Dyestuff Analysis of the Central Asian Woolen Textiles.

A Contribution of Dyestuff Analysis to the Study and Knowledge of the Textile Fragments

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Fabulous Creatures from the Desert Sands

Central Asian Woolen Textiles from the Second Century BC to the Second Century AD

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Introduction

The identification of natural dyestuffs in ancient textiles has a long tradition. During the last 25 years the ICN[1] has analyzed several thousand samples of all kinds of textiles of different origins and dates.[2] The methods used have developed from Thin Layer Chromatography[3] to High Performance Liquid Chromatography (HPLC).[4] The history of dyeing and the use of natural dyestuffs in textiles have been studied using written historical sources.[5] The lessons learned from our experience have been presented in several articles and reports. Relations between the Abegg-Stiftung and the ICN are long-standing and have led to the investigation of many important ancient textiles.

Why analyze the dyestuffs of ancient textiles? Does it contribute only to our knowledge of an object or also to its conservation? In this essay we attempt to interpret the analytical results of HPLC to illuminate the formation of groups among and the origins of the textile fragments.[6] The history of the dyestuffs identified in the fragments has already been discussed elsewhere and will be presented in more detail in the forthcoming publication of the Abegg-Stiftung, Riggisberger Berichte, volume 9, *Textiles between Persia and China*.

1 ICN (Netherlands Institute for Cultural Heritage) formerly the Central Research Laboratory for Objects of Art and Science in Amsterdam.

2 A database for the identified dyestuffs has been developed by Wilma G. Th. Roelofs. Up to this time about 2000 results have been added. The database is available through the documentation centre of the ICN.

3 Roelofs 1972.

4 Wouters / Rosario-Chirinos 1992.

5 Hofenk de Graaff 1992.

6 The results of the dyestuff analysis of the textile fragments are presented in the ICN report *Dyestuff Analysis of Central Asian Textiles*, by Maarten R. van Bommel and Judith H. Hofenk de Graaff, Amsterdam, 20/03/2001, Project number 2001–004. See also Table of HPLC results of dyestuff analysis, pp. 144–148 below.

Cat. no.	Sample	Dyestuff components						
		Alizarin	*Purpurin*	*Xantho-purpurin*	*Munjistin-like*	*Xantho-purpurin-like*	*Alizarin-like*	*Purpurin-like*
Red colors								
Cat. no. 2a (inv. no. 5156)	Reddish orange tapestry weft	95%	5%					
Cat. no. 2a (inv. no. 5156)	Dark red repair patch (tabby)	86%	10%		2%	2%		
Cat. no. 2b (inv. no. 5157)	Red tabby	93%	Trace	7%	Trace			
Cat. no. 7a (inv. no. 5145)	Red twill	72%	12%	1%	1%	1%		
Cat. no. 7a (inv. no. 5145)	Red tapestry weft	88%	12%	Trace	Trace			
Cat. no. 8 (inv. no. 5162)	Orange-red tabby	87%		2%	Trace		9%	Trace
Violet lilac colors, probably on an iron mordant								
Cat. no. 2a (inv. no. 5156)	Brown-lilac tapestry weft	94%	6%					
Cat. no. 2b (inv. no. 5157)	Lilac-brown tapestry weft	94%	Trace	4%	2%			

Table 1: *Dyestuff components in red and violet lilac colors*

Similar Textiles? Cat. nos. 2a, and 2b, 7a

Cat. nos. 2a and 2b are very similar in appearance. When we examine the dyestuff composition of these textiles the high concentration of alizarin in several red shades is striking. Other reddish samples of the same fragment include "normal" ratios of alizarin and purpurin, xantho-purpurin, and a munjistin-like component. The presence of the latter suggests the use of Indian madder *(Rubia cordifolia* L.).[7] The use of a dyestuff with a high concentration of alizarin appears not to have been accidental but a conscious choice to achieve a particular red shade. How can this high concentration of alizarin be explained? Knowing that in the same fragments Indian madder is also present, a mixture of two different dye plants of which one

7 In most samples a trace (1–2%) of an unknown anthraquinone was found, which is labelled *munjistin-like.* This compound was also found in the ICN-reference material of *Rubia cordifolia* L., whereas this was not the case in madder from *Rubia tinctorum* L. See ICN-report 2001–004.

was Indian madder could be the explanation. Another well-known red dyestuff, which was used in India, is Chay root. Chay root is obtained from the roots of *Oldenlandia umbellata* L. and grows in India and Burma.[8] The main coloring component in Chay root is alizarin, with no purpurin present. The supposition that the samples mentioned in Table 1 were dyed with a mixture of Indian madder and Chay root is very likely. This mixture could easily be responsible for the relatively high percentage of alizarin in relation to purpurin in the HPLC analysis.

Besides cat. nos. 2a and 2b, cat. no. 7a also exhibits these high concentrations of alizarin. Through this particular dyestuff composition cat. no. 7a becomes related to the other two textiles.

Pink colors

In pink samples from cat. nos. 1c, 2a, and 2b carminic acid as well as kermesic acid was detected. Kermesic acid indicates the use of kermes *(Kermes vermilio* Planch.), however kermes does not contain carminic acid. Carminic acid can come from Mexican cochineal *(Dactylopius coccus* Costa), Armenian (Ararat) cochineal *(Porphyrophora hameli* Brandt), or Polish cochineal *(Porphyrophora polonica* L.).[9] Other possibilities are *Porphyrophora uvae-ursi, Porphyrophora frangariea.* As Mexican cochineal and Polish cochineal are unlikely because of their place of origin, the most likely used dyestuff is Ararat (Armenian) cochineal, *Porphyrophora uvae-ursi, Porphyrophora frangariea,* or a mixture of kermes and one of these coccid insect dyes. As the ratios of carminic acid and kermesic acid differ from those known from literature, the results can only be explained as a mixture of kermes and Armenian cochineal or as a *Porphyrophora coccus*-type which has not yet been completely investigated.[10] Besides the above fragments, coccid insect dyes were used in red shades in cat. nos. 3a and 31, though they were not as dominant as in cat. nos. 1a, 2a, and 2b.

Piece-dyed fabrics
Cat. nos. 1c, 3a, and 8

The textiles under investigation are fragments of clothing where piece-dyed fabrics are combined with colorful patterned woven strips. To find a connection between the fragments through dyestuff analysis the dyestuff composition of piece-dyed materials is compared.[11] Cat. nos. 1a, 1c, 2a, 2b, 3a, 7a, 8, and 26 all

8 Hofenk de Graaff 1969; Chenciner 2000, pp. 184–185; Schweppe 1992, p. 241.

9 Verhecken / Wouters 1988–1989.

10 Wouters / Verhecken 1989.

11 The Abegg-Stiftung has coded the samples as *piece-dyed.* Piece-dyeing can easily be recognised when unravelling warp and weft. If some areas between the yarns are not completely dyed, this indicates that the fabric was dyed after it was woven. In patterned weaves the yarns (warp and weft) are dyed separately.

Cat. no.	Sample	Dyestuff components				
		Alizarin	*Purpurin*	*Xantho-purpurin*	*Munjistin-like*	*Alizarin-like*
Cat. no. 1a (inv. no. 5158)	Red twill	75%	11%	2%	2%	10%
Cat. no. 1c (inv. no. 5159)	Red braided flounce	67%	30%	1%	1%	2%
Cat. no. 3a (inv. no. 5161)	Red twill	66%	18%	3%	4%	9%
Cat. no. 26 (inv. no. 5130)	Dark violet tabby	68%	16%	Trace	Trace	10%

Table 2: *Comparison between piece-dyed red fabrics*

include fabrics that have been piece-dyed. The red dyestuff in these is similar. The dye plant used for these fabrics is *Rubia cordifolia* L. as indicated by the presence of the munjistin-like component. The ratios of the other components are also similar, which indicates that the same dye plant was used (see Table 2).

The pictorial tapestry bands of the fragments, however, show a different pattern of dyestuffs. In cat. no. 1a two wefts are dyed with a *Porphyrophora* coccid insect dye, whereas in cat. no. 3a most reds were obtained from *Rubia cordifolia* L. with a small amount of carminic acid present in only one weft. Does the use of a more expensive dyestuff (kermes) have any relation to the more elaborate pattern of the band? The yellows of both patterned parts are very similar to each other.

Purple colors without indigo
Cat. no. 26

The piece-dyed fabric of cat. no. 26 has also been dyed with the same type of *Rubia cordifolia* L. However, the color of this fragment, dark purple, is very different from the others. In many cultures good quality purple is achieved by a combination of dark blue, dyed with woad *(Isatis tinctoria* L.), or indigo *(Indigofera tinctoria* L.) and madder *(Rubia tinctoria* L.).[12] This combination is found in early Coptic textiles, as mentioned in the *Papyrus Graecus Holmiensis* and often identified in these textiles by the author.[13] However, analysis shows that no indigo is present in this sample, indicating that another procedure or dyestuff must be responsible for the purple color. As *Rubia cordifolia* L. is identified as the main dyestuff, it is very likely that in this sample Indian madder is dyed on an

12 Hofenk de Graaff 1996.
13 Reinking 1925.

iron mordant instead of alum. The poor condition of the fragment corresponds with the degradation phenomena of iron-gall corrosion.[14]

In dyeing and printing of textiles, the combination of dyestuffs (e.g. tannin or madder) with metal-salt solutions (e.g. iron sulphate) is a well-known process. The type of metal in the dyestuff complex determines the color-shade. Dyeing with madder using alum will produce a brick-red color, a bright red when using tin, and a violet (purple) shade when using iron. Textiles are mordanted with aqueous solutions of an iron-salt solution and subsequently rinsed thoroughly. The iron components are chemically and physically bound to the fibers. After that, dyeing takes place with tannins to obtain black, or madder (in this case *Rubia cordifolia* L.) to obtain purples. After dyeing, extensive rinsing with water takes place. In ancient textile objects black parts made of wool are sometimes in good, sometimes in fairly bad condition. The quality of the dyestuff and thorough rinsing after the dyeing process play important roles. The use of iron powder for cheap woolen cloth was supposed to have a negative effect on the quality. Traces of the iron can damage the fibers during the dyeing process and enhance the degradation of the wool through oxidation.

In India mordanting with iron salts was well known. Indian chintzes, white cottons painted or printed with exotic flowers and mythological animals, have black outlines and purple and red colors.[15] One of the most informative sources on the dyeing process was written by the Jesuit father Cœurdoux in the year 1742. From his information it is clear that the various shades of red and purple were obtained with alum and iron salts together with Indian madder or Chay root.[16] Although the chintzes are of much later date than the textiles under investigation, it may be assumed that knowledge of the use of iron salts as a mordant was available long before the seventeenth century. Madder on an iron mordant was not only known in Central Asia. Analysis of purple yarns from Masada, Israel, dated AD 66–73 (ICN Doc. map 2000/54, Obj. 2655) also showed madder on an iron mordant.

Besides the purple wool in cat. no. 26, cat. nos. 2a and 2b were dyed with Indian madder without indigo (s. Table 1). One can presume the use of an iron mordant in these samples also.[17] These results relate cat. no. 26 to the other two pieces.

Yellow dyestuffs

The identification of yellow dyestuffs is more difficult than red dyestuffs. In nature there are innumerable plants containing flavonoid components that can dye yellow. In many plants the main component is the same. It is therefore difficult to point with absolute certainty to a specific dye plant. The poor stability

14 Hofenk de Graaff 1999.
15 Hofenk de Graaff 1987.
16 Irwin / Brett 1970, pp. 34–56.
17 On all three samples, iron has in fact been positively identified with X-ray fluorescence.

Cat. no.	*Sample*	*Rham-netin*	*Comp. I*	*Comp. II*	*Comp. III*	*Comp. IV*	*Comp. V*	*Comp. VI*	*Comp. VII*	*Comp. VIII*	*Two UV-peaks*
Cat. no. 1a (inv. no. 5158)	Yellow tapestry weft	*	*					*			*
Cat. no. 1a (inv. no. 5158)	Green tapestry weft							*	*		
Cat. no. 1a (inv. no. 5158)	Yellow cord	*	*			*	*	*			*
Cat. no. 2a (inv. no. 5156)	Yellow tapestry weft	*	*			*	*			*	*
Cat. no. 2a (inv. no. 5156)	Beige (yellow) cord					*					
Cat. no. 2b (inv. no. 5157)	Beige tapestry weft	*									
Cat. no. 2b (inv. no. 5157)	Yellow tapestry weft	*	*			*	*			*	*
Cat. no. 2b (inv. no. 5157)	Yellow cord	*									
Cat. no. 3a (inv. no. 5161)	Yellow tapestry weft	*	*		*						*
Cat. no. 3a (inv. no. 5161)	Yellow cord	*	*			*	*				*
Cat. no. 7a (inv. no. 5145)	Orange tapestry weft	*	*								
Cat. no. 8 (inv. no. 5162)	Yellow tabby	*	*								*
Cat. no. 8 (inv. no. 5162)	Yellow cord	*	*	*	*	*					*

Table 3: *Yellow samples containing flavonoids*

of yellow dyestuffs makes it even more complicated. It is with that in mind that the following discussion on yellow dyestuffs present should be seen.

In most yellow samples rhamnetin, a flavonoid, was identified. However, this compound was not always the main component, and other flavonoids were also detected. The UV spectra of these are quite similar to apigenin, luteolin and

quercetin.[18] However, their retention times differ from the retention times of the reference material. In Table 3, all yellow samples that contain flavonoids are listed.

Rhamnetin and component I[19] were detected in most samples, indicating that the same dyestuff was used. In addition, eight samples show typical UV-peaks, which were not observed in others. The presence of these two typical compounds again indicates that the same dye plant was used.

Yellow dyestuffs that might be expected in the fragments include Chinese berries (*Gardenia jasminoides* Ellis), Curcuma (*Curcuma domestica*), Saffron (*Crocus sativus* L.), Berberis (*Berberis japonica* and *Phellodendron amurense*) and Coptis root (*Coptis teeta* Wall).[20] However, none of these dyestuffs contain flavonoids and are thereby excluded.

Dyestuffs that do contain flavonoids include the Chinese Pagoda-tree (*Sophora japonica* L.) with rutin as main component, Camboge from the Indian Camboge tree (*Garcinia morella* Desr.), and the Pallas tree (*Butea frondosa* Roxb.) with butin as the main component. However these compounds were not detected or could not yet be identified because of the lack of reference materials. The presence of rhamnetin in the fragments suggest that the dyestuff could belong to the Rhamnaceae family, such as *Rhamnus lycioides ssp. oleoides* L., which is a native of the region from which the textiles come. As said before, the uncertainty could lie in the deterioration of the yellow dyestuffs, or perhaps the flavonoids detected are degradation products of the original dyestuffs. Another possibility is that an unknown, not yet identified, dye plant is used. It is quite possible that local plants were used to prepare these dyestuffs. However, the results of the unknown components together with the presence of rhamnetin suggest that the same dyestuff was used. From this it might be concluded that cat. nos. 1a, 2a, 2b, 3a, and 8 are related.

Conclusion

Through careful interpretation of the analytical results it is possible to formulate groups of related fragments. Through cross examination of the results of the piece-dyed textiles with the reds with high alizarin contents and the *Porphyrophora coccus* insect dyes one could conclude that the whole group of fragments investigated are closely related. With the help of other studies, such as historical, art historical, and weaving techniques, it may be possible to draw even more precise conclusions.

18 Apigenin and luteolin are the main components of weld *(Reseda luteola* L.). Apigenin is also one of the main components of Dyer's-broom *(Genista tinctoria* L.). Quercetin is the main component of quercitron bark *(Querqus tinctoria* L.). However, these components are also present in many other yellow dye plants.

19 To facilitate cross-reference, unidentified compounds, which have spectra that can not be related to any compound in the HPLC-library, are labelled I through VIII in the sequence of detection.

20 Schweppe 1993, pp. 37–39.

HPLC Results of Dyestuff Analysis

from: Maarten R. VAN BOMMEL and Judith H. HOFENK DE GRAAFF, *Dyestuff Analysis of Central Asian Textiles.* Amsterdam, Instituut Collectie Nederland (Netherlands Institute for Cultural Heritage), project number 2001–004, 20 March 2001.

Cat. no.	Sample[1]	HPLC Results	Conclusion
Cat. no. 1a (inv. no. 5158)	Red twill	Alizarin (75%)[2] Purpurin (11%) Xantho-purpurin (2%) Munjistin-like (2%) Alizarin-like (10%)	Indian madder, *Rubia cordifolia* L.
	Yellow tapestry weft	Rhamnetin Two unknown flavonoids:[3] I, VI (plus 2 typical UV-peaks)	Unknown yellow flavonoid dyestuff
	Dark pink tapestry weft	Carminic acid (27%) Kermesic acid (62%) Flavokermesic acid (11%) Trace of flavokermesic acid-like	*Porphyrophora* coccid insect dyestuff
	Red tapestry weft	Alizarin (42%) Purpurin (43%) Xantho-purpurin (2%) Munjistin-like (3%) Alizarin-like (1%)	Indian madder, *Rubia cordifolia* L.
	Pink tapestry weft	Carminic acid (16%) Kermesic acid (70%) Kermesic acid-like (13%) Trace of flavokermesic acid-like	*Porphyrophora* coccid insect dyestuff
	Variegated natural beige and blue tapestry weft	Indigotin Indirubin	Indigo, *Indigofera tinctoria* L.
	Variegated brown and blue tapestry weft	Indigotin Indirubin	Indigo, *Indigofera tinctoria* L. No indication what the brown color might be, probably natural colored wool
	Green tapestry weft	Two unknown flavonoids: VI (75%) VII (14%) Luteolin (6%) Indigotin Indirubin	Indigo, *Indigofera tinctoria* L. and unknown yellow flavonoid dyestuff
	Dark brown tapestry weft	No result	–
	Yellow cord	Rhamnetin Four unknown flavonoids: I, IV, V, VI (plus 2 typical UV-peaks)	Unknown yellow flavonoid dyestuff

1 Colors as observed under the microscope. These may be different from the descriptions in the catalogue, pp. 115–135.
2 The percentage of dyestuffs is based on peak area at 254 nm.
3 For convenience sake and to facilitate cross-reference the unknown flavonoid compounds have been numbered I through VIII.

Cat. no.	Sample	HPLC Results	Conclusion
Cat. no. 1c (inv. no. 5159)	Red braided flounce	Alizarin (67%) Purpurin (30%) Xantho-purpurin (1%) Munjistin-like (1%) Alizarin-like (2%)	Indian madder, *Rubia cordifolia* L.
Cat. no. 2a (inv. no. 5156)	Orange (red) tabby	Alizarin (81%) Purpurin (16%) Xantho-purpurin (2%)	Indian madder, *Rubia cordifolia* L.
	Yellow tapestry weft	Rhamnetin Four unknown flavonoids: I, IV, V, VIII (plus 2 typical UV-peaks)	Unknown yellow flavonoid dyestuff
	Reddish orange tapestry weft	Alizarin (95%) Purpurin (5%)	Indian madder, *Rubia cordifolia* L.
	Brown-lilac tapestry weft	Alizarin (94%) Purpurin (6%)	Indian madder, *Rubia cordifolia* L. Probably on an iron-based mordant
	Blue tapestry weft	Indigotin Indirubin	Indigo, *Indigofera tinctoria* L.
	Beige tapestry weft	Trace of xantho-purpurin	Unknown
	Reddish pink tapestry weft	Kermesic acid	Kermes
	Dark reddish orange tapestry weft	Alizarin (56%) Purpurin (26%) Munjistin-like (6%) Xantho-purpurin (11%)	Indian madder, *Rubia cordifolia* L.
	Variegated natural beige and blue tapestry weft	Indigotin Indirubin	Indigo, *Indigofera tinctoria* L.
	Red braided flounce	Alizarin (75%) Purpurin (21%) Xantho-purpurin (4%)	Indian madder, *Rubia cordifolia* L.
	Beige (yellow) cord	Unknown flavonoid: IV Trace of xantho-purpurin	Unknown yellow flavonoid dyestuff
	Dark red repair patch (tabby)	Alizarin (86%) Purpurin (10%) Munjistin-like (2%) Xantho-purpurin-like (2%)	Indian madder, *Rubia cordifolia* L.
Cat. no. 2b (inv. no. 5157)	Blue tabby	Indigotin Indirubin Indirubin-like	Indigo, *Indigofera tinctoria* L.
	Red tabby	Alizarin (93%) Xantho-purpurin (7%) Traces of purpurin and munjistin-like	Indian madder, *Rubia cordifolia* L.

Cat. no.	Sample	HPLC Results	Conclusion
	Beige tapestry weft	Rhamnetin Xantho-purpurin Munjistin-like	Unknown yellow flavonoid dyestuff
	Ochre (beige-yellow) tapestry weft	Alizarin (100%) (very low response) Traces of munjistin-like, xantho-purpurin and rhamnetin	Indian madder, *Rubia cordifolia* L.
	Pink tapestry weft	Alizarin (49%) Purpurin (49%) Munjistin-like (1%) Xantho-purpurin (1%) Two unknown peaks with absorption at 460 nm	Indian madder, *Rubia cordifolia* L.
	Lilac-brown tapestry weft	Alizarin (94%) Munjistin-like (2%) Xantho-purpurin (4%) Trace of purpurin	Indigo, *Indigofera tinctoria* L., and Indian madder, *Rubia cordifolia* L.
	Blue tapestry weft	Indigotin Indirubin Indirubin-like	Indigo, *Indigofera tinctoria* L.
	Yellow tapestry weft	Rhamnetin Four unknown flavonoids: I, IV, V, VIII (plus 2 typical UV-peaks)	Unknown yellow flavonoid dyestuff
	Reddish pink tapestry weft	Carminic acid (52%) Kermesic acid (48%)	Coccus based dyestuff, probably *Porphyrophora polonica* or closely related *Porphyrophora* species
	Red tapestry weft	Alizarin (56%) Purpurin (31%) Munjistin-like (3%) Xantho-purpurin (6%) Alizarin-like (2%)	Indian madder, *Rubia cordifolia* L.
	Variegated natural beige and blue tapestry weft	No HPLC analysis done due to low sample size. The indigo micro test was positive.	Indigo, *Indigofera tinctoria* L.
	Red braided flounce	Alizarin (53%) Purpurin (36%) Munjistin-like (2%) Xantho-purpurin (8%)	Indian madder, *Rubia cordifolia* L.
	Yellow cord	Rhamnetin Xantho-purpurin Xantho-purpurin-like	Unknown yellow flavonoid dyestuff and a red dyestuff, probably *Rubia peregrina* L.
	Red braided repair patch	Alizarin (70%) Purpurin (23%) Munjistin-like (1%) Xantho-purpurin (6%)	Indian madder, *Rubia cordifolia* L.

Cat. no.	Sample	HPLC Results	Conclusion
Cat. no. 3a (inv. no. 5161)	Yellow twill	Trace of alizarin No yellow dyestuffs were detected	Indian madder, *Rubia cordifolia* L.
	Red twill	Alizarin (66%) Purpurin (18%) Xantho-purpurin (3%) Munjistin-like (4%) Alizarin-like (9%)	Indian madder, *Rubia cordifolia* L.
	Yellow tapestry weft	Rhamnetin Two unknown flavonoids: I, III (plus 2 typical UV-peaks)	Unknown yellow flavonoid dyestuff
	Orange-red tapestry weft	Alizarin (71%) Purpurin (11%) Xantho-purpurin (2%) Munjistin-like (4%) Alizarin-like (12%)	Indian madder, *Rubia cordifolia* L.
	Dark red tapestry weft	Alizarin (38%) Purpurin (47%) Munjistin-like (1%) Purpurin-like (10%) Carminic acid (4%)	Indian madder, *Rubia cordifolia* L. and trace of Ararat cochineal, *Porphyrophora hameli* Brandt
	Variegated blue and olive tapestry weft	Indigotin Indirubin	Indigo, *Indigofera tinctoria* L.
	Yellow cord	Rhamnetin Three unknown flavonoids: I, IV, V (plus 2 typical UV-peaks)	Unknown yellow flavonoid dyestuff
Cat. no. 7a (inv. no. 5145)	Brown twill	No result	–
	Red twill	Alizarin (72%) Purpurin (24%) Xantho-purpurin (1%) Munjistin-like (1%) Xantho-purpurin-like (1%)	Indian madder, *Rubia cordifolia* L.
	Ochre tapestry weft	No result	–
	Red tapestry weft	Alizarin (88%) Purpurin (12%) Traces of xantho-purpurin and munjistin-like	Indian madder, *Rubia cordifolia* L.
	Variegated green and natural beige tapestry weft	Indigotin Indirubin	Indigo, *Indigofera tinctoria* L.
	Green tapestry weft	Indigotin Indirubin No yellow dyestuffs were detected	Indigo, *Indigofera tinctoria* L.

Cat. no.	Sample	HPLC Results	Conclusion
	Orange tapestry weft	Alizarin (40%) Purpurin (33%) Unknown flavonoid: I (27%) Trace of rhamnetin	Indian madder, *Rubia cordifolia* L. and unknown yellow flavonoid dyestuff
	Dark brown tapestry weft	Trace of indigotin	Indigo, *Indigofera tinctoria* L.
Cat. no. 8 (inv. no. 5162)	Orange-red tabby	Alizarin (87%) Alizarin-like (9%) Xantho-purpurin (2%) Traces of munjistin-like and purpurin-like	Indian madder, *Rubia cordifolia* L.
	Yellow tabby	Rhamnetin Unknown flavonoid: I (plus 2 typical UV-peaks)	Unknown yellow flavonoid dyestuff
	Yellow (light brown) twill	No Result	–
	Red twill	Alizarin (60%) Purpurin (18%) Purpurin-like (22%) Trace of munjistin-like	Indian madder, *Rubia cordifolia* L.
	Yellow cord	Rhamnetin Four unknown flavonoids: I, II, III, IV Alizarin Munjistin-like Alizarin-like Xantho-purpurin (plus 2 typical UV-peaks)	Unknown yellow flavonoid dyestuff and Indian madder, *Rubia cordifolia* L.
Cat. no. 14 (inv. no. 5153)	Brown (violet) tapestry weft	Alizarin (96%) Purpurin (4%)	Indian madder, *Rubia cordifolia* L. Probably on an iron-based mordant
Cat. no. 25 (inv. no. 5152)	Red tapestry weft	Alizarin (40%) Purpurin (60%) Trace of carminic acid	Indian madder, *Rubia cordifolia* L. and trace of Ararat cochineal, *Porphyrophora hameli* Brandt
	Blue-green tapestry weft	Indigotin Indirubin	Indigo, *Indigofera tinctoria* L.
	Light yellow tapestry weft	No result	–
Cat. no. 26 (inv. no. 5130)	Dark violet tabby	Alizarin (68%) Purpurin (16%) Alizarin-like (10%) Traces of munjistin-like and xantho-purpurin	Indian madder, *Rubia cordifolia* L. Probably on an iron-based mordant