transform the fur of an animal into a durable and usable material, certain operations are necessary, such as de-fleshing, removal of hair and tanning. Evidence for the knowledge and skill involved in these steps will reveal details of the technological know-how of the day. Investigating what kind of leather was prepared and which techniques were used will also help us to understand the craft technologies of early societies; these are fundamental skills that are still relevant today. The prehistoric technologies of leather preservation (*i.e.* tanning techniques) will be examined via a scientific analysis of tannins.

Leather and fur were used to produce various artefacts in prehistoric times. In addition to those mentioned above, there are many objects found in the salt mines whose function remains unclear. Based on the production technique and use-wear, the project also hopes to determine these further uses.

Traces on the finds themselves will help us to determine what kinds of tools were used to process them. This is a particularly exciting question because specialised tools for leather working have been discovered that date to the Central European Iron Age. In addition, traces of repairs will provide valuable information on the recycling of finished objects. Investigating whether objects of a specific type were made regularly from the same animal should reveal details of the properties of the raw materials. This project, with its

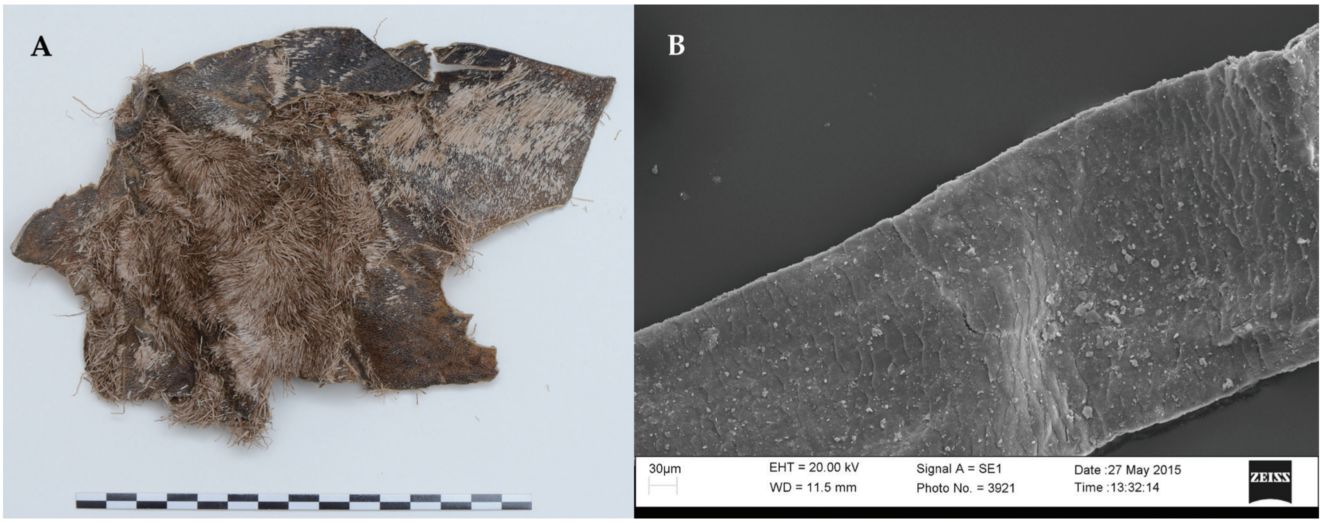

Fig. 6: Dürrnberg, Austria: A) Find No 3680, fragment from an elk fur (© Deutsches Bergbaumuseum Bochum). B) Find No 3680, SEM-picture from an elk hair fibre (© Antionette Rast-Eicher, Archeo Tex, after: A. Rast-Eicher, in press).

research on skin, leather and fur objects, represents a contribution to the history of craft technology and economy, shedding light on the economic background of prehistoric salt mining.

Preliminary results

Studies conducted thus far on the species of animals used at the two sites demonstrate that both at the Dürrnberg and in Chehrābād it was almost exclusively domestic animals that were processed into leather, fur or skin[1]. Calves and adult cattle as well as sheep and goats were the most commonly-used animals for objects at the Dürrnberg. Despite the numerous pig bones found in the Dürrnberg settlement, domestic pigs are absent as raw material for skin and leather objects in the salt mines (*cf.* Groenman-van Waateringe 2002). A single skin find from the Dürrnberg was derived from a wild animal (Elk). Four objects from the Dürrnberg originally attributed to the material group 'skin, leather and fur' were later identified as internal organs such as bladder, bowel and omentum, presumably of animal origin. A comprehensive discussion of the results with detailed documentation will be published after the completion of the dissertation project.

Notes

1. Refers to the material, that was examinated for this PhD project.

Acknowledgements

The determination of the animal species was kindly carried out by A. Rast-Eicher (Archeo-Tex) based on hair fibres. The examination of the hair follicle patterns on the skin and leather finds was performed by M. Kissné-Bendefy (Hungarian National Museum) and G. Ruß-Popa. The ongoing histological examinations have been conducted by I. Walter (Institute of Anatomy, Histology and Embryology) and VetBiobank (Vet Core Facility for Research, Veterinary University).

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Lise Ræder Knudsen

Early Iron Age Tablet Weaving in Denmark

Introduction
The following is a report on my doctoral research, undertaken at the School of Conservation at the Royal Academy of Fine Arts in Copenhagen and completed in November 2014. In this work, I used a multidisciplinary approach combining archaeology, conservation and material culture studies.

Aim
The aim of the dissertation was to achieve new knowledge on textiles, tools, technological development and human relations in the early Iron Age within the area of modern Denmark. The research questions were as follows:

- Do the few large and well-preserved textiles with tablet weaving have characteristics in the thread course that aid in the interpretation of the many smaller fragments? (Fig. 1)
- Can technical analysis of all available finds from the Danish area offer new knowledge about regional and/or period differences in tablet weaving technique?
- Can technical analysis of archaeological tablet woven textiles/tools related to tablet weaving provide new knowledge on textiles, tools, technology and human relations in the early Iron Age in the current Danish territory?

Theory
The theoretical approach is based on the theory of '*chaîne opératoire*', in which the tablet-woven textiles are seen as the result of a chain of actions. Based on especially lithic studies of stone tools and their manufacturing technology, this theory has been developed so that knowledge of production processes can lead to an understanding of the craftsmen who made the objects. Through the craftsmen's mental perception of these processes and the methods thus implied, we may reach an understanding of the ethnicity, tradition and social organisation of which they were a part.
When using the *chaîne opératoire* method, three levels are often used in the interpretation process: the objects, the actions that formed the objects and

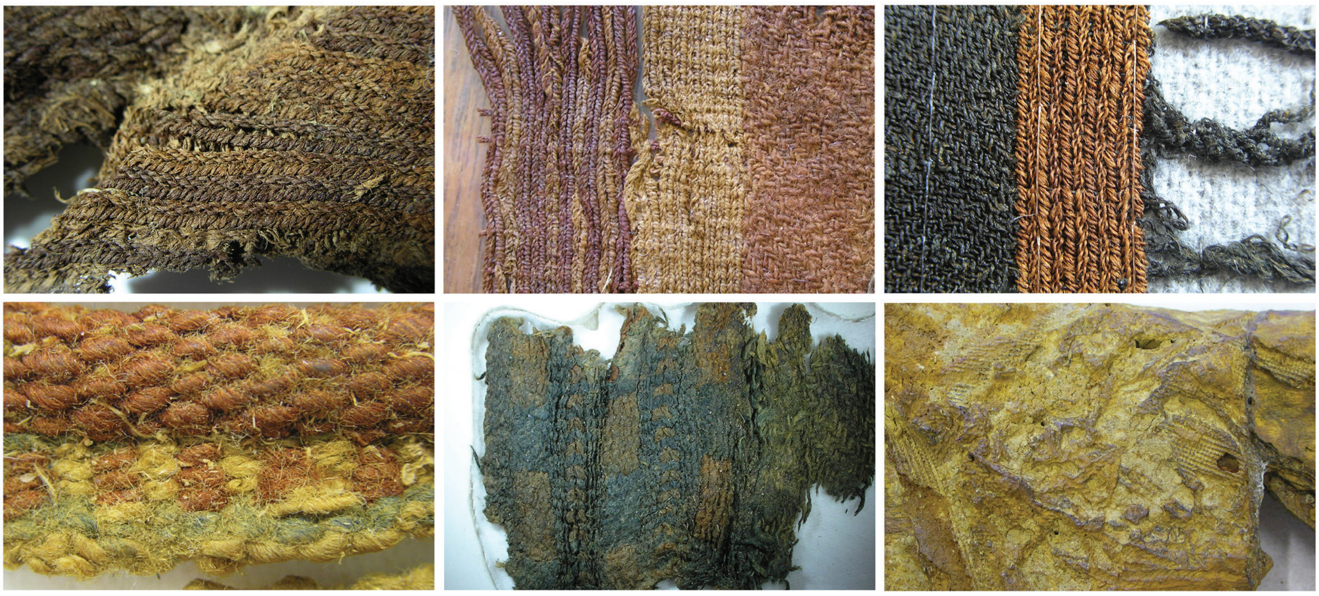

Fig. 1. Early Iron Age tablet-woven textiles from Denmark. Top: Vrangstrup NM C 23594e, Vrangstrup NM C 23585 c, Rovsbjerghøj ÅHM 1260; Bottom: Lønne Hede NM C 33259, Lønne Hede NM C 33308, Lærkenfeldt NM C 19679. (Photo: Lise Ræder Knudsen).

the ideas of the person who performed the actions (Fig. 2). The description of these ideas is often referred to as the *schéma opératoire* and constitutes the overall mental perception (the scheme) of how to produce an object – something that may differ from one cultural environment to another (or from one period to another). From *chaîne opératoire* studies of a prehistoric object it is thus possible to reach some understanding of the society in which the object is produced. This level of interpretation is referred to as the anthropological level. The anthropological level contains all the elements that derive from ethnicity, transmitted knowledge, tradition, constraints, taboos and socio-political organisation of a given society *etc.* (Sørensen, 2006a, 15-26; Sørensen 2006b, 40; Desrosiers and Sørensen, 2008, 8-12). The *chaîne operatoire* for tablet-woven textiles is defined as follows:

- Providing the necessary raw material (wool for weaving and wood for tablets)
- Production of threads and tablets
- Production of tablet-woven band or border (setting up the warp, weaving the band, finishing the ends of the weaving)
- Use as an integrated border in another textile or as an independent band
- Recycling
- Deposition (grave goods, sacrifice, discarding).

The archaeological data, the *chaîne opératoire*, the individual and environmental factors, the concept, intentions and *schéma opératoire* of the craftsman in combination give a framework that in some cases makes it possible to reach a deeper understanding of the social context in which some of the finds were produced.

Method

The research undertaken includes studies of all known tablet-woven bands and tablets dated to the early Iron Age found in Denmark. The textiles were recorded and statistics were compiled based on the recorded data. For the analysis of the tablet-woven textiles, I developed a method I call 'preservation-weighted comparative analysis'. In short, the method works like this: in the database, all finds are sorted into groups according to their state of preservation. The thread courses and the production method of the well-preserved finds are analysed. If the macrostructure of a well-preserved tablet-woven band belonging to a certain kind of textile has a specific thread course that other bands/textiles do not have, then the possibility is high that small and less well-preserved fragments having the same thread course would also originally be part of the same kind of feature/textile. For instance, all well-preserved tablet weavings analysed in this study that had two threads as weft and double threads as warp were cloak edgings. This thread course was the same in German and Polish finds of cloaks with

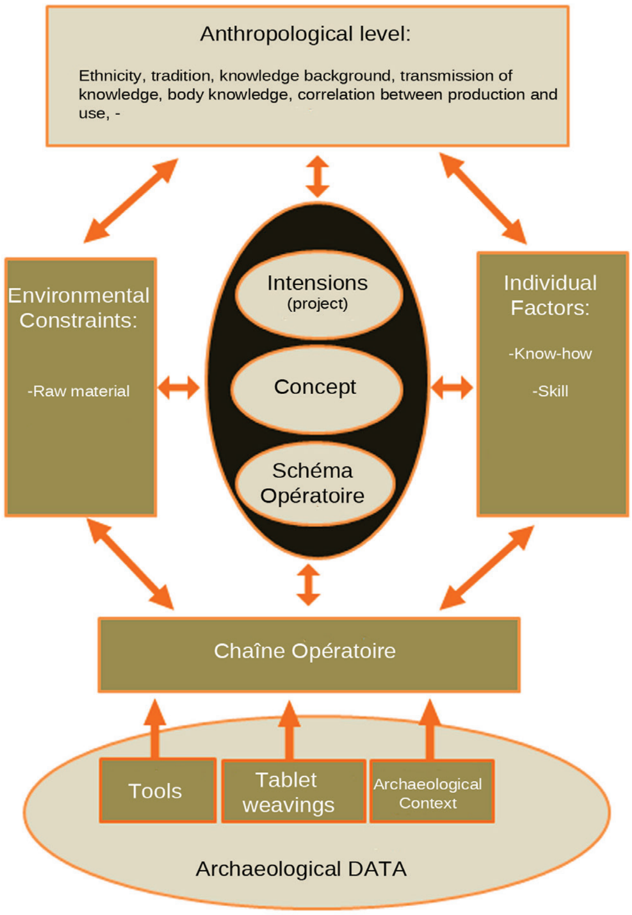

Fig. 2. Desrosiers and Sørensen's model as used in the study of tablet weaving (After: Desrosiers and Sørensen 2008, 10).

tablet weaving whenever it was registered. Therefore, also small fragments of tablet-woven bands with two threads as weft and double threads as warp were with some certainty also defined as cloak edgings.
A method for evaluating the normal quality of an early Iron Age tablet-woven textile was also developed. This was possible due to a great deal of personal experience in the practicalities of tablet weaving and the analysis of ancient tablet-woven textiles (> 10,000 hours of work). Using this experience, a 'good, normal-quality' tablet-woven textile during the early Iron Age was defined and this made it possible to see if a tablet-woven border was made in a more or a less elaborate way according to the norm (Ræder Knudsen 2013, 19-25). If a tablet-woven textile does not follow the typical quality, then a thorough technical analysis of the weave might give information that makes it possible to interpret the reason why – and it might be precisely in the answer to the question 'why' that there is the possibility of new knowledge (Bender Jørgensen 2007, 8-9).

Results
The results of the research on tablet-woven textiles in Denmark show that tablet weaving can yield information on a number of issues beyond the technology of the weaving method itself, for instance that the method came to Denmark in an already-developed state around the beginning of the Common Era. One find is dated to the Pre-Roman Iron Age (the blanket from Skærsø, Mannering *et. al.* 2010, 265), a few weavings to the early Roman Iron Age, and significantly more to the late Roman Iron Age (Bender Jørgensen 1980, 34-58; Bender Jørgensen 1986, 194-204). In the early Roman Iron Age, 84 % of the tablet weavings were made such that they were integrated into other textiles and only 16 % were woven as independent bands.
The statistics show that in the late Roman Iron Age tablet weaving can be divided into two different handicraft traditions which use different yarn types, band widths and numbers of tablets per cm, even though there are examples of both handicraft traditions preserved in the same context (Vorbasse grave 4 (VKM and NM Vorbasse grave 4) and Vrangstrup grave III (NM C 23594)). The two tablet weaving handicraft traditions are:

- Tablet weaving as an auxiliary technique for the warp-weighted loom, in which it served a primarily practical function and was executed as part of household production. The tablet weavings had warps of single yarn.
- Tablet weaving as a work of prestige, in which it had a primarily decorative function. The tablet weavings had warps of 2-ply yarn.

This means that if the warps can be observed on small, less well-preserved tablet woven fragments we may be able to interpret if they were originally made in the context of household or prestige production. Further, it was demonstrated that tablet weaving with a 2-ply warp and two single weft threads most certainly was part of cloaks with wide tablet-woven borders – the so-called '*Prachtmanteln*'. Fragments of 14 cloaks of this type have been found in the analysed material, and thus the number of known '*Prachtmanteln*' has increased substantially.
It has hitherto been assumed that if a piece of textile has a tablet-woven upper border it must have been woven on a warp-weighted loom because this loom requires a stable starting border holding the warp (Wild 1970, 55; Schlabow 1976, 44; Bender Jørgensen 186, 138; Walton Rogers 2007, 87). The other loom used during this period – the two-beam loom – produces textiles without a stable starting border. The starting

Fig. 3. The starting border of a large cloak from Skærsø in Denmark (MKH 366 dated to the pre-Roman Iron Age). The starting border was woven very accurately and without weaving mistakes. Is this the work of an experienced weaver – the master? (Photo: Lise Ræder Knudsen).

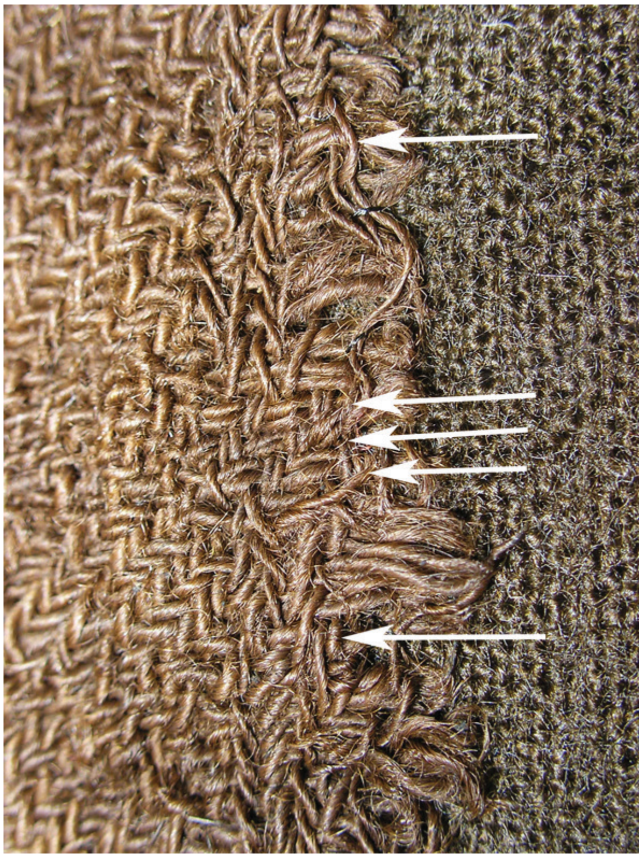

Fig.4: The right-hand border of a large cloak from Skærsø in Denmark (MKH 366). Even though the side border should be the easier to produce than the starting and finishing borders, there are multiple weaving mistakes where the tablets were turned in the wrong direction. Is this the work of an inexperienced weaver – the apprentice? (Photo: Lise Ræder Knudsen).

point of the two-beam loom consists of warp loops. In previous research, it is assumed that an upper border was woven *before* the remaining textile. This PhD project has shown that the upper border of cloaks with wide tablet-woven borders was woven to the edges of the textile *after* weaving the entire ground fabric using the upper loops of the fabric as wefts of the tablet woven upper border. Therefore, some of the weavings that have previously been interpreted as having been produced on a warp-weighted loom were probably woven on a two-beam loom instead. The results of my work indicate that the change of weaving technology and the change from the two-beam loom to the warp-weighted loom was probably not as sudden as previously believed (Bender Jørgensen 1980, 25; Bender Jørgensen 1986, 31, 140). The two types of looms may have co-existed for a considerable period of time.

The *chaîne opératoire* approach was applied to reach an understanding of the weavings at the level of ideas and psychological processes with the aim of contributing to our understanding of human relations in the early Roman Iron Age. Two examples serve to illustrate the approach:

The large cloak from Skærsø in Denmark (MKH 366 belonging to Museet på Koldinghus) has four tablet-woven borders of straight, warp-twined tablet weaving. The starting border was woven first and held the warps of the cloak (Fig. 3), the side borders were integrated with the fabric (Fig. 4) and the finishing border was woven after the whole cloak was finished using the remaining warp threads of the twill fabric as wefts in the border. The twill fabric was woven by two weavers – one on each side – as there are weft crossings in the middle of the fabric (Hald 1950, 63; 153; 1980, 67; 152). The analysis of the tablet-woven borders shows that the starting and finishing borders had been woven in a more regular and precise way than the side borders, which had numerous weaving mistakes and errors. This begs the question as to why there are so many weaving mistakes in these borders, which were the easiest to produce. The answer is that possibly several people with different levels of experience worked on the cloak. It is possible that the difficult parts of the weaving, like the starting and finishing borders, were woven by an experienced weaver (the master) and the easier middle part was woven by two people with less experience (apprentices). Thus, this weaving can be seen as an indication of a learning process (Ræder Knudsen 2014, 28-29).

*A leg wrap found in Thorsberg in North German*y (F.S. 3692 belonging to Stiftung Schleswig-Holsteinische Landesmuseen Schloss Gottorf), is woven in tabby and edged along the sides by small tablet-woven borders. The leg wrap is 13.5 cm wide and the technical analysis revealed that the side borders were woven simultaneously with the ground weave. This means that the leg wrap was not cut to size, but was woven as a very narrow fabric on a warp-weighted loom. The fabric has numerous weaving mistakes (Möller-Wiering 2011, 59) even though the weaving method and the size of the fabric would have made it very easy to produce compared to other weavings. The interpretation is that the leg wrap is most probably the result of an unexperienced person learning the weaving craft. Furthermore, it is possible that the loom used was very small – this could be evidence of a child weaving on a small-sized loom. In future when excavating contexts in which the remains of looms could be expected, archaeologists should be aware of the possibility of a small-sized loom, for instance indicated by a few loom weights lying in a row.

The doctoral thesis was written in Danish but I am currently trying to raise funds for an English translation and publication.

Acknowledgements
The work on the PhD thesis has been a great challenge – and a great pleasure. Many people have helped and encouraged me. Special thanks go to Ulla Mannering, Ulla Lund Hansen, Mikkel Sørensen, René Larsen, Eva Andersson Strand, Beate Federspiel, Jane Richter, Lone Petersen and Lise Bender Jørgensen.

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Ellen Harlizius-Klück

The Textile MATRIX Exhibition

In spring 2015, the Museum for Plaster Casts of Classical Sculptures in Munich, Germany was the stage for a retrospective exhibition (29th April-7th June 2015) of my textile art, book art, drawings, installations and reconstructions of ancient textile technology. The works were exhibited in the three parts of the museum basement: the northern and southern atrium and the garden hall (Fig. 1). A supporting programme accompanied the exhibition including guided tours on related topics like the technique of sprang by Dagmar Drinkler, weaving for the gods by Susanne Pfisterer-Haas, the story of the *Iliad* and the *Odyssey* by Isabella Stürzer, and fabric borders in art by Tamara Eisenhut. On the weekend of 8th-10th May, the Munich Art Areal festival included citizen science workshops and live coding events with the pattern matrix machine, a device developed in the weaving codes project (Fig. 2).

Fig. 1: View of the garden hall at the Museum for Plaster Casts of Classical Sculptures in Munich, Germany with book art and *Isaiah* 6.1 installation (Photo: Roy Hessing).

Today, 'matrix', the Latin word for mother or uterus, is mainly used in mathematics and engineering to denote a system of junctions like the columns and rows in a table. But it can also describe the basic structure of weaves where warp and weft threads cross. The term also describes my work, which oscillates between art and research, and it is the title of a quilt featuring a matrix engraving from the 18th century against the background of the Nike of Samothrake.

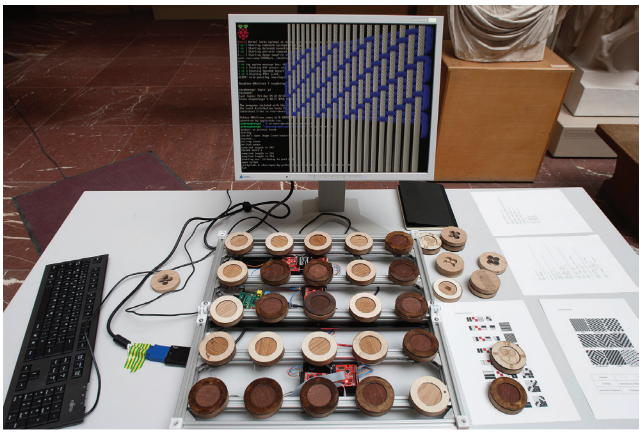

Fig. 2: The pattern matrix machine. A result of the *Weaving Codes - Coding Weaves* project. It allows the structure of a weave to be displayed according to a grid of dark and light wooden blocks on the frame. In this case, however, the machine was coded for the music performance and interpreted the input in a different way to generate sound (Photo: Roy Hessing).

Most of the artwork in the exhibition was from the 1990s. Since then, I have concentrated on research topics like the mathematical principles of ancient weaving and the reconstruction of weaving on a warp-weighted loom. The results of these works were displayed in the southern atrium of the museum where, in 2006, a classical statue of Penelope was reconstructed and placed together with a reconstructed classical loom (Fig. 3).

The exhibition was a unique opportunity to show such research results in an (almost) ancient context. But also my earlier artwork fitted very well in these surroundings, together with the book art and installations which allude to ancient ideas, quotes and characters. Displayed in this context, the works started to communicate with the exhibited museum objects: Narcissus fell in love with his own portrait hidden in the ripples of the water installation; Ariadne fell asleep surrounded by books and objects dealing with dreams or memory like the *omphaloi* (navels); Marsyas' pains were mirrored in the loops of the installation referring to *Isaiah* 6.1 – "In the year that King Uzziah died, I saw the Lord sitting on a throne, high and lofty; and the hem of his robe filled the temple" (Fig. 4 in the background) – a work that shows the significance of the hem that plays a major role in my work and can be traced back to the technological importance of the ancient starting border explored on the reconstructed loom. Samples of this were displayed in front of the *korai* from the Acropolis (reconstructions by Emile Gilliéron with remains of painting that is now lost on the originals, *cf.* Fig. 4).

During the Munich Art Areal festival there was a live coding and weaving event where the pattern matrix machine was demonstrated for the first time. It consists of a tactile computer keyboard of sorts where anyone can test weaving structures and patterns (Fig. 2). For the performance at the Art Areal Festival, the pattern was translated into sound. This machine is a first result of the on-going project *Weaving Codes – Coding Weaves*, funded by the Arts and Humanities Research Council (UK) and conducted by me and Alex McLean from the School of Music in Leeds, assisted by the game designer Dave Griffiths.

Fig. 3: Functional model of a warp-weighted loom with a combined tablet- and double weave made by Ellen Harlizius-Klück. Reconstructed Penelope statue to the right (Photo: Roy Hessing).

Fig. 4: The *korai* from the Acropolis (reconstructions by Emile Gilliéron). Showcase with the result of weaving experiments by Ellen Harlizius-Klück in the foreground (Photo: Roy Hessing).

Sue Harrington and Susan Möller-Wiering

Reflections on an International Collaboration on a Corpus of Early Anglo-Saxon textiles from the RAF Lakenheath Cemeteries, Suffolk, England

Introduction

A crucial aspect when working on archaeological textiles is the research environment, either academic or informal, that can generate active discussion on a particular dataset. At UCL's Institute of Archaeology (SH) there is a small and active group of textiles specialists and students, working on a diverse range of periods and regions. This provides an excellent setting for the resolution of general textile research queries and issues. However, it was when working as a consultant for the Suffolk (England) Archaeological Service Field Team on the textiles from the early Anglo-Saxon cemeteries at RAF Lakenheath that it became apparent that consultation with a fellow period textiles specialist would bring added value to the project. In agreement with the academic lead John Hines of Cardiff University and the project director Joanna Caruth, consultation with a northern European specialist was written in and costed for in the second phase of the research design.

The reasoning behind seeking out a northern European collaborator reflected the nature of this English burial community. The Lakenheath cemeteries were excavated in the late 1990s and produced over 400 inhumations datable from AD 425 to *c.* 650. It was not the first excavation of this site on the edge of the Fenlands of East Anglia. A small area had already been excavated in the 1950s by the local archaeological society, finding 33 inhumations. A textiles report was produced by the late Elisabeth Crowfoot (1966), although unfortunately her original archive and that of much of the site can no longer be found, so had lost much of its potential as a comparator for the new material. One of the key research issues for the early Anglo-Saxon period in eastern and southern England is the extent to which Romano-British communities survived and the processes through which incoming Germanic populations apparently gained hegemony – given that the material culture of the period was significantly northern European in cultural origin. Recent analysis by Penelope Walton Rogers (2012) of the textiles corpus for East Anglia had already highlighted the possibility of surviving and coexistent textile-making cultures, with definable geographical distributions. As with many of these inland communities, their material culture indicated that they were not wholly insular in character, but part of a wider social and economic network that included links across the North Sea to mainland Europe. In this context, specific textile issues relevant to the period as a whole might come to the foreground through investigations of this community – the distribution and usage of the elusive *pallium frisonium*, the intermittent presence of 3/1 twill and the inception of the use of eastern Mediterranean-type cloths, in abeyance in Britain since the late Roman period. Was there a possibility of finding common traits in the textiles culture that were familiar in the Anglian region of northern Germany/southern Denmark, the putative homeland of the Germanic settlers? Susan Möller-

Wiering (SM-W) accepted the proposal to collaborate within this project – having met briefly at the NESAT and EAA conferences. Her previous work on the Liebenau corpus (2005) and her monograph on textiles from weapon deposits in Denmark and northern Germany (2011), with its very clear photographic images, suggested a way forward.

Methods

It is important to reflect on the workstream of the post-excavation processes of this project. The entire project aimed at producing a draft publication for submission to the funders by early 2015. Comprising three distinct cemetery areas, the conservation of the metalwork was carried out on a site-by-site basis over three to four years. Once the material was conserved it then went on a tour of finds and organics specialists, with the associated problem of the potential for the deterioration of the mineral-preserved textiles through repeated handling. Fortunately, where practicable, much of the textile recording took place immediately after conservation and benefitted from a close working relationship with the conservator. Nevertheless, with an artefact corpus on such a scale (over 4000 organic and inorganic objects) it was never possible to see a complete grave group of all material types at any one time. Thus there was little practical opportunity to review the material as new comparisons and queries came to light as one worked through the corpus. Having worked previously mainly on Saxon and Kentish textiles (Harrington 2003, 2007 and forthcoming) the variations in the Anglian corpus produced some unfamiliar aspects and nuances that were profitably referred to SM-W for consultation.

A standard catalogue record was produced for each of the 1100 surviving textile fragments (average size 10 x 10 mm) from 215 inhumations, together with a photographic record. This last aspect was integral to the methodology for forming a permanent archive of the material. A Digiscope AM-413T at 35-50x magnification was used, with the additional use of 180-220x magnification for further exploration, and a Pentax Lumix DMC-F27, on a tripod with optimum lighting, for archive images. There are images of most of the textile fragments, some with multiple magnifications and views. These images were reviewed for further identification once the material had been returned to store and amendments made to the dataset.

Collaborative work

Selected images of 82 fragments (7.5% of the corpus) were sent to SM-W for verification, comparison and comment. It must be stated that these images may not be at a standard for publication, as they are of mineral-preserved fragments, rather than extant fibres. For a textile researcher this was not necessarily an ideal working method. When the textiles are under the microscope, the focus and light can be changed in various ways to reveal features that are not clear at first. On a photo, one is restricted to a single view and is dependent on the quality of the image of an uneven surface. Still, notable details could be determined. However, that is not to assume that the same interpretations were necessarily made, although useful questions did result. The major addition to the textiles record was the resolution of technical issues in terms of weave structure and format. Most notably SM-W highlighted a possible woven stripe within a non-costume cloth in an early burial, the intricacies of folds underneath a cruciform brooch and introduced due circumspection to SH identifications of 3/1 twills (this cloth type had been identified by Elisabeth Crowfoot in a boat burial from Snape, Suffolk (2001) but could not be conserved and was thus unavailable for reference). SM-W's report is an appendix to the textile report in the Lakenheath Cemeteries project archive.

The method outlined above allowed for the resolution of queries at a basic level of the cloth, but could not begin to address more general issues of cloth and costume without more extensive exchanges of information. Our comments on wrist clasps could clearly be investigated in greater detail in the longer term. For example, what was the relationship between clasps and other artefacts that reflect wealth and status? Whilst the presence of different textiles under a pair of brooches, one at each shoulder, is becoming noted increasingly in the English corpus (discussed by Penelope Walton Rogers (2007) and also a trait at Lakenheath), this combination had not been discussed within German burial communities. What was the implication for burial dress if the body was in a coffin? At what point in time did shroud-like coverings begin to be used?

SM-W commented that in Liebenau, shrouds seem to have been an alternative to coffins, independent of the dating from the 5th century to *c.* 600. What might be the relationship of the cloths to other organic materials? But, as SM-W stresses, it is so important to have access to information about all kind of textiles, not only the very special and best-preserved ones.

Conclusions

The importance of a photographic archive of textile fragments is increasingly important, particularly due to the tendency of the mineral-preserved textiles to degrade over time. This is partly an issue of packaging methods. Problematically, archaeologists tend not to have professional skills in photography, although initial guidelines for photo documentation of textiles were presented by Scharff (2007), and a detailed image archive would add greatly to the expense of a project. Nevertheless, new digital cameras and the advent of digital microscopes with a camera function that can send images directly to a computer hard drive have increased the possibility of adequate images being captured for longer-term research and analysis. Image enhancement via computer packages such as Adobe Photoshop adds to the quality and value of even poorly-lit images. This technology will only improve over time to make it both affordable and easier to use, as will the skills of the archaeologists to produce consistent images. The transfer of images via online resources is freely available. In other words, there is a level of potential here to be exploited.

Inevitably, a colleague would want to know more about the positioning of the host object, the gender and sex of the individual, the grave plan and the provenances of the artefacts and the full data set in order to discuss the details. Whilst this would be an ideal situation and would lead to protracted and interesting exchanges, this element of research would rarely receive adequate funding, regardless of the potential of the outcomes. But there may be a way forward if we, as a research community, can make our data and its full contextualisation more easily available to each other, in order that any question can be explored quickly and accurately. So, the proposal must be to build national and international online resources of catalogue data and images of textile fragments for each period. In the evolving world of digital resources, this must, through collaboration, be a realisable possibility.

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Małgorzata Siennicka

Textiles in a Social Context and First Textiles – Two Conferences on Prehistoric Textiles

13 September 2014, Istanbul, Turkey and 7-8 May 2015, Copenhagen, Denmark

In 2013 the collaborative research project *First Textiles. The Beginnings of Textile Manufacture in Europe and the Mediterranean* was initiated by Małgorzata Siennicka at the Danish National Research Foundation's Centre for Textile Research, University of Copenhagen, Denmark (http://ctr.hum.ku.dk/economy/first_textiles/).

The project focuses on the beginnings of textile manufacture, tools and techniques, principally in the Neolithic and early Bronze Age in Europe and the Mediterranean. One of the main objectives is to review and systematise recent achievements in the field of research into the most ancient textiles and textile techniques and to set the agenda for further work. A main activity of the project is the organisation of two international scientific meetings and the subsequent publication of their proceedings.

The session *Textiles in a Social Context. Textile Production in Europe and the Mediterranean in the 4th and 3rd Millennia BCE* at the European Archaeologists' Association (EAA) conference in Istanbul in 2014 was organised by Małgorzata Siennicka together with Lorenz Rahmstorf from the Institute for Pre- and Protohistory, University of Mainz, Germany, now at the SAXO Institute, University of Copenhagen, Denmark and Agata Ulanowska from the Institute of Archaeology, University of Warsaw, now at the Centre for Research on Ancient Technologies at the Institute of Archaeology and Ethnology, Polish Academy of Sciences. The session aimed to explore the social context and cultural aspects of textile manufacture and to present recent research on textiles based on archaeological, ethnographic, textual, iconographic and experimental evidence. The meeting comprised of 18 oral and three poster presentations (for a detailed summary of the presentations see also *The European Archaeologist* 43 (Winter) 2015, 41-44).

The chronological focus of the session was on the 4th and 3rd millennia BC in Europe and the eastern Mediterranean, divided into five sections on methodology, Anatolia and the Levant, the Aegean, the Carpathian Basin and the Balkans, as well as a poster session. The introduction by Lorenz Rahmstorf demonstrated various approaches used to investigate ancient textile production: ethnographic, iconographic, textual, contextual, experimental and material-typologic. In the methodology section several topics were discussed: ways of approaching textile production without preserved textiles or tools (E. Andersson Strand), studying textile impressions and imprints (S. Möller-Wiering), the famous iceman in the Ötztal Alps as a starting point for a discussion about regional and social variations in plant fibre technology, and the spread of textile techniques in Europe in around 3500 BC (E. Wigforss).

In the Anatolia and Levant session the following topics were explored: Neolithic Anatolian stamp 'seals' and their possible use in textile production (A.U. Türkcan), textiles and textile tools from the Chalcolithic Southern Levant (O. Shamir), textile production in Western Anatolia in the 4th and 3rd millennia BC (C. Britsch and

B. Horejs), textile manufacture at Arslantepe in Turkey during the 4th and 3rd millennia BC (R. Laurito), and secondary urbanisation and textile industry in the early Bronze Age in the northern Levant (L. Peyronel). In the third session on the Aegean, the focus was on iconographic evidence from Neolithic Greece (K. Sarri), the Cretan Neolithic and early Bronze Age evidence for the production of cloth (J. Cutler), archaeological evidence for textile production from the early Bronze Age in southern Greece (M. Siennicka), yarn production on the Aegean islands in the early Bronze Age (S. Vakirtzi), and the potential use of specialised band looms for weaving bands and starting borders in the Aegean (A. Ulanowska). The presentations in the last section on the Carpathian Basin and the Balkans treated the major Neolithic innovations in textile manufacture in south-eastern and central Europe (T.J. Chmielewski), textile tools and other implements possibly associated with textile manufacture during the late Neolithic and early Bronze Age in Bulgaria (P. Hristova), textile tools and the introduction of the woolly sheep in central and south-eastern Europe (A. Grabundzija), the extraordinary find of a mineralised woven structure from a burial tumulus in eastern Romania dating to the early Bronze Age (N. Bolohan, C. Lazanu and P. Mazăre) and important changes in weaving technology and the organisation of textile production in early Bronze-Age Bulgaria (V. Petrova). In the poster session we were introduced to atypical textile tools from Bulgaria (T. Valchev), woven fabrics in the Andronov costume (E. Usmanova) and semantic web ontologies for ancient textile production (F. Lynam).

The aim of the two-day international conference *First Textiles. The Beginnings of Textile Manufacture in Europe and the Mediterranean* in 2015 was to present and discuss recent achievements in the field of textiles and textile techniques in Europe and the Near East in the Neolithic, Chalcolithic and early Bronze Age (*c.* 8th-3rd millennia BC).

The first day of the conference was hosted by The Danish National Research Foundation's Centre for Textile Research at the University of Copenhagen. The first session was dedicated to fibres and textiles: textile plant production and trade (D. Fuller; S. Karg), development and changes in textile techniques from the Neolithic period to the Chalcolithic period in the southern Levant (O. Shamir), textile provenance investigations by isotopic tracing techniques (K.M. Frei), rare finds, unusual materials and different technologies for studying early textiles (L. Hurcombe), textiles from lacustrine Neolithic settlements at Lake Constance in south-west Germany (J. Banck-Burgess), the earliest cloth (skin and fur) culture in Denmark (U. Mannering), and a review of clothing traditions in the southern Levant 13,500-4,000 BC (J. Levy). In the second session, experimental archaeology and cultural comparisons were discussed. Eva Andersson Strand introduced us to the world of the first looms. Karina Grömer dedicated her paper to experiments with Neolithic crescent-shaped loom weights from central Europe. Kalliope Sarri explored the subject of decorative craft transfer in the Aegean in the Neolithic (textiles, baskets and pots). Finally, the functionality of early Bronze Age weaving tools from Greece was discussed by Agata Ulanowska.

The second day of the conference was hosted by the National Museum of Denmark. This day was dedicated to textile production and textile tools from different archaeological sites and contexts. Miriam de Diego presented a joint paper on textile technology in the Neolithic site of La Draga, Spain (M. de Diego, A. Palomo, R. Piqué, M. Saña, X. Terradas, I. Clemente, M. Mozota). Textile production in western Europe from the late Neolithic to the early Bronze Age was discussed in detail by Fabienne Médard. Maria Irene Ruiz de Haro presented an overview of the use of spinning bowls from the Chalcolithic period (in the Balkans, Palestine and Egypt) to the Iron Age (Iberian Peninsula). Ana Grabundzija debated the symbolic and functional role of early spindle whorls from south-eastern Europe, while Giorgos Gavalas focused on textile production in the early Bronze Age in the Cyclades. Lisa Völling questioned the interpretation of early Bronze Age clay objects from Troy as spindle whorls. Textile implements from the Eskişehir region in north-western Anatolia were introduced by Deniz Sarı. Carmen Marian presented an interpretation of textile impressions in clay on pottery, and finally Maria Rosaria Belgiorno summarised textile production in Pyrgos/Mavroraki on Cyprus *c.* 2,000 BC.

The proceedings of these two conferences will be published in 2016/2017 in a peer-reviewed volume edited by Małgorzata Siennicka, Agata Ulanowska and Lorenz Rahmstorf in the Ancient Textile Series published by Oxbow Books.

Rebecca Peake and Yann Lorin

A New Look at Textiles in the Bronze and Early Iron Ages

5 March 2015, Musée d'Archéologie Nationale, Saint-Germain-en-Laye, France

This study day centred on textiles was organised by the *Association pour la promotion des recherches sur l'âge du Bronze*, France (*Aprab*) as part of a series of one-day annual meetings on specialised topics. Archaeological contexts have produced plenty of evidence of production and use of textiles showing that they have been an integral part of human society for millennia. Textile production, closely linked to the domestic sphere, is a complex procedure that entails technical knowledge from the choice of the fibres to spinning and weaving. Many objects found in Bronze- and early Iron Age domestic contexts bear witness to this daily but nevertheless specialised activity. Consequently, the aim of the study day was to provide a forum for French archaeologists to discuss textile activities with renowned specialists, to present objects from the archaeological record pertaining to textile production and use, as well as the preserved textiles themselves. It also provided an opportunity to discuss recent discoveries and new work on textile production and use during the Bronze and early Iron Ages in a multidisciplinary and international perspective.

The twelve papers presented by specialists and archaeologists from Europe and the United States covered various aspects of textile production, from the preparation of raw materials (vegetal fibres and wool) to spinning, weaving and dying techniques as well as the tools of textile production usually found in Bronze- and early Iron Age contexts.
The opening paper by Emmanuelle Martial and Fabienne Medard gave an overall view of the *chaine opératoire* of textile production with particular emphasis on the preparation of vegetal fibres, using evidence from the Deûle Valley in Northern France. It was complemented by the subsequent presentation by Laura Mazow on evidence of Bronze Age wool scouring in the Near East. Approaches to the technical aspects of textile production and in particular spinning and weaving were provided by Eva Andersson Strand and Ulla Mannering using data from Scandinavian sources which included the study of tools and the use of analyses to determine raw materials and their sources. An insight into weaving techniques was also given by Karina Grömer, who presented evidence for the specialisation of textile craft in early Iron Age Europe from the Bronze/Iron Age salt mines of Hallstatt, Austria. Regina Hofmann de Keijzer presented a paper on prehistoric textile dying which detailed the natural dyes and mordants that were used as early as the Bronze Age to be further developed during the Iron Age. To follow on from this, Yann Lorin talked about the link between textile crafts and symbolic imagery provided by personal adornment. The study day was brought to a close by a series of papers on textile tools. The question of the diversity of spinning whorls was addressed by a collaborative paper using data from Iron Age sites in eastern France and Switzerland by Fabienne Médard, Michael Landolt, Anne-Marie Adam and Cynthia Dunning Thierstein. Vincent Riquier and Elise Sehier subsequently presented the abundant finds relating to textile production from the site of Buchères in the Champagne area of France and the discovery of a late Bronze Age textile workshop in Normandy was presented by Cyril Marcigny, Bruno Aubry, Emmanuel Ghesquière and Elise Sehier. The

question of loom weights was tackled by two papers: the first by Théophane Nicolas, Roxane Kleinhaus-Pénisson and Gabrielle Vicomte presented a series of loom weights from the Bronze Age site of Bédée in Brittany and the second was a study of Iron Age Loom weights from Belgium by Carole Cheval.

A full list of the papers, posters and their abstracts can be found on the *Aprab* website: www.aprab.org/manifestations, sub-menu "journées d'étude". All presentations will be published in French as a supplement to the *Bulletin de l'APRAP*.

Marie-Louise Nosch

Silks from the Silk Road: Origin, Transmission and Exchange. International Symposium

11th-14th October 2015, China National Silk Museum (CNSM), Hangzhou, China

It is impossible to give a satisfactory summary of all the many papers at this year's silk conference, but the following presents a selection of papers with most relevance to archaeological textiles.

The first session grouped new and old archaeological textile finds together. Susan Whitfield opened the conference with a lecture on the fundamental role silk plays in Buddhism. It was used as decoration and votive offerings in temples in antiquity and up to the present day. In the Dunhuang caves monks are depicted wearing silk, and early Buddhist texts were written on silk, despite the fact that paper techniques were well developed. Feng Zhao presented an overview of the present knowledge of archaeological finds of silk in China and Kazakhstan. Sim Yeon Okm presented archaeological textiles with in-woven gold from an ancient Korean Buddhist temple dating to the 14th century AD. The finds include women's accessories such as small incense bags. The fabrics, lampas (which are silk weaves with supplementary weft), brocade and tapestry are woven with metal threads mainly of gold but also a few of silver and other metal alloys.

Svetlana Pankova presented the early silks from the 3rd century BC to the 3rd/4th centuries AD in Russia, mostly from Siberia and Central Asia because of climatic conditions. From the Altai Mountain burials, the renowned Pazyryk textiles were described, such as a *jin* silk, a silk horse cloth of 3 m length, cut in two parts, and a bright yellow tabby purse, all probably of Chinese origin; from Katenda she presented a remarkable tailcoat with silk part and from Ak-Alakha a 130 cm-wide Tussah silk tabby shirt, probably not of Chinese origin according to analyses conducted in the museum. From the Xiongnu tombs of northern Mongolia dating to the 1st century BC and the 1st century AD, 950 textiles, among which are 250 pieces of silk, especially in Noin Uul, are currently under study in the State Hermitage and will be published in the near future. In Ilmova Padj a 1st-century AD jin silk with inscription was found, and at the 3rd/4th-century AD Oglakhty cemetery in Minusinske valley remarkable burial rites were discovered in which the face of the deceased was covered with silk and a gypsum burial mask concealed the face. The burials also include life-sized 'puppets' stuffed with grass and clothed in textiles, rags and silk.

Judith Cameron presented a paper on the Dong Son culture excavations in Vietnam, many of which contained mineralised textiles that in some cases could be identified as silk. In Yen Bac, a burial with a silk shroud was found and in Dong Xa a burial was found of a female corpse wearing a ramie shroud which also included embroidered items. Zvedana Dode reported on archaeological textile research in the Caucasian part of the Silk Road, in particular Mostcevaia Balka and Khasaut, explored in summer 2015. She presented the new research strategies for these sites and the new methods applied. Among the important finds were a kaftan decorated with leather appliqués and silk embroidery as well as silk loops and leather buttons covered in silk.

Liu Bin reported on early silks from the Neolithic Qianshanyang culture, *c.* 2200 BC. He compared silk and jade as materials, their appearance and symbolic meaning. The site of Qianshanyang was excavated several times, and during excavations in 1956-58 and 2005, some textiles came to light. In 1980-1981, scientific research discovered that the textiles found were from domestic silkworms. Among the textiles found were tabbies and thread made from bombyx rather than wild silk. The textile finds from the 2005 excavation were analysed in the laboratory of the China National Silk Museum (CNSM). The woven belt and tabby textiles were probably made of ramie. There were also spindle whorls from the site, and circumstantial evidence of silk textiles in the Neolithic including spindle whorls, parts of wooden looms, images of silk worms on vessels and wooden tools made of mulberry tree wood. The earliest evidence for archaeological textiles date to the Liangzhu culture (3400–2250 BC).

Dominique Cardon reported on dyes on the Silk Road and especially on dye plants containing purple/purpurine.

Li Wenying presented an overview of the spectacular archaeological textile finds from Xinjiang dating from the Bronze Age to the second part of the 1st millennium AD and stemming from numerous excavations of the 20th century and recent years. Silk textiles from the excavations of the 1980s can be matched with those found in the Swedish expeditions in the early 20th century. Han and Qin dynasty brocades are quite rare in Han contexts, and in 2003 graves with silk robes and gold foil and painted decoration were found. Another find includes silk diamond pattern. Remarkable costumes were found at the Yin Pan site with warp-faced compound weave and weft-faced tabbies. 167 burials from the Zaghunluq cemetery contained further warp- and weft-faced tabbies. Here the patterns are different to those of the Yin Pan finds but there seems to be an imitation of motifs from the Yin Pan textiles. In the Loubsempre cemetery silk textiles of a high value with blue dye have been found. At Astana the archaeologists explored 500 tombs, of which 300 can be dated 400-600 AD, the rest to 700-800 AD. They also contain silk textiles, lampas, warp-faced and weft-faced tabbies. Stylistic analyses have enabled scholars to create a chronology of the finds.

The presentation by Qurbonow Sharof dealt with the textile archaeology of Sogdian periods in Tajikistan. The excavations in Panjakent unveiled numerous wall paintings and wooden sculpture dated to the 8th century AD. The citadel of Sandasha, dating to the 7th/8th centuries contained a child's shirt of cotton tabby weave with 18/14 threads per cm. Fragments of a coarse plant fibre fabric was analysed by CNSM and turned out to be a combination of silk and cotton. At Mount Mugh, Sogdian documents and fragments of silk, perhaps dating to the Chinese Han dynasty, were found. The site of Hisorak, excavated in 2013, revealed many textile fragments of silk and cotton.

Orit Shamir presented medieval textiles of Byzantine and Islamic origin, among which were several silks from collections in Israel. On Coral Island in the Red Sea, 236 medieval textiles were found, including seven silks, 22 fragments with silk wefts and cotton warps and linen textiles embroidered with silk thread. 768 textiles dating to the 9th-13th centuries were excavated at the Jericho Cave, among which were 38 silk textile fragments. A further nine linen fabrics were decorated with silk tapestry. One fragment has linen warp, silk weft and silk tapestry. Also a red silk in 3/2 twill and 18 compound weave silk fragments with patterns and pseudo-inscriptions were recorded. The silks are probably not from China. The textile fragments may have been collected for re-use as rags in the early paper industry.

Lin Meicun reported on silk terms in the Gandharan language and how it mentions silk and China. Duan Qin reported on mentions of silk in Khotanese texts. Production of silk was very important in the kingdom of Khotan and economic documents dated to 785 BC record state-controlled sericulture activities. Official documents list instances of the leasing of land to grow mulberry trees. Payments were made in cash or in brocade fabrics. Texts also list pre-installments for brocade production, stipulating prices and sizes of fabrics. Sericulture also belonged to the sacred rituals. Dagmar Schaefer explained the state-owned silk manufacture of the Ming dynasty. Although her paper did not deal with archaeological textiles, it contained highly relevant theoretical reflections on the intertwining of sericulture and political systems. She argued that sericulture shaped and impacted on Chinese politics (and not *vice-versa*).

During the conference, the statutes of the newly-founded International Association for the Study of Silk Road Textiles, ISSRT, were created and co-signed. ISSRT is an international association jointly established by organisations (including universities, museums, libraries, archaeology institutes, research institutes and research groups) conducting research on themes relevant to the Silk Roads. The mission of the association is to establish a platform for cooperative research and mutual benefit, to share scientific and technological resources, to promote transformation and application of new research technologies, and to enhance dissemination of this research. The ISSRT aims in the coming years to investigate the cultural heritage resources related to Silk Road textiles and to construct joint databases. Further aims are to study the key technologies needed to identify and protect the material culture related to Silk Road textiles, to exchange human resources and establish laboratories for the protection and conservation of textiles, and to launch joint exhibitions on the theme of material culture related to Silk Road textiles. The founding member institutions of ISSRT are CMSM, CTR, the British Library, Bryant University, Peking University, Zhejiang University, Donghua University, ICOMOS Conservation Centre, the Chinese Academy of Sciences, the Institute of Archaeology Xinjiang, the Institute of Ancient History and Archaeology of the Northern Caucasus at Stavropol, the Israel Antiquities Authority, Korea National University, Needham Research Institute, the Max Planck Institute for the History of Science and the Queen Silikit Textile Museum, Thailand. Other institutions will join the association in 2016.

Jacobo Tabolli

The Fabric of Life: Approaches to Textile Resources, Economy and Production in Ancient Italy

26 February 2015, Rome, Italy

As Christopher Smith, Director of the British School of Rome, stressed in his introduction for this one-day international workshop, the happy circumstance of seeing the Sainsbury Lecture Theatre filled with people at 9 am (in Rome!) testifies to the exceptional interest in the world of ancient textiles both from scholars and from the general public in Italy. Such an increasing curiosity captured most of the audience during an intense day, with a variety of papers that continued in the afternoon, in the Sala della Fortuna at the Etruscan National Museum of Villa Giulia. The two organisers, Margarita Gleba (University of Cambridge) and Romina Laurito (CTR, University of Copenhagen/ Soprintendenza Archeologia del Lazio e dell'Etruria meridionale), like in a beautiful ancient 'warp and weft', were able to bring together and mix different scholars from different universities, museums, superintendences, and different regions of ancient Italy, interested in a variety of chronological horizons, strategies of outreach and public engagement. As the

organisers assessed in the call for the workshop, "the overall aim of this session is to demonstrate the potential of archaeological textiles and related sources for the investigation of ancient Italian economy, technology and agriculture and to discuss new methods that can be applied to the investigation of ancient textiles". Rarely in the past conferences of Italian archaeology has the potential of new methods and approaches been so successfully achieved in a single workshop. In addition, it is important to stress here the success of a workshop with a truly international soul, where most of the participants were young researchers, with papers both in Italian and in English, a balance that is hard to achieve and which at the same time contributes to the definition of new trends in Italian archaeology (and gives some hope for a different and better future).
Pulling the strings of the different papers, the potential of new interdisciplinary approaches was firstly presented by Margarita Gleba, who in the past ten years has been leading a new season of studies on textile production, inheriting the legacy of the noble mother of Etruscan dress, Larissa Bonfante (who could unfortunately not join the workshop, but who sent her best wishes to the participants). Through the microscope of Margarita Gleba, textile fibres were described in a stratigraphical account of the different production styles among the various pre-Roman cultures. Susanna Harris (University College London) gave a fresh understanding of textile iconography in proto-historic Italy, stressing the importance of sources such as tomb paintings for the comprehension of the nature of ancient dress and the textiles behind it. Within the numerous other sources of evidence an important emphasis was reserved for the study of raw materials.
Especially linen seems to have played an important role in Iron Age Italy and during the workshop. Mauro Rottoli (Musei Civici di Como) presented the ongoing studies on linen, hemp and wool in central and northern Iron-Age Italy. The archaeozoological remains appeared to be an exceptional source in the paper of Angela Trentacoste (University of Sheffield), including the Hamlet question "sheep or goats?" From prehistory to protohistory, from the palafittes of Molina di Ledro and Fiavé presented by Marta Bazzanella (Museo degli Usi e Costumi della Gente Trentina), to the amazing men's garments from Verucchio described by Annemarie Stauffer (Cologne Institute of Conservation Sciences), ancient textiles and their colours were revived. Interdisciplinary approaches were productive, especially regarding the contribution of ancient epigraphy and studies of Roman statues. New evidence for Sabellic textile terminology was presented by Peder Flemestad and Birgit Olsen (University of Copenhagen). Berit Hildebrandt (CTR, University of Copenhagen) guided the audience through the marvellous folds of the cloak demonstrating once again the possibility of investigating textiles in marble sculpture. Textile production in southern Italy was the focus of different papers. Loom weights and identity in archaic Sicily was the main topic of the presentation of Hedvig Landenius Enegren (CTR, University of Copenhagen). Francesco Meo (University of Salento) gave an impressive survey of Salento in Puglia, and especially the potential of a comprehensive, functional, spatial and typological study of thousands of loom weights in their context. Moving from southern to northern Italy, Maria Stella Busana, Anna Rosa Tricomi and Cecilia Rossi (University of Padova) shed light on the archaeology of textiles in Veneto during the Roman period, with a focus on wool production.
Challenging the traditional understanding of spinning and weaving tools among the Etruscans, Romina Laurito presented her ongoing research on the functional aspect of textile tools. Moving from typology to function resulted in a sort of Copernican revolution around spindles, wear and tear traces. These studies introduced the audience to the final part of the workshop focused on "experimental and experience archaeology". The idea of involving experimental archaeology in a scientific workshop is particularly striking, considering especially the potentials of the study of ancient weaving for public engagement. Cristina Lemorini (University of Rome La Sapienza) with contributions by Assunta Perilli and Vanessa Forte presented new analyses and experiments conducted at the Museo delle Origini at Sapienza University of Rome. Ettore Pizzutti and his tablet weaving presented the long tradition of experimental ancient weaving. Finally, Jacopo Tabolli from the Museo Civico Archeologico – Virutale di Narce (MAVNA museum) traced the tradition of weaving linen in Narce and Mazzano Romano and the involvement of this ancient knowledge in the creation of the MAVNA museum as an excellent tool for public engagement.
The colourful cloth woven by the different papers resulted in a well-designed and very successful workshop. It is also worth mentioning here the choice of the organisers to publish the conference proceedings in *Forma Urbis* (*Forma Urbis* XX/9, September 2015), a well-known popular journal. This decision demonstrates that Margarita Gleba and Romina Laurito have grasped the challenge with both hands of reaching and involving the general public in the fascinating word of textile studies: the fabric of life.

Sophie Bergerbrant

Textiles at the European Association of Archaeologists (EAA) Meeting 2015

1-3 September 2015, Glasgow, UK

The annual meeting of the EAA (European Association of Archaeologists) was held this year in Glasgow, UK from 1st-3rd September, and textiles played a central role in the meeting. In fact, the organisers had clearly been thinking in textile terms from the very beginning, with the creation of a special archaeology tartan called "Ancient Gathering". The tartan was specially designed for the meeting and many of the organisers wore it during the conference. The pattern has been registered as the official archaeology tartan, and it was possible to buy various items of merchandise made from it during the conference. One of the conference excursions was also textile-related: the pre-conference excursion 'Science and Conservation' on Tuesday 1st September included a visit to the Centre for Textile Conservation in Glasgow.

The subject of textiles was also well-represented in the programme of academic presentations, including both a session and a round table discussion entirely devoted to research and teaching in this area. The subject also came up in a number of papers in sessions with a non-textile focus. Textiles were definitely well-represented in many sessions.

The first part of the programme with a primary focus on textiles was the session *Global markets and local manufacturing wool production and trade*, on Thursday, 3rd September. It was organised by Idoia Grau Sologestoa, Chiara Corbino and Alessandro Quercia and contained six papers, an introduction and four posters. The posters each had a short, five-minute presentation during the session. The session was organised via MERC (The Medieval Europe Research Committee) and therefore focused on later time periods. In the introduction it was pointed out that certain regions and time periods are much better researched from a textile perspective than others, and this session was a way to bring into focus the period from the Roman era to the early modern era. The presentations discussed textiles from many different perspectives and drawing on different sources, such as textile tools, structures, illustrations, texts and scientific methods. The emphasis was on demonstrating how textiles were an important part of a period's economic strategies as well as how environmental changes may have shifted focuses. It could be said that the session was 'thinking big' when it came to the importance of textiles in prehistory and history.

Thinking big was also one of the points that Penelope Walton Rogers made as first speaker of the roundtable discussion *Integrating textile studies into the mainstream archaeology/anthropology curriculum* via Skype. The round table was organised by Isabella von Holstein and Barbara Klessig. Eleven people gave short presentations about their courses and how textiles could be taught. A keen audience filled the room (Fig. 1). The participants came from many different parts of Europe and the USA, revealing that textile studies are already a part of the curriculum in many universities. The roundtable presentations also showed the great diversity of courses that exist. From hands-on courses in experimenting with copies of prehistoric textiles, to learning to analyse textiles and the use of different methods of analysis available, as well as presenting textile production in a broader social context. I am sure the round table inspired many people to appreciate the variety of ways in which one can teach textiles in archaeology.

Seen from my own perspective it was good to learn about these courses and where they are taught (and perhaps it would be good if the many options were listed and presented on a single website for easy access, so interested students can compare the courses). Especially the idea of 'thinking big' seems useful to me and the importance of teaching textiles to undergraduates so they not only recognise the textile during excavation and conservation, but also understand why textiles are important. After all, textiles were and still are an essential part of many aspects of life. Textiles must be taught as central to our understanding of the past, not only confined to a specialist area, and the majority of students (within science and the humanities) should graduate with a full understanding of their importance.

Textile research was covered in other sessions as well, such as a presentation about using textiles in pottery production by Jasna Vukovic, or a presentation about the health of textile workers from 1200-1860 by Marit van Cant in a session about epidemics, or the paper by Emeline Retournard in the session *Artistic legacies*. These are just a few of the many papers dealing with textiles, textile production or textile workers that were presented at the different sessions at the 2015 annual EAA meeting. This shows how textile studies are becoming well integrated into both archaeology and history. After looking at this year's EAA programme it is difficult to argue that textiles are an overlooked material in research. It shows that recent research in textiles has been very active and successful, and the discipline is in the process of becoming a focal point in mainstream archaeology. I can only hope textile research in all its facets and permutations will be equally well represented next year, and the year after, and that it continues to weave its way into diverse areas of research, as at the 2015 EAA conference.

Recent publications

***Aspects of the Design, Production and Use of Textiles and Clothing from the Bronze Age to the Early Modern Era. NESAT XII. The North European Symposium for Archaeological Textiles, 21st-24th May 2014 in Hallstatt, Austria* (2015) edited by Karina Grömer and Frances Pritchard. Archaeolingua Main Series 33. Budapest: Archaeolingua Publishers.**
ISBN: 978-963-9911-67-3
Price: € 64
http://www.archaeolingua.hu/ordering.html

***Body, Dress, and Identity in Ancient Greece* (2015) by Mireille M. Lee. Cambridge: Cambridge University Press.**
ISBN: 9781107055360
Price: £ 65
http://www.cambridge.org/tr/academic/subjects/classical-studies/classical-art-and-architecture/body-dress-and-identity-ancient-greece?format=HB

***Das Bild vom Kind im Spiegel seiner Kleidung. Von prähistorischer Zeit bis zur Gegenwart* (2015) edited by Annette Paetz gen. Schieck and Isa Fleischmann-Heck. Regensburg: Schnell und Steiner.**
ISBN: 978-3-7954-3021-4
Preis: € 34.95
http://www.schnell-und-steiner.de/artikel_8569.ahtml

***Die frühbyzantinischen Textilien des Römisch-Germanischen Zentralmuseums* (2015) by Petra Linscheid. Monographien des Römisch-Germanischen Zentralmuseums 48, Mainz: Verlag des RGZM.**
ISBN: 978-3-7954-3037-5
Price: € 55
http://www.schnell-und-steiner.de/artikel_8557.ahtml

***Drei Schnittbücher: Three Austrian Master Tailor Books of the 16th Century* (2015) by Katherine Barich and Marion McNealy. Kennewick: Nadel und Faden Press.**
ISBN: 978-0692472453
Price: € 77.04
http://www.amazon.de/Drei-Schnittbucher-Austrian-Master-Century/dp/0692472452

***Gerüstlöcher als Tresore für archäologische Textilen. Fori pontai come casseforti di stoffe archeologiche* (2015) by Beatrix Nutz, Irene Tomedi, Armin Torggler and Penelope W. Rogers. Schriftenreihe Landesmuseum Schloss Tirol, Heft 6. Innsbruck.**
ISBN 978-88-95523-01-9
Price: € 20
http://www.uibk.ac.at/urgeschichte/publikationen/sonstige.html

Global Textile Encounters **(2014) edited by Marie-Louise Nosch, Zhao Feng and Lotika Varadarajan. Ancient Textiles Series Vol. 20, Oxford: Oxbow Books.**
http://www.oxbowbooks.com/oxbow/global-textile-encounters.html

Helenas Töchter. Frauen und Mode im frühen Griechenland. Die Geschichte der europäischen Mode reicht bis weit in die Antike zurück **(2015) by Klaus Junker and Sina Tauchert. Sonderbände der Antiken Welt. Mainz: Verlag Philipp von Zabern.**
ISBN 978-3-8053-4858-4
Price: € 29.95
https://www.zabern.de/buch/Helenas_Toechter/24651

… hexen und blaufärben. Textildruck in Tirol **(2015) by Beatrix Nutz. Innsbruck: Universitätsbuchhandlung Golf Verlag.**
ISBN 978-3-900773-95-6
Price: € 38
http://www.durst.it/index.php/corporate_citizenship/publications; ur-fruehgeschichte@uibk.ac.at

Medieval Clothing and Textiles 10 **(2014) edited by Robin Netherton and Gale R. Owen-Crocker. Woodbridge: Boydell Press.**
ISBN: 9781843839071
Price: £ 35
http://www.boydellandbrewer.com/store/viewItem.asp?idProduct=14454

Medieval Clothing and Textiles 11 **(2015) edited by Robin Netherton and Gale R. Owen-Crocker. Woodbridge: Boydell Press.**
ISSN 1744-5787
Price: £ 35
http://www.boydellandbrewer.com/store/viewItem.asp?idProduct=14693

Medieval Dress and Textiles in Britain **(2014) edited by Louise M. Sylvester, Mark C. Chambers and R. Owen-Crocker. Woodbridge: Boydell Press.**
ISBN: 9781843839323
Price: **£** 60
http://www.boydellandbrewer.com/store/viewItem.asp?idProduct=14538

Neolithische und bronzezeitliche Gewebe und Geflechte. Die Funde aus den Seeufersiedlungen im Kanton Zürich **(2015) by Antoinette Rast-Eicher and Anne Dietrich. Monographien der Kantonsarchäologie Zürich 46. Zürich.**
ISBN: 978-3-906299-00-6
Price: 65 CHF
http://www.are.zh.ch/internet/baudirektion/are/de/archaeologie/archaeologie/

PURPUREAE VESTES IV. Production and Trade of Textiles and Dyes in the Roman Empire and Neighbouring Regions **(2014) edited by Carmen Alfaro, Michael Tellenbach and Jonatan Ortiz. Valencia: Publications Universitat de Valencia.**
ISBN: 978-84-370-9183-9
Price: € 35
http://puv.uv.es/product_info.php?cPath=21_25_8590_9659&products_guage=es&osCsid=9ced9c9f560be8e74e2ffaf763c9e862
To purchase the book, please send an email to: m.juliamartinezgarcia@gmail.com

Textile Trading and Distribution in Antiquity - Textilhandel und -distribution in der Antike **(2014) by Kerstin Droß-Krüpe. Philippika XII. Wiesbaden: Harrassowitz.**
ISBN-10: 3447102209
ISBN-13: 978-3447102209
Price: € 48
http://www.harrassowitz-verlag.de/search.ahtml?act=suchen&reqid=1447200946&referenzart=ISBN&stichwort=&autor=Dro%DF-Kr%FCpe&isbn=

The First Book of Fashion. The Book of Clothes of Matthaeus and Veit Konrad Schwarz of Augsburg **(2015) by Ulinka Rublck and Maria Hayward. London-New York: Bloomsbury Academic.**
ISBN: 9780857857682
Price: **£** 27
http://bloomsbury.com/uk/the-first-book-of-fashion-9780857857682/?utm_source=Adestra&utm_medium=email&utm_content=More%20info%20%C2%BB&utm_campaign=NL-CT_Fashion%20History%20%2B%202016%20cat_NOV15_UK/

Tools, Textiles and Contexts: Textile Production in the Aegean and Eastern Mediterranean Bronze Age **(2015) edited by Eva Andersson Strand and Marie-Louise Nosch. Ancient Textiles Series Vol. 21, Oxford: Oxbow Books.**
ISBN: 9781842174722
Price: **£** 48
http://www.oxbowbooks.com/oxbow/tools-textiles-context.html

Unwrapping Ancient Egypt: The Shroud, the Secret and the Sacred **(2014) by Christina Riggs. London: Bloomsbury Academic.**
ISBN-13: 978-0857855077
ISBN-10: 0857855077
Price: $ 34
http://www.amazon.com/Unwrapping-Ancient-Egypt-Shroud-Secret/dp/0857855077/ref=sr_1_39?s=books&ie=UTF8&qid=1447182648&sr=1-39&keywords=Costume+archaeology

Wrapping and Unwrapping Material Culture: Archaeological and Anthropological Perspectives **(2014) edited by Susanna Harris and Laurence Douny. Walnut Creek: Left Coast Press.**
Price: $ 79
ISBN: 978-1-61132-887-5
https://www.lcoastpress.com/book.php?id=498

Websites

Distinguishing between Different Plant Fibres: A Video on How to Perform the Modified Herzog Test

H. Gardner and B. Holst

In archaeology it is important to be able to identify fibres. Animal fibres have scales and so can be easily distinguished from plant fibres using a white light optical microscope. However, it is not possible to distinguish between fibres of different plant species using this method. Instead, the modified Herzog test can be used in some cases. For example, the Herzog test can be used to distinguish between flax, hemp and cotton, provided you know that your fibre must be one of those three materials. The test can be carried out on very small fibre samples, even less than a mm long.

The modified Herzog test has been known for many years, but it had not been 'proven' how it works and why it sometimes does not give a result. In a recent paper, we explained why the Herzog test sometimes does not work and showed why, if you get a result, you can always be sure that it is the correct one (Haugan and Holst 2013).

As a supplement to this paper we have now made a video, which explains step by step how to carry out the modified Herzog test using a standard polarisation microscope. The video is accessible on Youtube. We hope it will inspire more textile archaeologists and conservators to use this test in their work.
The video can be found at the following link:
www.youtube.com/watch?v=sC9GlUKjBDE&feature=youtu.be

Haugan, E. and Holst, B. (2013) Determining the fibrillar orientation of bast fibres with polarized light microscopy: the modified Herzog test (red plate rest) explained. *Journal of Microscopy* 252, 159-168.

PhDs

Cecilie Brøns was awarded a PhD in Classical Archaeology by the SAXO Institute at the University of Copenhagen, Denmark for her dissertation "Gods and Garments. Textiles in Greek Sanctuaries in the 7th-1st Centuries BC".

Luise Ørsted Brand was awarded a PhD in Prehistoric Archaeology by the SAXO Institute at the University of Copenhagen, Denmark for her dissertation "Species Identification of Skins and Development of Sheep Wool. An Interdisciplinary Study Combining Textile Research, Archaeology, and Biomolecular Methods".

Lasse Sørensen was awarded a PhD in Prehistoric Archaeology by the SAXO Institute at the University of Copenhagen, Denmark for his dissertation "From Hunter to Farmer in Northern Europe. Migration and Adaptation during the Neolithic and Bronze Age".

Sophia Vakirtzi was awarded a PhD by the University of Crete for her dissertation "Η νηματουργία στο Αιγαίο κατά την Εποχή του Χαλκού μέσω της παρουσίας των σφονδυλιών στις αρχαιολογικές θέσεις : μελέτη της τυπολογίας, των λειτουργικών δυνατοτήτων και της διασποράς των εξαρτημάτων του αδραχτιού που βρέθηκαν σε οικισμούς και νεκροταφεία" (Yarn production in the Bronze Age Aegean: a study of typology, functionality and distribution of spindle-whorls found at settlements and cemeteries).

John Peter Wild and Penelope Walton Rogers

Obituary, Michael Ryder (1927-2015)

The announcement that Dr Michael Lawson Ryder had died on 6th February 2015 at the age of 87 brought an immediate and deep sense of loss to the whole archaeological textile community, to whom he was an almost legendary figure. Few textile archaeologists will not have been familiar with his work, or not have consulted his magnum opus *Sheep and Man* (Duckworth 1983, reprinted 2007) – a veritable encyclopaedia on that topic, but written by one man. Moreover, away from the printed page, he was a fount of knowledge about sheep, their characteristics and history, and he was always happy to tackle questions on the topic from any quarter.

Ryder was the first to realise that the method of wool fibre diameter measurement practised at the Wool Industries Research Association in Leeds for modern industrial applications could also be applied to archaeological wool fibres and yarns, wherever they survived and however old. At the core of his research was a histogram based on 100 fibre diameter measurements from a single yarn. Multiple sampling and comparison with recent data enabled him to argue that ancient raw wool and textile yarns reflected and could be attributed to a spectrum of fleece types, from 'true hairy' to 'true fine'. In due course he made a number of adjustments to his scheme; and others following in his footsteps have added their own modifications.

Michael L. Ryder MSc PhD CBiol FIBiol FSA Scot was a Yorkshireman from Leeds by birth, upbringing, education, accent and attitude – and it was entirely natural that he should become an authority on Yorkshire's premier product, wool. After graduating from Leeds University as an animal biologist, he worked at the Wool Industries Research Association alongside colleagues such as Harry Appleyard who were a formative influence upon him. Nevertheless, for his first academic job he migrated to the University of Armidale, New England, in Australia – another famous wool centre – where he was appointed Senior Lecturer in Livestock Husbandry. But Michael and his first wife Mary did not find Armidale congenial, and they returned when Michael obtained a research post in the Animal Breeding Research Organisation at Roslin near Edinburgh (now the Roslin Institute of the University of Edinburgh). There he met Audrey Henshall in the National Museum of Antiquities of Scotland, and it was through Audrey that I (JPW) first got to know him: as a research student, he opened up for me an exciting new window on Roman wool textiles.

In the late 50s Michael's vast output of publications on sheep, wool and 1001 related topics was just beginning, and never abated (for a bibliography see www.aslab.co.uk/bibliography/ryder-bibliography/). While his textbook *Wool Growth* (1968, with S. K. Stephenson) was a landmark in livestock studies, he tackled with aplomb some of the key historical issues, memorably the identification of the 'wool' fibres from Neolithic Çatal Höyük as flax (1965), the origin of spinning (1968), and the need to preserve rare breeds of farm animals (1970, 1976). Beyond his strictly scientific papers he published numerous popular accounts of aspects of his work, including a handbook for archaeologists on bone identification and for spinners, weavers and dyers on sheep and wool. He travelled widely to inspect primitive and obscure sheep breeds: he had visited (he once said) every country for which the British Council would give him a travel grant.

Michael regularly demonstrated and taught his techniques of fibre diameter measurement, using a (WIRA-approved) x500 projection microscope. Michael insisted that apprentices should first analyse his standard samples, to check the accuracy of their work, and their microscopes, and to ensure that their results would be compatible with his own – a wise precaution. Penelope Walton Rogers was amongst those to exchange samples and data, and to benefit from his visits in the 1980s and 1990s.

Later in his career, when the existence of the Animal Breeding Research Organisation was under threat, he fought hard for its survival in the form in which he knew it. On retirement to Southampton, he revisited his childhood love of the Yorkshire Dales and their sheep (Thomas and Michael Ryder, *My Ramblings in Wharfedale* (2002)); but he remained happy to be interrogated on ovine matters. To claim that his death marks the end of an era is not a cliché: it is a sad fact.

General Information

Guidelines to Authors
The ATN aims to provide a source of information relating to all aspects of archaeological textiles. Archaeological textiles from both prehistoric and historic periods and from all parts of the world are covered in the ATN's range of interests.

1. Contributions can be in English, German or French.

2. Contribution may include accounts of work in progress. This general category includes research/activities related to archaeological textiles from recent excavations or in museums/galleries. Projects may encompass technology and analysis, experimental archaeology, documentation, exhibition, conservation and storage. These contributions can be in the form of notes or longer feature articles.

3. Contributions may include announcements and reviews of exhibitions, seminars, conferences, special courses and lectures, information relating to current projects and any queries concerning the study of archaeological textiles. Bibliographical information on new books and articles is particularly welcome.

4. References should be in the Harvard System (e.g. Smith 2007, 56), with bibliography at the end (see previous issues). No footnotes or endnotes.

5. All submissions are to be made in electronic text file format (preferably Microsoft Word) and are to be sent electronically or by mail (a CD-ROM).

6. Illustrations should be electronic (digital images or scanned copies at 600dpi resolution or higher). Preferred format is TIFF. Illustrations should be sent as separate files and not imbedded in text.
Colour images are welcome.

7. All contributions are peer-reviewed by the members of scientific committee.

8. The Editors reserve the right to suggest alterations in the wording of manuscripts sent for publication.

Please submit contributions by post to:
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