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Assemblage of Wool and Silk Textiles from Medieval Waste Layers in Prague, Czech Republic

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Abstract
The article summarises information on a large assemblage of medieval wool and silk textiles found during an archaeological excavation of waste layers from the fourteenth and fifteenth centuries in the centre of Prague. The work primarily presents wool cloths (fulled fabrics) and fabrics (without fulling) in plain and twill weave, which make up the vast majority of the more than 1,500 fragments. The silk textiles presented are interesting evidence of the presence of expensive imported goods in the Bohemian environment. The results, based mainly on textile technology studies of the fabrics, are also supplemented with information acquired during analyses of their current and original colour, including an identification of dyeing sources.

Key words: *archaeological textiles, Middle Ages, Prague, waste layers, dyeing analyses.*

Introduction

The historical development of textile production ranks among the important topics that directly concern the everyday life of human society. Thanks to the large number of both written and iconographic medieval historical sources capturing the craft itself, as well as methods of use, terminology and even prices, there is a relatively good understanding of the structure, organisation and method of the functioning of the textile craft in the medieval economy. Archaeological textile finds represent a specific category of sources whose value lies mainly in the number of direct contacts with products of medieval spinners, cloth makers, weavers, dyers and tailors. Thanks to the use of a broad spectrum of archaeometric and chemical analyses, it is possible to investigate in detail production technology, methods of craft processing and even details of individual products, facilitating deeper insight into the quality level of the craft at the time [1, 2]. The detailed investigation of the larger assemblage of late medieval textiles of more than 1,500 fragments therefore enables a detailed view of the spectrum of commonly used fabrics in the Prague agglomeration at the time [3, 4].

The study of archaeological textiles faces many pitfalls, especially in the early phases during the archaeological excavations and the removal of organic finds from the ground, their demanding restoration, and primarily measures for long-term storage. The textile assemblage from Prague's New Town comes from rescue archaeological excavations of inflow collector shafts, conducted by the National Heritage Institute in 2004-2008 (Vodičkova, Jungmannova and Školská streets). The thick dump layers from the fourteenth and fifteenth centuries investigated at these sites yielded a large number of organic finds, including textiles, leather and wood. Following the demanding phase of the actual excavation, during which it was necessary to deal with large quantities of finds of an organic nature, and their immediate treatment and deposition in order to prevent their deterioration, the textile fragments underwent professional conservation work and were properly stored (***Figure 1***). The fast and constructive cooperation between the head of the excavation M. Selmi Wallisová, the investor in the construction project necessitating the archaeological investigation, and textile restorer V. Otavská resulted in the rescue of a remarkable collection of medieval non-burial waste textiles related to the development of Prague's newly-founded New Town by Emperor Charles IV. The assemblage is completely unique in the Bohemian environment for its size and diversity.

The textile assemblage underwent a professional study and evaluation in 2014-2016 [5]. The study employed the full range of analytical methods focussed primarily on the textile technology parameters of individual types of textiles and on dyeing sources. The result is a detailed description of textile techniques used and the dyeing craft which, thanks to the size and diversity of the assemblage studied, can be generalised for a deeper understanding of both the production of high medieval textile, and especially cloth workshops, as well as apparel and non-apparel textiles commonly used among the population at the time.

The entire processed assemblage is composed of 1,593 fragments from 921 different types of textiles. These include woven products (88%), unwoven products such as felt and thread (7%), and unprocessed animal fibres (4%) whose connection to textile production is not clear. From the perspective of material representation in the assemblage, sheep wool clearly dominates (91%); appearing far less often are silk (4%) and other animal fibres, while the remnants of plant fibres make up a negligible part (1%). The ratio of material represented clearly does not reflect that of individual textile raw materials used in the Middle Ages. The nearly absent products from plant fibres had definite uses, determined by the characteristics of this type of material that could not be met by other textile materials (e.g. light weight, permeability, absorbability). The sharp disparity between animal (wool) and plant fibres in the archaeological material is simply the result of the different durability of cellulose fibres in soil and does not indicate preferences for a certain group of textiles. Silk fibres, which were also preserved in far fewer numbers than wool, represent a specific phenomenon tied primarily to more luxury and less available goods not produced locally and which were probably used to express social standing. Their greater use in everyday life cannot be assumed in the urban environment.

Therefore wool fabrics and fulled cloth are a representative sample enabling a more detailed evaluation and comparison, naturally with the understanding

Figure 1. *Wood panel with a countersunk bed for individual textile fragments. Photo: Z. Kačerová.*

that they make up only part of the textile products from the period. As a result of the unfavourable conditions for preservation of plant fibres, a detailed understanding of the remaining part is not possible.

Methods

Textile technology study

A key part of the professional processing of archaeological textile fragments is a textile technology study of each fragment preserved, including a technological analysis and detailed documentation. An integral part of the textile technology study is the determination, description and measuring of the following parameters: the state of preservation, the type of textile, the number and dimensions of fragments, colour, textile raw material, weave, hem, thread count, direction of thread twist, thread thickness, patterning and tailoring details, and interpretations. Optical and electron microscopy was used for textile technology study.

Dye analysis

The original colour was determinated by liquid chromatography with mass spectrometry. After being collected, 1-5 mg of fibres were placed in a 1.4 ml PE vial tube and covered with 400 µl of the extraction mixture (methanol: dichloromethane: formic acid; in a volume ratio of 17:17:6). The extraction occurred by submersing the vial tube in a ultrasonic water bath for 30 minutes at 40 kHz and at a temperature of 60 °C.

Prior to the actual measurement with a mass detector, the analytes were separated on a heated column (35 °C) of Hypersil Gold C18 (50 x 2.1 mm) with a particle size of 1.9 µm in reversed phase. A linear gradient elution was used to separate the dyes before being placed in the mass spectrometer. The mobile phase was made up of component A: H_2O with 0.1% HCOOH, and B: MeOH with 0.1% HCOOH. A linear gradient elution was used to separate samples: 0 min. → 3 min. 50% A and 50% B → 5% A, 95% B, 3 min. → 5 min. 5% A and 95% B, 7 min. → 10 min. 50% A and 50% B, with a mobile phase flow rate of 250 µl/min. The analytes were ionised with a heated electrospray (270 °C) in the negative and positive mode, and the resulting molecular ions: $[M-H]^-$ and $[M+H]^+$ were detected by Orbitrap Velos (Thermo Fisher Scientific, Germany). The chromatograms of the total ion current (TIC) were converted to reconstructed chromatograms (RIC), focusing on the monoisotopic mass ions of individual analytes calculated [6-10].

Wool textiles

The main part of the textile assemblage studied is comprised of wool fabrics (***Figure 2.a***) woven from warp and weft threads on a loom, among which 772 various types of wool fabrics were identified (***Figure 3***). The largest group of wool fabrics is composed of cloth with a plain weave (430 types; 56%), followed by cloth with a 2/1 twill weave (153 types, 20%), unfulled fabrics with a plain weave (103 types, 13%), unfulled fabrics with a 2/1 twill weave (65 types, 8%), fabrics in a 2/2 twill weave (9 types, 1%), cloth with a 2/2 twill weave (4 types, 1%) and finally band (8 types, 1%). Side selvedges occur on 87 fragments and, based on their production method, six different types were differentiated in various combinations of plied or multiple selvedge warp threads. Selvedges are very often preserved in the form of narrow strips trimmed from the original fabric, which certainly had numerous practical applications (***Figure 2.b***).

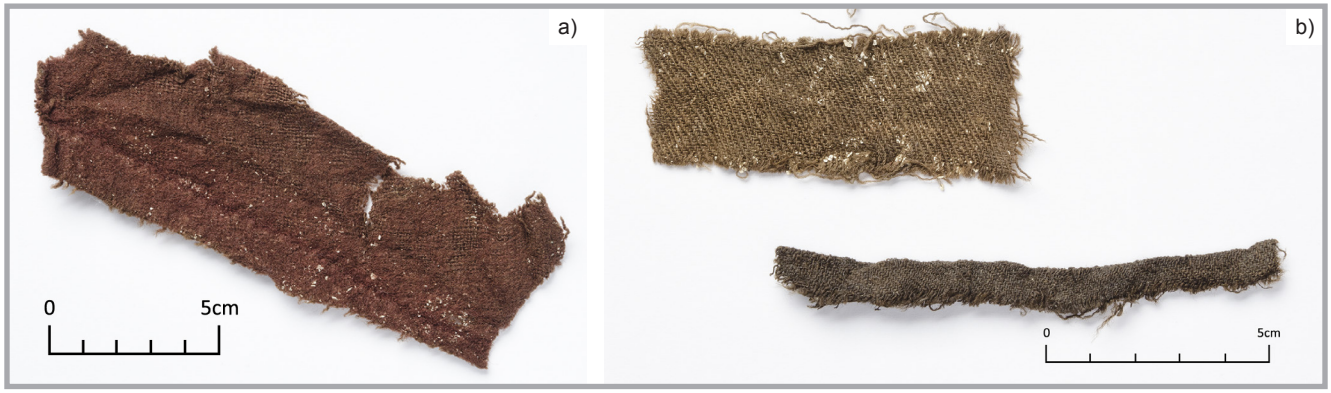

Figure 2. *Wool fabrics: a) cloth with a plain weave, b) 2/2 twill with worsted fibres. Photo: Z. Kačerová.*

Threads with a Z twist and S twist dominate plain weave cloth, and according to preserved side selvedges, threads with a Z twist always form the warp and threads with an S twist in the weft. The assemblage is qualitatively dominated by cloth in medium (11-15 warp threads per 10 mm) and coarse (up to 10 warp threads per 10 mm) quality, while representation in finer categories (16-20 and over 20 warp threads per 10 mm) is relatively low; the ratio of thread counts in the warp and weft is typically nearly the same (***Figure 4***). The thickness of warp and weft threads was most often in the range of 0.4-0.55 mm, and a comparison of thread counts and thread thickness showed that as the thread count decreased, the thread thickness increased, and vice-versa.

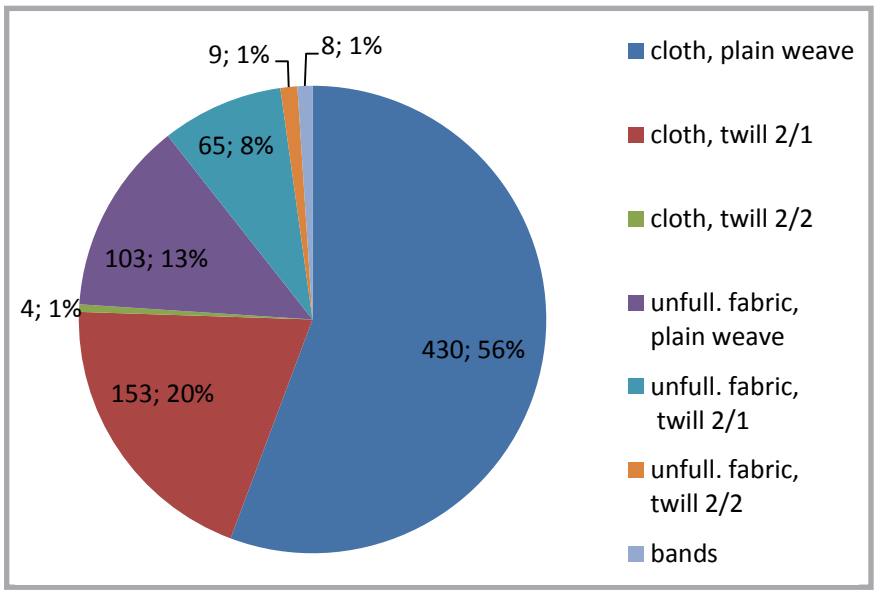

Figure 3. *Total number of cloths and unfulled fabrics.*

A twill weave appeared on cloth in two variants – in three-end and four-end versions. Opposite twists completely dominate 2/1 twill weaves – a Z twist in the warp, and an S twist in the weft. The vast majority of this type of cloth belongs to the coarse quality category, with the warp thread count exceeding or equal to the weft thread count. Thread thickness here reached relatively high values – 0.6-0.75 mm in the warp and 1-1.45 mm in weft. Represented in only four cases, 2/2 twill cloth showed an identical use of opposite twists in the warp and weft, although according to the thread count, it ranged qualitatively from the coarse to fine category, which is also indicated by the thread thickness.

Unfulled fabric in a plain weave was heavily dominated by a combination of a Z twist in the warp and S twist in the weft. Fabric of medium and coarse quality appeared most often and had an equal or higher thread count in the warp (***Figure 5***). Thread thickness with both twists most often ranged from 0.4-0.55 and 0.6-0.75 mm, and the general trend of thicker threads associated with lower thread counts and vice-versa was again observed.

Unfulled fabric in a 2/1 twill weave most often has a combination of opposite twists, and the majority belong to the category of coarse textiles; the occurrence of medium and fine thread counts is rare. Even in this group thread count values in the warp and weft are even or the number of warp threads is higher; the thickness of threads with a Z twist was in the 0.6-0.95 mm range, whereas that of opposite threads was in the 1-1.45 mm range.

Fabrics with a 2/2 twill weave make up the most diverse group. Twists were dominated by a combination of identical Z twists in both the warp and weft, and thread counts were also higher in the category of very fine fabrics, which is also indicated by thinner threads. This group also included three fabrics whose textile parameters could be proof of higher quality imported goods (***Figure 2.b***).

The group of wool fabrics also contains thin bands with preserved side selvedges, i.e. the original width of the product woven on a tablet loom. A total of seven finds of this type were identified in

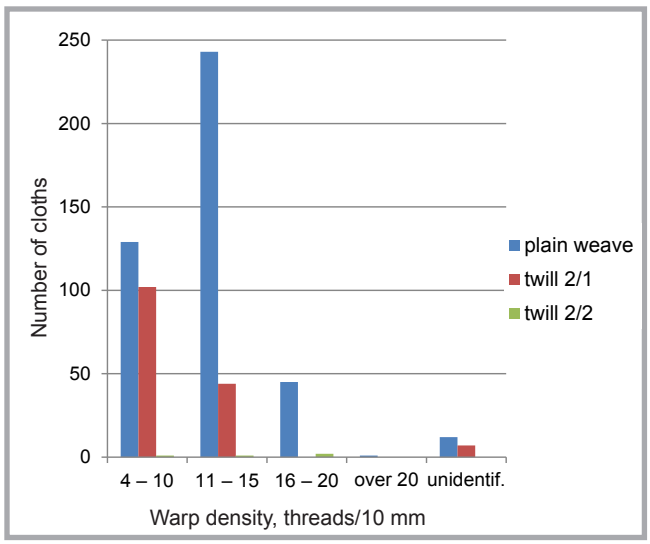

Figure 4. *Cloths – warp density.*

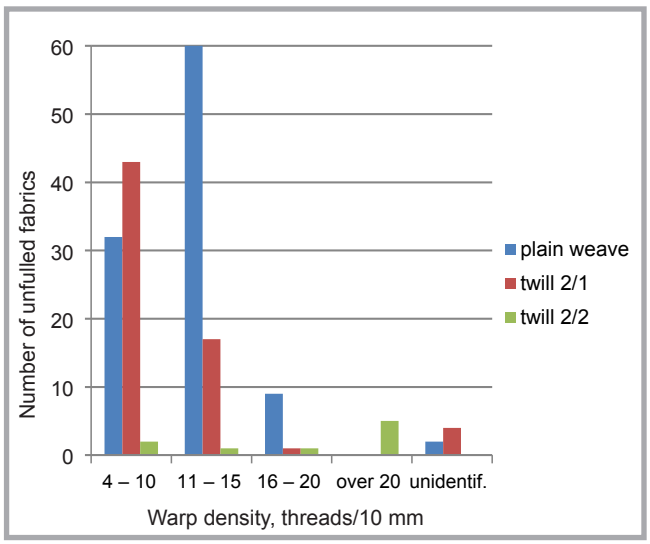

Figure 5. *Unfulled fabrics – warp density.*

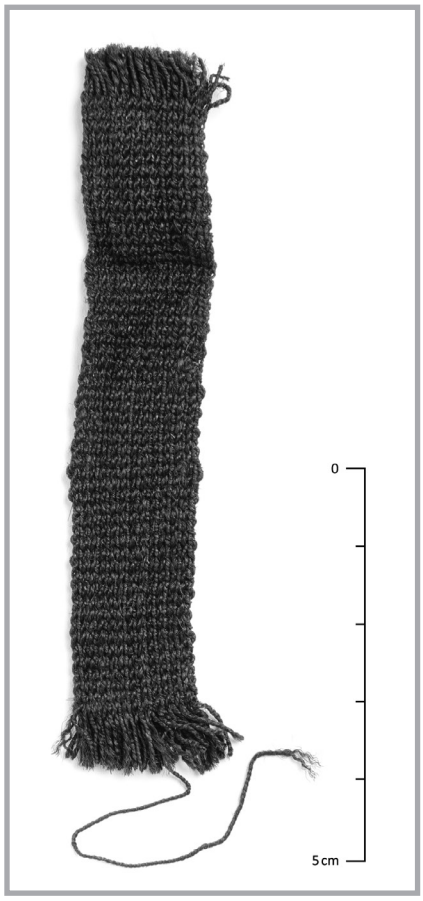

Figure 6. *Tablet loom band. Photo: Z. Kačerová.*

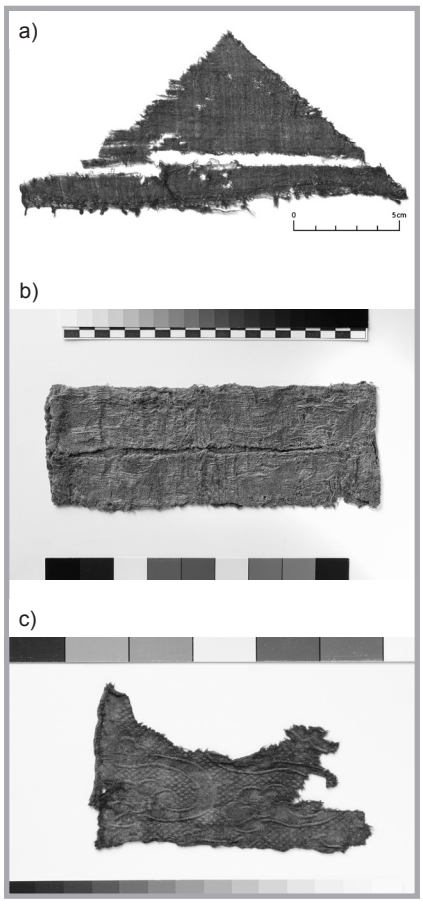

Figure 7. *Silk fabrics: a) plain weave, b) weft-faced compound twill, c) damask. Photo: Z. Kačerová.*

the assemblage, and they all share similar parameters: a width of 10-22 mm, twisted warp and weft threads, a thread count of 32-48 warp threads, and 7-15 weft threads per 10 mm. Remnants of the original coloured geometric pattern could be distinguished on only two specimens (***Figure 6***).

The study of wool textiles provided a great deal of information on the method and variants of their production. As a domestic origin can be assumed for a vast majority of them, they represent the spectrum of textiles produced by local cloth-making and weaving workshops. However, a more precise determination of the production location, an identification with manufacturing centres known from written sources or even a specification of the origin of the raw materials used in the production, is not possible with the current inventory of finds and analyses available. A certain group of possibly imported goods from an area with more advanced textile production was identified on the basis of textile parameters and determined dyes. This primarily concerns three textiles in a 2/2 twill weave made from brushed fibres, a group of scarlet cloths and fabrics, the colour source of which was determined by dye analysis as scarlet worm.

The general description of wool fabrics from the Prague assemblage with a predominant share of fulled cloth, an absolute predominance of plain weave, a full predominance of a combination of opposite twists in the warp and weft, and a prevailing thread count of 10-20 threads per 10 mm corresponds to data from the analysis of similar assemblages from European urban sites, the majority of which also come from waste layers. Based on a comparison with these data, it is possible to regard the assemblage as a reflection of the mass textile production of specialised workshops, the basic elements of which were highly similar throughout the European continent. Given the occurrence of specific elements (button holes, trims, pleating) and their parallels, it is possible to date the wool textiles described to the period between the second half of the fourteenth century and the first half of the fifteenth century, which is consistent with the archaeological evaluation of the waste layers investigated and interpretation of radiocarbon dating analyses.

Silk textiles

Silk textiles, unlike wool products and clearly of imported origin, occur as 35 various types in the assemblage studied. The majority of the specimens are monochrome fabric in a plain weave and without a pattern, which can be linked to the simplest and probably the most commonly available silk production (***Figure 7.a***). Due to the absence of patterning, one of the most important qualities, it is not possible to precisely determine the date or origin of these fabrics. All that is certain is that they were not made locally, since silk was not processed in Bohemian textile workshops and all silk textiles represented imported goods [11].

The most interesting and valuable silk fabrics are three types of weft-faced compound twill, three types of damask, two types of five-end satin weave and two bands made from metal threads. According to available parallels [12, 13], weft-faced compound twill with metal threads (silver-plated and gold-plated animal membranes wound around an inner core of plant fibres) with preserved parts of a pattern with sitting lions, with birds and with basilisks (***Figure 7.b***), or with geometrically arranged rosettes and small crosses dates to the end of the thirteenth century and is attributed to Spanish silk production [14]. A highly surprising find involved three fragments of monochrome damask with a vegetal pattern, which were, also based on parallel textiles [15], interpreted as Chinese imports from the fourteenth century (***Figure 7.c***). These were the first fabrics from an archaeological context in the Bohemian environment that could come directly from the cradle of silk production – China. Fabrics of these types have not appeared thus far in any other assemblage, not even in a burial one [16]. Textiles with a more complicated weave are supplemented by representatives of a five-end satin weave without preserved patterning, which also come from one of the silk centres, probably from southern or western Europe. Two narrow bands made of metal threads in a plain weave are also luxury goods. Warp, and in one case even weft, threads were composed of a silk core wound with a flat and narrow solid-metal strip. Analyses indicate that the appearance of these bands with a surface featuring a large

number of gold-plated silver threads must have been highly decorative.

Silk textiles from the waste layers of Prague's New Town represent the largest non-burial assemblage of medieval silk fabrics found in Bohemia and Moravia. The main benefit of their professional processing and interpretation is the identification of unique evidence of Chinese silk in the Bohemian environment, a deeper awareness of imports of silk textiles from Spain to Bohemia, and further proof of the availability of luxury goods to the urban population. Silk has always been a luxury good, the ownership of which is a reflection of a certain degree of wealth and social standing; this type of textile was by no means affordable for everyone. The largest collection of silk textiles, including expensive patterned fabric, found in waste layers most probably produced by burghers and craftsmen from the surrounding area therefore provides an interesting view of the textiles owned by these classes of society. It is necessary to bear in mind that the waste investigated could also have been produced by residents of more distant locations, including Church institutions, where the assumption of the use of silk textiles is high. It is also not possible to rule out the secondary and subsequent use of expensive fabrics, which could have been the subject of gifts, dowries or inheritances, been used or collected over a longer period, and their ownership may also have been transferred among individual classes of society. The weft-faced compound twills discovered could be consistent with this assumption, as its dating to the end of the thirteenth century or beginning of the fourteenth century is significantly older than the other components of the textile assemblage.

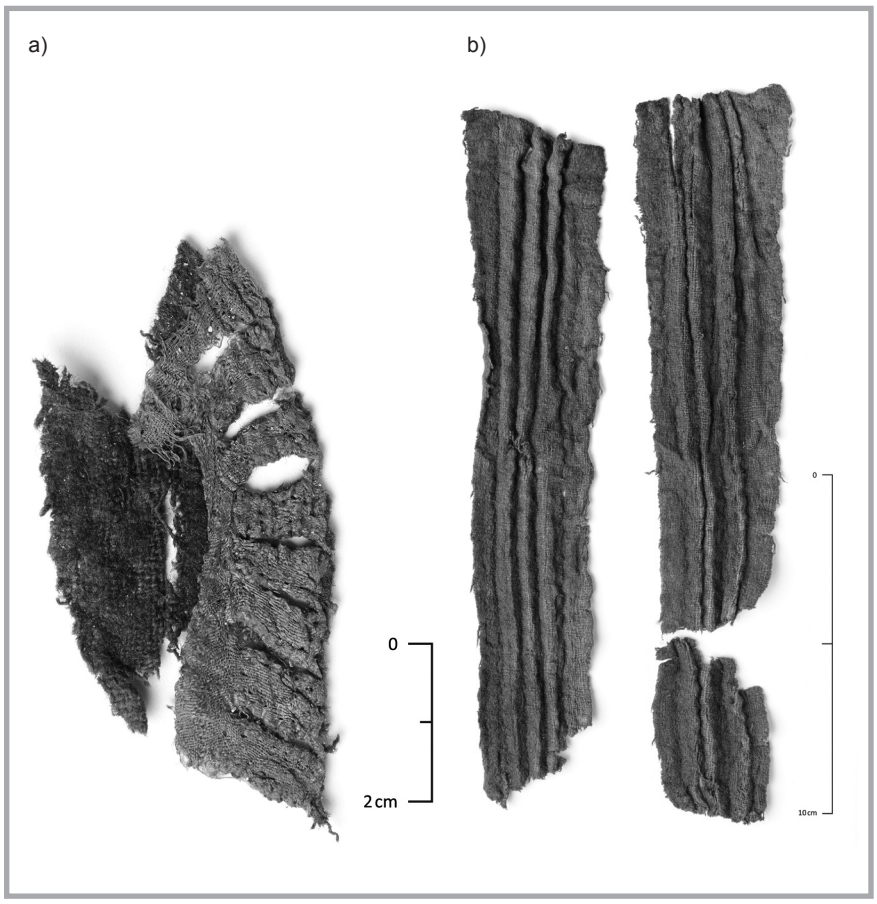

Figure 8. *Wool fabric: a) with silk-padded buttonholes, b) cloth with remains of pleating. Photo: Z. Kačerová.*

Textiles made from plant materials and other animal fibres

Information on the appearance and working of textiles made from plant fibres is negligible, as material of this nature appears among archaeological finds only rarely. Indirect evidence of the use of plant fibres are mixed fabrics, part of which were originally composed of plant threads that have, naturally, completely disintegrated, leaving gaps in the remaining wool structure. Also relatively well documented is the use of sewing thread made of plant fibres, even if their preserved remains are so degraded and fragmented that an identification of the plant species is impossible. Various cords and ropes were also made of plant fibres; their state of preservation is also highly fragmentary. The processed New Town assemblage contained remnants of plant fibres identified on one specimen of fabric, on four mixed fabrics, on more than 80 minute remains of sewing thread, and on nine ropes.

Felt from sheep, lamb and kid wool makes up a specific group of textile products represented in the assemblage by 30 different types differing in colour, thickness and the degree of felting. Also interesting is the occurrence of textile products (bands) made from horsehair, which documents the practical use of this uncommon textile material.

Tailoring

The greatest benefit from the study of archaeological textiles is the possibility to learn about their production technology and details of their working. Although a large number of historical sources speak volumes on the overall appearance and changes in garments, they contain no information on textile or tailoring details documenting their actual production. Despite the heavily fragmented condition and lack of preservation of larger pieces of clothing, archaeological textiles are a unique source of information. Evidence of the work of tailors who transformed the fabric into specific products is preserved in the studied assemblage on many fragments. This most often involves the remains of stitches and seams, identified in nearly one hundred cases. The absolute majority of these concern the remains of stitches from thread made of plant materials in the form of minute remnants of threads, needle punctures or imprints from the original stitches in the structure of the fabric. Also documented is stitching using silk and wool thread. The range of stitches employed is relatively broad and includes running stitching, overcast stitching, blanket stitching, hem stitching, and buttonhole stitching. The preservation of entire seams joining two pieces of fabric together is relatively rare and could only be studied on ten specimens. It was interesting to study the

***Table 1**. Present colour of wool textiles.*

Present colour	Cloths			Unfulled fabrics			Bands	Plyed threads	Felt	Unidentif	Total
	Plain weave	2/1 twill	2/2 twill	Plain weave	2/1 twill	2/2 twill					
Crimson	22			3							25
Russet	116	11		18	1						146
Dark red	25	2		18	1					1	47
Brown	110	25		29	14	2		3	3	3	189
Light brown	83	19	2	18	9	3		2	2		138
Dark brown	40	41	2	9	17	2		4	12	2	129
Grey	21	49		5	19	2		2	5	1	104
Black	13	6		3	4		8	17	8	1	60
Total	430	153	4	103	65	9	8	28	30	8	838

manner in which the selvedges of individual fragments were treated, as this played an important role in preventing the unravelling of the fabrics. Preserved on more than 200 fragments are the remains of folds of various widths lining one or more hems of the fragments; therefore undoubtedly representing the remains of a tailor's finishing of individual garment pattern segments.

***Table 2**. Identified dyeing sources.*

Natural sources	Count
Total amount of samples	**172**
Not detected	**27**
One natural source	**64**
Coccid	7
Madder	31
Brazil wood	5
Woad	5
Tannins	7
Weld	8
Persian berries	1
Double combination	**60**
Madder, woad	19
Madder, weld	12
Coddid, madder	9
Madder, tannins	4
Woad, tannins	6
Brazil wood, weld	4
Coccid, woad	3
Brazil wood, tannins	2
Brazil wood, woad	1
Triple combination	**19**
Madder, woad, tannins	7
Madder, woad, weld	3
Madder, tannins, weld	2
Coccid, madder, weld	2
Coccid, woad, weld	2
Woad, tannins, weld	2
Coccid, woad, tannins	1
Quadruple combination	**2**
Coccid, madder, tannins, weld	1
Coccid, madder, woad, tannins	1

Preserved buttonholes identified in 12 cases are evidence of advanced tailoring skills. While the majority of cases involve the remains of individual holes, several specimens document an entire course of buttonholes, which were padded with a wool or silk fabric lining, from the highly fashionable and practical treatment of garment fronts or the lower parts of sleeves (***Figure 8.a***). Other similar fashion elements were decorative trims on hemming garment sections, e.g. the tips of hoods, and the selvedges of cloaks or hanging sleeves, which were preserved on two textile fragments.

A special construction element used to shape the resulting appearance of a garment was pleating, which is preserved on nine wool fabrics. Fixed with stitches, these folds ensured even and continually pleated garments and were used primarily on the upper layers of clothing (***Figure 8.b***).

Connecting certain textile fragments with specific garment parts is relatively difficult due to the high fragmentation of finds. The probability of a connection to a garment on the upper or lower half of the body is highest on fragments with preserved, distinctly cut or shaped selvedges, hems, buttonholes or slits. The vast majority of such fragments belong to the category of wool cloth with a plain weave and with a warp thread count of 10-20 threads, i.e. in medium and fine quality. This fabric can therefore be regarded as a typical representative of commonly used clothing textiles in the given period.

Analyses of dyes and dyeing sources

The study of original colour – analyses of dyes and organic mordants made from plants and animals – produced highly interesting and unique results for medieval textiles from the Bohemian environment [17-19].

Wool fragments of cloth have been preserved in shades of eight colours – scarlet, reddish-brown, dark red, brown, light brown, dark brown, grey and black. Wool bands were preserved in shades of black and dark brown (***Table 1***).

An important factor for determining the current colour was the visual observation and assessment of fibres under an optical microscope (Olympus, Czech Republic), where purely monochrome yarn fibres were identified in scarlet, reddish-brown, brown, light brown and high-quality black fabrics. The addition of black weft and warp threads was observed mainly in grey, dark brown, certain dark red, and lower quality black fabrics.

The majority of fragments give an overall monochrome impression and differences were found in only a few specimens in the form of weft strips in a different colour, the different colour of warp and weft threads or the varied colour of warp threads.

In rare cases a different colour was also observed in preserved side selvedges; an end warp thread of a clearly distinct colour occurred on only five fragments. On the remaining fragments with a preserved side selvedge, the colour at the selvedge and on the surface of the fabric was the same; however, in the majority of cases this colour consistency could not be determined because the side selvedge had been torn from the original fabric.
Silk fragments were preserved in only four colours – red, yellow, light brown and brown (***Table 1***). The majority of silk fragments are red, yellow or light brown monochrome unpatterned fabric in a plain weave. Yellow and red weft strips bound with a yellow warp were

preserved on a single fragment. Two silk bands in a plain weave were preserved in yellow. Brown silk is represented by monochrome patterned damask and five-end satin weave. Patterned weft-faced compound twill is dominated by yellow warp and weft threads, and a scarlet patterning weft was also used only on weft-faced compound twill with parrots and basilisks.

A total of 172 samples were taken for analyses of natural dye sources (34 silk, 138 wool). Confirmed among the natural sources used by medieval dyers were scarlet worm, red dyer's madder and other *Rubiaceae* plants, red Brazilwood, blue woad, yellow dyer's rocket, sawwort and dyer's broom, and dark tannins, most probably from oak-apple, bark or walnuts [20].

The study of combinations of individual dyeing sources also produced interesting results (***Table 2***). The use of a single natural dye source was determined in 65 cases, a combination of two sources on 60 samples, a combination of three sources 19 times and a combination of four natural sources twice. The most common combinations of two sources were madder and woad (19 times), madder and dyer's rocket (12 times), scarlet worm and madder (8 times) and woad with tannins (6 times). The use of madder, woad and tannins (7 times) and madder, woad and dyer's rocket (3 times) was confirmed in combinations of three sources. Combinations of four sources were comprised of scarlet worm, madder, tannins and dyer's rocket in one case, and scarlet worm, madder, tannins and woad in the other. An interpretation of the results of the analyses conducted confirmed the assumed medieval dyer's method of achieving various colour shades by tinting individual primary

Conslusions

The professional study of the assemblage of archaeological textiles, focussed primarily on textile technology parameters and the identification of sources of the original colour, produced interesting results characterising the mass production of medieval textiles. The assemblage presented is unique in the Bohemian environment, as no assemblage this size of non-burial archaeological textiles has been found thus far. The data acquired are therefore a good source for gaining a better understanding of the types of textiles produced and utilised within the Lands of the Bohemian Crown in the relevant period. At the same time, the data can also be a heretofore missing source for comparison with surrounding regions of Europe with a larger number of similar textile finds [21-25].

Acknowledgements

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