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Radiocarbon Dating and Dye Analysis of Roman Linen Tunics and Dalmatics with Purple Coloured Design

Introduction

Immediately after the start of DressID project (see Schieck and Tellenbach in this issue) a sub-project on radiocarbon and purple dye analyses of Roman dresses from Egypt was initiated by the Study Group 4 (Colours and Dating). The idea was to assemble groups of 'similar' garments or dress accessories, with "similar" meaning: made of the same basic material(s), having the same shape, same decoration or pattern, same technique and same colour. Firstly, we concentrated on a series of linen tunics and dalmatics with purple-coloured decoration, a type that is known from numerous representations in mosaics and wall paintings of Roman times in the Mediterranean area.

Eighteen examples of almost complete or substantial fragments of tunics and dalmatics from the Katoen Natie collection in Antwerp, the Sculpture collection and Museum of Byzantine Art in Berlin, the Royal Museums for Art and History in Brussels, the Gustav-Lübcke-Museum in Hamm, the British Museum and the Victoria and Albert Museum in London, the Whitworth Art Gallery in Manchester, and the Museum for Applied Arts in Vienna were selected and – where possible – classified according to their shape.

Four items are of the typical tunic shape, woven in one piece from sleeve to sleeve (Table 1). One is a sleeveless tunic. Nine objects could be identified as dalmatics (Table 2), a special type of tunic produced in the same manner but fitted out with extra wide sleeves (Pausch 2003, 180-187). The original shape of another seven fragments could not be determined with certainty (Table 3).

The linking element between all tunics and dalmatics is their decoration which is made of purple-coloured wool in tapestry technique, often accompanied by the so called 'flying shuttle'. The decoration is either monochrome or bi-chrome, the latter meaning that the ornaments appear in the natural bright colour of undyed linen on a ground of purple-coloured wool or vice versa.

The decoration of two tunics (SBM 9930 Fig. 1; BM EA 72491 Fig. 5) merely consists of plain purple-coloured stripes. Other garments combine plain stripes with foliate ornaments and geometric motifs (KTN 989 Fig. 14; SBM 9936 Fig. 15; WAG T.1996.92 Fig. 9; BM PE 1955.2-6.10 Fig. 16). Twelve pieces show an interlace pattern (KMKG ACO.Tx 2474 Fig. 11 and ACO. Tx.2477 Fig. 4; WAG T.1995.145 Fig. 7; GLM 1704 Fig. 13; V&A 361-1887 Fig. 6) or an interlace pattern with supplementary geometric and/or foliate motifs (KTN 489 Fig. 12; KMGK ACO.Tx.2485 Fig. 3; WAG T.1994.129 Fig. 8 (tunic) and T.1968.80 (sleeve), MAK T 9890-1952 (1); MAK T 9677-1951 (2); KMGK ACO. Tx 2472 Fig. 2; KMKG ACO.Tx 2467 A-B Fig. 10). The patterns and motifs occur on both tunics and dalmatics types alike. This means that we cannot distinguish between tunics and dalmatics by their decoration if they are incomplete.

Results of the Radiocarbon Dating

The 18 almost complete or fragmentary tunics and dalmatics were radiocarbon dated (Van Strydonck, Nelson, Crombé *et al*. 1999). Three similar pieces from the Musée du Louvre already radiocarbon dated before the start of this project (Bénazeth, pers. comm.; 2006; Cortopassi 2008) were added in order to obtain 21 tunics and/or dalmatics.

Collection	Inv. no	Object	C14-date Sample no and years BP	C14-date Calendar years (95.4 %)	Bibliographical reference
1. SBM	9930 (Fig. 1)	Front/back of sleeved tunic with plain stripes	KIA-37619, 1815 +/- 25 BP	120-260 AD (94.2 %) 300-320 AD (1.2 %)	Cat. Berlin 2000, 201-203, no 131
2. KMKG	ACO.Tx.2472 (Fig. 2)	Front/back of tunic with stripes and roundels decorated with interlace and leave motifs	KIA-37915, 1715 ± 30 BP (= tunic) KIA-37914, 1810 ± 35 BP (= sewn onto roundels)	250-410 AD 120-330 AD	Errera 1916, 30-31, no 74; Cat. Brussels 1988, fig. 29
3. KMKG	ACO.Tx.2485 (Fig. 3)	Front and back of tunic with geometric pattern and interlace	KIA-37918, 1755 ± 40 BP	130-390 AD	Errera 1916, 9, 27; Cat. Brussels 1988, fig. 30
4. KMKG	ACO.Tx.2477 (Fig. 4)	Fragment of sleeved tunic with interlace pattern	KIA-37923, 1730 ± 30 BP	240-400 AD	Errera 1916, 19-20, no 49
5. BM	EA 72491 (Fig. 5)	Sleeveless tunic with plain stripes	KIA 38657, 1570 ± 25 BP	420-550 AD	Walker and Bierbrier 1997, 177, no 223

Table 1. Tunics.

Collection	Inv. no	Object	C14-date Sample no and years BP	C14-date Calendar years (95.4 %)	Reference
1. V&A	361-1887 (Fig. 6)	Dalmatic with interlace pattern	KIA-38857, 1890 ± 30 BP	50-220 AD	Kendrick 1920, 40-41, no 1, pl 1; Walker and Bierbrier 1997, 178-179, no 227
2. WAG	T.1995.145 (Fig. 7)	Front/back of dalmatic with stripes, clavi and roundels showing interlace patterns	KIA-38474, 1705 ± 25 BP	250-410 AD	Pritchard 2006, 53-55
3. WAG	T.1994.129 (= tunic) (Fig. 8) T.1968.80 (= sleeve)	Fragments of front/back, neck section and sleeves of dalmatic with heart shaped motifs and interlace, roundels with meander and row of dots, red woollen cord around neck	KIA 38476, 1610 ± 25 BP	400-540 AD	Pritchard 2006, 56-57
4. WAG	T.1996.92 (Fig. 9)	Fragment of dalmatic with plain stripes and star motif with meander	KIA-38477, 1670 ± 35 BP	250-440 AD (93.3%); 490-530 AD (2.1%)	Pritchard 2006, 51-52
5. MAK	T 9890-1952	Fragment of a dalmatic with geometric pattern, interlace and foliate motifs	KIA-38475, 1690 ± 25 BP	250-300 AD (16.8%); 320-420 AD (78.6%)	Cat. Vienna 2005, 161-162, no 97
6. KMKG	ACO.Tx.2467 A, B (Fig. 10)	Fragments of two sleeves from a dalmatic with interlace and heart shaped motifs	KIA-39629 / KIA-39630 mean: 1615 ± 21 BP	390-540 AD	Errera 1916, 116, no 43
7. KMKG	ACO.Tx.2474 (Fig. 11)	Sleeve from a dalmatic with interlace pattern	KIA-39826 / KIA-39838, mean: 1760 ± 60 BP	120-410 AD	Errera 1916, 39, no 88
8. KTN	489 (Fig. 12)	Fragment of a dalmatic (sleeve) with interlace pattern and geometric motifs	KIA-37614, 1585 ± 25 BP	410-540 AD	Cat. Zottegem 1993, 111, no 20
9. GLM	1704 (Fig. 13)	Fragment of a dalmatic (sleeve) with interlace pattern	KIA-40433, 1695 ± 30 BP	250-420 AD	Cat. Hamm 2004, 225-226, no 112

Table 2. Dalmatics.

Collection	Inv. no	Object	C14-date Sample no and years BP	C14-date Calendar years (95.4 %)	Reference
1. KTN	989 (Fig. 14)	Fragments of a dalmatic or tunic with plain stripes, foliate motif and red cord around neck	KIA-37615, 1670 +/- 25 BP	260-280 AD (5.5 %); 320-430 AD (89.9 %)	Unpublished
2. SBM	9936 (Fig. 15)	Front/back of tunic or dalmatic with plain stripes and roundels with meander and foliate motifs	KIA-37620, 1625 +/- 25 BP	380-540 AD (95.4 %)	Cat. Berlin 2000, 208-209, no 136
3. BM	PE 1955.2-6.10 (Fig. 16)	Dalmatic or tunic with double stripes with row of fine lozenges and foliate motifs, roundel with lozenges, framed by heart shaped leaves	KIA 38862, 1725 ± 25 BP	240-390 AD	unpublished
4. MAK	T 9677-1951	Fragment of a tunic or - most probably – a dalmatic with interlace pattern, geometric and foliate motifs	KIA-40407, 1685 ± 25 BP	250-300 AD (13.6%); 320-420 AD (81.8%)	www.mak.at (collection online, Late Antique Textiles)
1. ML	E29312	Front/back of a tunic or dalmatic	KIA-28768, 1660 ± 25 BP	260-290 AD (3.4%); 320-440 AD (92.0%)	Cortopassi 2009, 150-151, fig. 1
2. ML	AF5842	Front/back of a tunic or dalmatic	KIA-28767, 1710 ± 25 BP	250-410 AD	Cortopassi 2009, 152-153, fig. 3
3. ML	AF13169	Tunic or dalmatic	KIA-28766, 1680 ± 25 BP	250-300 AD (9.8%); 320-430 AD (85.6 %)	Cortopassi 2009, 151-152, fig. 2

Table 3. Tunics or dalmatics. 1.ML- 3.ML are tunics or dalmatics from the Musée du Louvre which have been radiocarbon dated before the start of this project.

Tables 1, 2 and 3 show the results of the ^{14}C-analyses for each piece. The years BP – the conventional radiocarbon age – means before present *i.e*. before 1950, the start of the radiocarbon dating. The estimated age uncertainty of this radiocarbon age is given as 1 standard deviation, mostly plus/minus 25 years. This radiocarbon age however must be calibrated in order to obtain the calendar ages. This calibration curve relies on the accurate measurement of dendrochronologically absolutely dated tree rings (Bronk Ramsey 1995; Stuiver *et al*. 1998).

The graph of the 21 pieces is shown in Graph 1.

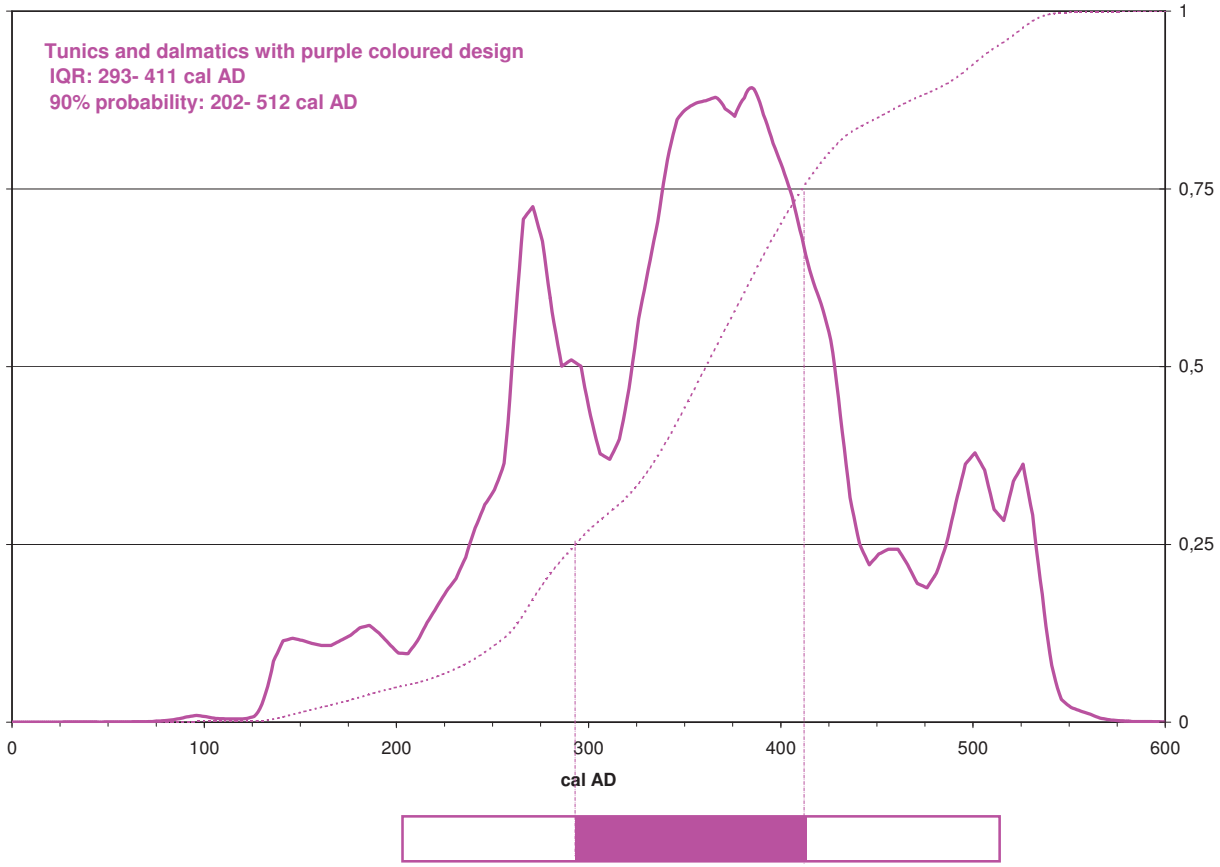
The interquartile range (IQR) of the 21 tunics and dalmatics is between 293 and 411 AD (Aitchison, Ottaway and Scott 1990). The 90 % probability range is between 202 and 512 AD. The IQR which takes into account the middle 50 %, excluding the early and late dates is a stable parameter and can be considered as the flourishing period for these textiles. The 90 % probability range was used instead of the usual 95 % probability range because the latter overestimates the period by a few decades. This was proved by Mark van Strydonck (Van Strydonck 2007).

The interquartile range for the dalmatics – the plain blue rectangle – is between 303 and 434 AD. The 90 % probability range is between 217 and 520 AD.

The interquartile range for the 5 tunics is between 247 and 377 AD – this is the plain red rectangle. The 90 % probability range – the complete red rectangle is between 157 and 516 AD. These tunics were definitively older than the group of 12 woollen tunics radiocarbon dated in 2004 (De Moor, Van Strydonck and Verhecken-Lammens 2004).

Dalmatic V&A 361-1887 caused a particular problem. The calculated calendar age was very early in contrast to those of the other dalmatics, namely between 50 and 220 AD (95.4 % probability). This dalmatic had been glued to a support fabric by means of polyvinylacetate, a petroleum derivate with an infinite radiocarbon age. In the laboratory in Brussels we attempted to remove all of this glue but apparently a little amount of it remained in the fibres, resulting in this early date. A second sample was taken from a section where the dalmatic very probably had not been in contact with the glue. The calendar age (95.4 % probability) from the second radiocarbon analysis is between 130 and 340 AD.

Tunic ACO.Tx.2472 is a special case. The basic tunic (ACO.Tx.2472B) provided a radiocarbon date of 1715 ± 30 BP (KIA-37915) and a calendar age (95.4 % probability) between 250 and 410 AD (68.2 % probability: 250-300 (24.9 %) and 320-390 AD (43.3 %)).



Graph 1. Sum probability and integrated probability distribution of 21 tunics and dalmatics.

The sewn-on decorations (ACO.Tx.2472A) were separately woven and reused to decorate the tunic ACO. Tx.2472 (Van Raemdonck, pers. comm. 2010), and therefore resulted in a different date. The radiocarbon date for these pieces is 1810 ± 35 BP (KIA-37914), the calendar age is 130-250 AD with 68.2 % probability, and 120-330 AD with a probability of 95.4 %. The sewn on decorations were not included in the graphic of this group of tunics and dalmatics as we do not know to what textile they belonged originally.
The radiocarbon date of dalmatic ACO.Tx.2474 was also problematic. The first radiocarbon date was 1520 ± 25 BP, (KIA-38158) (calendar date (95.4 %) probability: 430-490 AD (19.8 %), 500-610 AD (75.6 %)), which was unacceptably young. Therefore, two more samples were taken from this dalmatic (KIA-39826: 1805 ± 25 BP, 135-235 AD (95.4%) and KIA-39838: 1720 ± 35 BP, 240-410 AD (95.4 %)). The difference between these two dates is too important to be caused by the inherent statistical uncertainty. Similar cases in which repeated measurements do not give coherent results do exist but are very rare, *i.e*. not more than 1 % of all cases. Although we cannot be absolutely sure, the most probable explanation might be the presence of modern (natural) fibres from conservation or from the support fabric. Such fibres cannot be removed chemically. If these fibres cannot be recognized microscopically they will give a later date than expected (Van Strydonck *et al*. forthcoming 2011).
Although the tunics showed a tendency to be slightly earlier than the dalmatics, the difference was not significant. There was a substantial overlapping of the interquartile ranges and even more of the 90 % probability ranges. The number of tunics – only five – was rather small to obtain reliable results.
It is regrettable however that we also have a group of seven pieces in cases of which – due to their fragmentary condition – we were not sure whether they were tunics or dalmatics. The interquartile range of this group is between 336 and 401 AD, the 90 % probability range between 268 and 477 AD.
If we compare the three groups – tunics, dalmatics and tunics or dalmatics – we see a substantial overlapping of the interquartile ranges and surely of the 90 % probability ranges.

Inv. N° / Collection	Sample n° / Analysis n°	Sample Description	Anthraquinone dye constituents	Indigoid dye constituents	Biological dye source specification
Tunics					
ACO.TX 2472 / KMKG	09896 / 01, 07/221008/01	purple wool	+ag, 23 al, 38 pu	39 in	red dye source from *Rubiaceae* family and indigo/woad
	09896 / 02, 02/231008/01	purple wool, medallion	6 al, 55 pu	39 in	red dye source from *Rubiaceae* family and indigo/woad
ACO.TX 2485 / KMKG	09896 / 05, 05/231008/01	purple wool	+ag, 19 al, +xp, 56 pu	24 in	red dye source from *Rubiaceae* family and indigo/woad
9930 / SBM	09896 / 08, 07/231008/01	purple wool	+ag, 22 al, + xp, 62 pu	14 in, 1 ir	red dye source from *Rubiaceae* family and indigo/woad
EA 72491 / BM	09896 / 19, 07/090309/01	purple wool	+ag, 18 al, 74 pu	8 in	red dye source from *Rubiaceae* family and indigo/woad
ACO.TX 2477 / KMKG	09896 / 04, 04/231008/01	purple wool	-	73 in, 20 mbi, 7 xbir	Mollusc purple (*Hexaplex trunculus* type)
Dalmatics					
ACO.TX 2474 / KMKG	09896 / 03, 03/231008/01	purple wool	12 al, +xp, 72 pu	16 in	red dye source from *Rubiaceae* family and indigo/woad
489 (DM 20) / KTN	09896 / 06, 06/231008/01	purple wool	17 al, 62 pu	21 in	red dye source from *Rubiaceae* family and indigo/woad
T.1996.92 / WAG	09896 / 15, 10/051108/01	purple wool	8 al, 70 pu	22 in	red dye source from *Rubiaceae* family and indigo/woad
T.1995.145 / WAG	09896 / 16, 11/051108/01	purple wool	12 al, 74 pu	14 in	red dye source from *Rubiaceae* family and indigo/woad
T 361-1887 / V&A	09896 / 12, 03/041108/01	purple, fine wool	+ag, 12 al, +xp, 64 pu, 1 xp'	21 in, 1 ir	red dye source from *Rubiaceae* family and indigo/woad
	09896 / 13, 05/041108/01	purple, coarse wool	+ag, 11 al, +xp, 65 pu	22 in, 2 ir	red dye source from *Rubiaceae* family and indigo/woad
T 9890-1952 / MAK	09896 / 17, 02/061108/01	purple wool	6 al, 67 pu	27 in	red dye source from *Rubiaceae* family and indigo/woad
1704 / GLM	09896 / 21, 04/121009/01	purple wool	12 al, 84 pu	4 in, +ir	red dye source from *Rubiaceae* family and indigo/woad
T.1994.129 / WAG	09896 / 14, 09/051108/01	purple wool	20 al, +xp, 49 pu	31 in	red dye source from *Rubiaceae* family and indigo/woad
Tunics or dalmatics					
989 / KTN	09896 / 09, 08/231008/01	blue wool	+ag, 21 al, +xp, 54 pu	24 in, 1 ir	red dye source from *Rubiaceae* family and indigo/woad
9936 / SBM	09896 / 07, 04/221008/01	purple wool	+ag, 15 al, +xp, 65 pu	19 in	red dye source from *Rubiaceae* family and indigo/woad
PE 19552-6.10 / BM	09896 / 20, 08/090309/01	purple wool	+ag, 6 al, 84 pu, +xp	10 in	red dye source from *Rubiaceae* family and indigo/woad
T 9677-1951 / MAK	09896 / 18, 03/061108/01	purple wool	+ag, 20 al, 61 pu	19 in	red dye source from *Rubiaceae* family and indigo/woad

Table 4. Results of the dye analysis for each purple wool sample (relative ratios of components are calculated after the peak areas integrated at 255 nm; al: alizarin, pu: purpurin, ag: anthragallol, xp: xanthopurpurin, xp': xanthopurpurin like spectra, in: indigotin, ir: indirubin, mbi: 6-bromo indigotin and xbir: brominated indirubin).

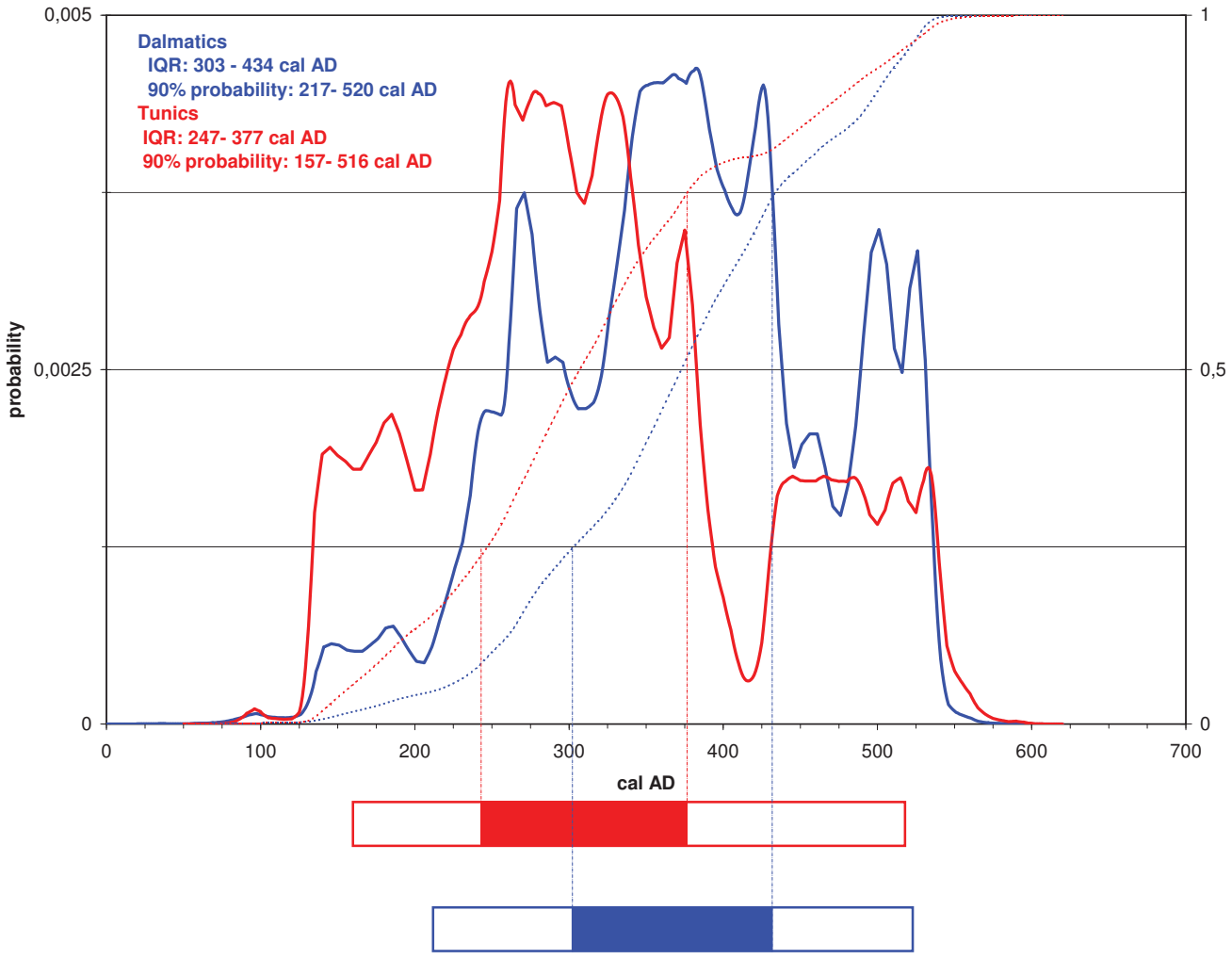
Dye Analyses

Nineteen purple coloured woollen decoration threads from 17 of the fragmentary tunics and dalmatics under study were analysed with HPLC-DAD for the identification of organic dyes. Chromatographic analysis was carried out after extraction of the dyes from the wool fibres using acidified methanol. Full description of the applied technique was published before (Wouters 1985). Table 4 shows the outcome of the dye analyses for each sample, expressed by means of the relative ratio of both the anthraquinone (column 4) and the indigoid (column 5) dye constituents found after integration at 255 nm. Column six gives the interpretation towards the possible vegetable or animal sources applied for dyeing.

Table 4 presents the results of the dye analysis for

Objects	Relative content alizarin: range	Indigotin + indirubin: Mean value (sd)	Alizarin + purpurin: Mean value (sd)
Roman Egyptian purple tunics and dalmatics (n=18)	7-38	21 (9)	79 (9)
Roman Egyptian purples (n=22)	0-23	8 (5)	92 (5)
'Coptic' Egyptian purples (n=4)	10-37	9 (5)	91 (5)

Table 5. Comparison between the analytical composition of dyestuffs in the purple tunics and dalmatics and other studies of purple Roman and 'Coptic' Egyptian textiles. A. Range of the relative content of alizarin (= the relative ratio between alizarin and purpurin calculated from integration values of the peak areas at 255 nm). B. Mean value and standard deviation (sd) of the relative ratio between the indigoid and the madder dyestuffs (all calculations based on the integration values of the peak areas at 255 nm). Data collected from Wouters 2009.



Graph 2. Sum probability and integrated probability distribution of 9 dalmatics and 5 tunics.

Fig. 1. SBM 9930. © Staatliche Museen zu Berlin - Stiftung Preußischer Kulturbesitz. Photo Antje Voigt.

Fig. 2. KMGK ACO.Tx.2472. © Royal Museums for Art and History, Brussels.

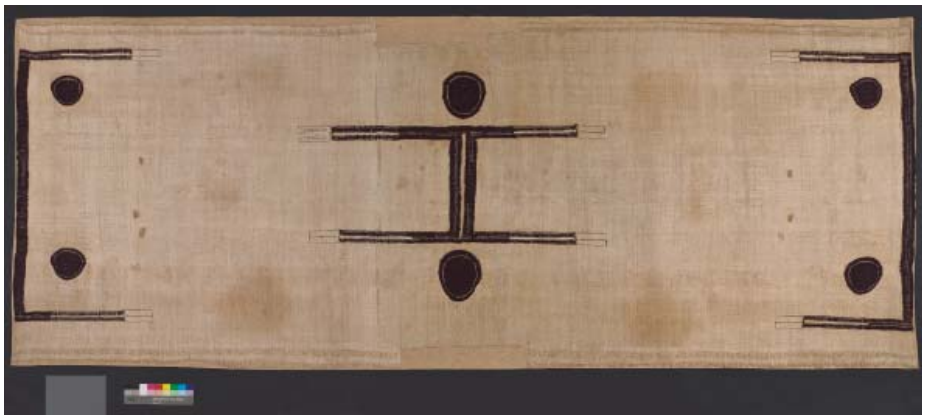


Fig. 3. KMGK ACO.Tx.2485. © Royal Museums for Art and History, Brussels.

Fig. 4. KMKG ACO.Tx.2477. © Royal Museums for Art and History, Brussels.

Fig. 5. BM EA 72491. © Trustees of the British Museum.

Fig. 6. V&A 361-1887. Photo © Victoria and Albert Museum, London.

Fig. 7. WAG T.1995.145. © The Whitworth Art Gallery, The University of Manchester.

Fig. 8. WAG T.1994.129 © The Whitworth Art Gallery, The University of Manchester.

Fig. 9. WAG T.1996.92 © The Whitworth Art Gallery, The University of Manchester.

Fig. 10. KMKG ACO.Tx.2467 A-B. © Royal Museums for Art and History, Brussels.

Fig. 11. KMKG ACO.Tx.2474. © Royal Museums for Art and History, Brussels.

Fig. 12. KTN 489. © Collection Katoen Natie, Antwerp.

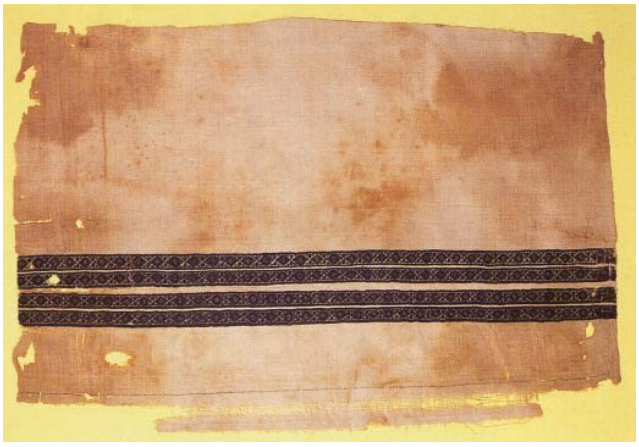


Fig. 13. GLM 1704. © Gustav Lübcke Museum, Hamm.

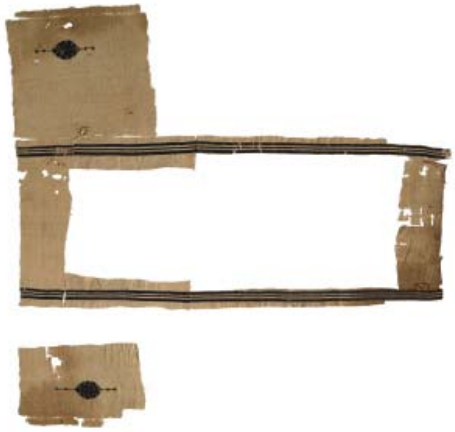


Fig. 14. KTN 989. © Collection Katoen Natie, Antwerp.

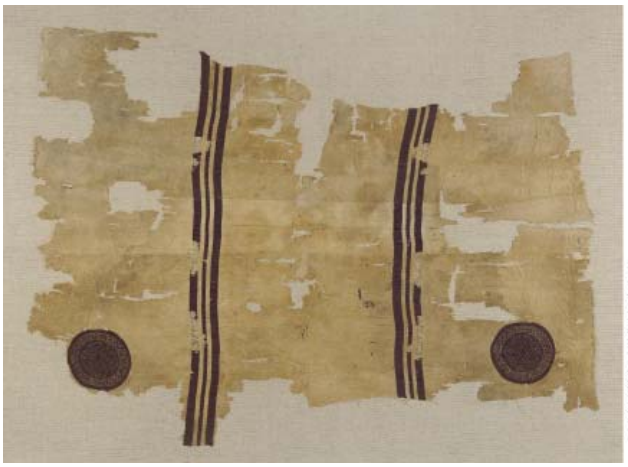


Fig. 15. SBM 9936. © Staatliche Museen zu Berlin - Stiftung Preußischer Kulturbesitz. Photo: Antje Voigt.

Fig. 16. BM PE 1955.2-6.10. © Trustees of the British Museum.

each purple wool sample (relative ratios of components are calculated after the peak areas integrated at 255 nm; al: alizarin, pu: purpurin, ag: anthragallol, xp: xanthopurpurin, xp': xanthopurpurin like spectra, in: indigotin, ir: indirubin, mbi: 6-bromo indigotin and xbir: bromated indirubin).

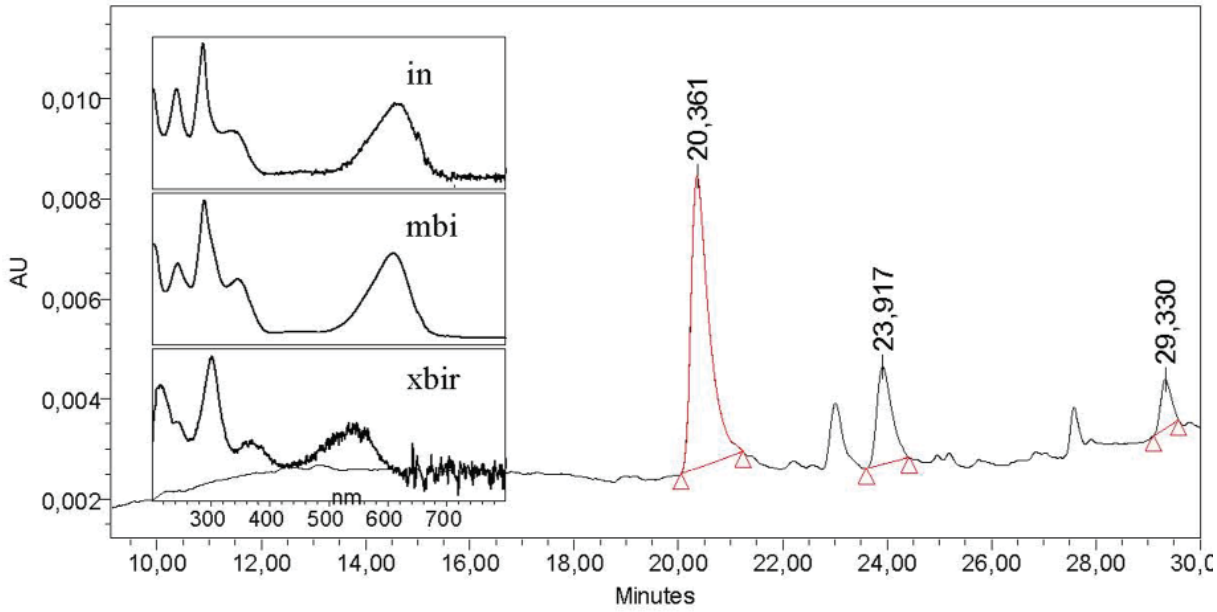
All purple-coloured threads from the tunics and dalmatics were found to be dyed in a similar way except one, the purple from ACO.Tx.2477 from KMKG. The detection of anthraquinone dye components alizarin (al), purpurin (pu) and the minor components anthragallol (ag) and xanthopurpurin (xp) is indicative for the use of the roots of a red dye source belonging to the *Rubiaceae* family. Indigoid components indigotin (in), sometimes in combination with the isomer indirubin (ir) refers to a vat dyeing with an indigo source (*Indigofera* species or *Polygonum* species) or with woad (*Isatis tinctoria* L.). As the same dye constituents are found after chromatographic analyses of the extracts of woad or indigo dyed fibres, no distinction can be made between both sources. Historically, both types were known in Egypt during the period under consideration (Forbes 1956, 108-110).

In the purple woollen thread used for the small decorations of the tunic ACO.Tx.2477, brominated indigoid constituents were identified in the presence of indigotin: 6-bromo indigotin (mbi) and bromated indirubin (xbir). Such brominated indigotin or indirubin components are the evidence for the use of an indigoid dye source of animal origin, commonly named mollusc, shellfish or Murex purple. The most important species used in antiquity were *Bolinus brandaris* (L. 1758, old name *Murex brandaris*) and Hexaplex *trunculus* (L. 1758, old name *Murex trunculus*) but also *Stramonita haemastoma* (L. 1766, old names *Thais* or *Purpura haemastoma*), the latter present only on the Atlantic coast. The dye was mentioned by Pliny the Elder in his *Naturalis Historia* (Forbes, 1956, 117). *Bolinus brandaris* is better known as the spiny dye-murex, as it has grooves and spines on the outside of the shell. This species is found at the depth of 9-200 m in shallow bays of the Mediterranean coast. *Hexaplex trunculus*, also called the banded dye murex can be found on the Mediterranean as well as on Atlantic coasts, on cliffs between the stones or muddy bottoms at a depth of 2-130 m, while *Stramonita haemastoma* inhabits shallow coasts of North African coastal areas and western Atlantic coasts, at a depth between 1 and 9 m.

The colouring material produced by enzymatic reaction of the hypobranchial glands from *B. brandaris* and *S. haemastoma* is mainly 6, 6'-dibromoindigotin, in the former species together with minor quantities of 6, 6'-dibromoindirubin, while from the *H. trunculus* mollusc, mainly indigotin and 6, 6'-dibromoindigotin are formed and minor quantities of indirubin. It is the presence of indigotin which is the cause of the more bluish coloration of the latter shellfish dye (Hofenk de Graaff 2004, 264-266). In the 1990s, pigments (stains) and vat dyes prepared from these three mollusc species were investigated by Wouters in order to characterise the analytical composition of the dyestuffs using HPLC-DAD analyses (Wouter 1992). More recent research on the analytical protocol for indigoid dyes was published by Koren (2008).

The HPLC-DAD result of the shellfish purple coloured fibres is presented in Graph 3, showing the chromatogram and the UV-Vis absorbance spectra of the identified peaks of indigotin and the two brominated constituents. The actual analytical composition of the dyestuffs in the present sample, with mostly indigotin, can be considered as indicative for the use of molluscs from the banded dye murex (*H. trunculus)* rather than from the two other species. However, it is preferable not to make any definite assignment considering that not much is known yet about the influence of the methods of harvesting, the dyeing process, the natural ageing and the way of extraction of the dyestuffs from the dyed fibres, on the analytical composition of the dyestuff found in archaeological fibres.

In ancient Rome, the use of mollusc or Tyrian purple was restricted to members of the royal family and the court. As true purple dyeing was so expensive, other dyestuffs were often used to mimic the royal purple. One of these methods is the production of purple hues by means of top dyeing with madder of premordanted and indigo vat dyed fibres. This must have been a very popular procedure in Egypt, as concluded in previous studies of Egyptian textile fragments dated in the Roman (Wouters *et al*. 2008) and 'Coptic' period (Wouters 1993). The recent results in the present series of linen tunics and dalmatics are in complete correspondence with these conclusions. A more in-depth study (Table 5) of the analytical composition of the madder source, by means of calculating the relative ratio between the two components alizarin and purpurin (calculated from integration values obtained at 255 nm) demonstrates that a relative content of alizarin ranges between 7 and 38. The very low relative amount of alizarin found in the purple samples from the tunics and dalmatics is consistent with the earlier studies of purple-dyed fibres from Roman and 'Coptic' period Egyptian textiles and confirms the differences in composition between the threads dyed in purple and the other colours, obtained by a madder dyeing alone or in combination with other dyes (Wouters 2009).



Graph 3. Chromatogram and spectra of dye components from purple wool fibres (KIK-IRPA sample code: 09896/04) from ACO.TX 2477 dyed with mollusc purple (integration at 288 nm): indigotin (in; 20.4 rt); 6-bromo-indigotin (mbi; 23.9 rt) and brominated indirubin (xbir; 29.3 rt).

Conclusion

Egyptian purple dyeing, a two-step dyeing process consisting of the top dyeing with a madder type of dye on premordanted and indigo or woad dyed fibres, was the overall procedure applied for the purple-coloured woollen threads from the 17 Roman dresses from Egypt.

This way of producing a high quality, though 'false' Royal purple can clearly be considered as very characteristic for purple dyeing in Egypt. Evidenced by the numerous purple decorations of Egyptian textiles in which it was found, this more economic way of purple dyeing was clearly applied on a large scale in Egypt and during a very long time span, covering the entire 1st millennium AD. Very few exceptions using true mollusc purple have been found. In this series, tunic ACO.Tx.2477 (Graph 3) with very narrow *clavi* was the only piece dyed with true purple. This could probably be expected. Because true purple was extremely expensive one can assume that it was mostly used sparingly. True purple was also detected in two other pieces with tiny decorative elements in the collection of Katoen Natie (De Moor, Verhecken-Lammens and Verhecken 2009, 166-167: inv. KTN 1475, 14C-dating: 420-550 AD (95.4 % probability) and 194-195, inv. KTN 620/DM139, 14C-dating: 660-780 AD (95.4 % probability)). Small sized decorations are often – in addition to the visual colour – an indication for the use of this precious dyestuff.

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Abbreviations

BM	London, British Museum
GLM	Hamm, Gustav-Lübcke-Museum
KMKG	Brussels, Koninklijke musea voor kunst en geschiedenis
KTN	Antwerp, Katoen Natie
MAK	Vienna, Museum für Angewandte Kunst
ML	Paris, Musée du Louvre
SBM	Berlin, Skulpturensammlung und Museum für Byzantinische Kunst
V&A	London, Victoria and Albert Museum
WAG	Manchester, The Whitworth Art Gallery

(1) For an image see: http://www.sammlungen.mak.at/sdb/do/start.state, link: Spätantike Textilien, no 195.
(2) For an image see: http://www.sammlungen.mak.at/sdb/do/start.state, link: Spätantike Textilien, no 196.

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