

Textile History

Aims and Scope

Textile History was launched in 1968 by the Pasold Research Fund as part of its policy of fostering research and publication on the history of textiles, their technological development, design, conservation, the history of dress and other uses of textiles. The Editors are always pleased to learn of new research in this area and welcome inquiries about publication, major exhibition reports, or reviews. The activities of the Fund fall into three main categories: sponsoring publications, organizing conferences, and awarding grants for research. The Director, Mr N. B. Harte, will be pleased to hear from anyone interested in any of the Fund's activities. Please write to him at the following address: Pasold Research Fund, London School of Economics, Houghton Street, London WC2A 2AE.

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'In a Dressmaking Shop' from the illuminated Code of Balthasar Behem donated to the town council of Cracow in 1505. The Code is now in the Jagiellonian Library, Cracow, and reproduced here by kind permission. For the context see Dr Frank Carter's article in this issue.

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The Evaluation of Metal Wrappings from Medieval Textiles Using Scanning Electron Microscopy-Energy Dispersive X-Ray Spectrometry

N. INDICTOR, R. J. KOESTLER, C. BLAIR, AND A. E. WARDWELL

INTRODUCTION

In a previous study in these laboratories, some metal wrapped textile specimens were examined by SEM-EDS, and the pitfalls and difficulties were enumerated.¹ Although considerable information may be gained regarding structural features of metal wrapped fibres, caution must be exercised in describing some technical features: surface homogeneity; identity of wrapping substrate; and the meaning of elemental analysis of the core fibres. Greater confidence may be assumed in the description of: fibre and wrapping twists; dimensions of wrapping material; approximate surface metal composition; and overall mechanical structure of the specimen. When the metallic component is independent of a substrate wrapping material (that is, metal alone wrapped around a core fibre directly), the description of the system is relatively simple.² When the metallic component is first applied to a substrate (paper, parchment, membrane, leather) with (or without) a stabilizing ground and then wound about a core fibre, the description of the system becomes more difficult. Interaction of the structural elements, inherent inhomogeneity in the manufacturing processes, wear, metal corrosion, degradation of the organic materials — all tend to lower analytical confidence. In this study, samples have been taken from textiles which have appeared in art historical literature for many years with fairly consistent dating but varying geographical attributions. Attributions have usually been made on the basis of style. This method has led to confusion and contradiction, particularly in the field of fourteenth-century silks because of the international style that prevailed at the time. A detailed comparative study of weave structures along with the composition of metallic threads may prove to be a sounder method of attribution. Table 1 lists accession numbers, brief attributions, and literature citations for the textile or obviously identical fabrics.³ An appendix lists additional references for the textiles and related pieces and lists other collections with related pieces. Figure 1 shows some of the textiles from which samples were taken. Figure 2 shows some SEM micrographs of the metal wrapped yarns.

EXPERIMENTAL

The details of examination, using light microscopy and SEM-EDS has been described previously.¹ See Figure 2 for illustrations of specimens examined with SEM. The descriptions of the condition of the samples are for the specimens analysed and not for the textile as a whole. These textiles all have clearly visible areas of lost metallic surfaces. It should be noted that occasionally in the handling of specimens some structural details and important

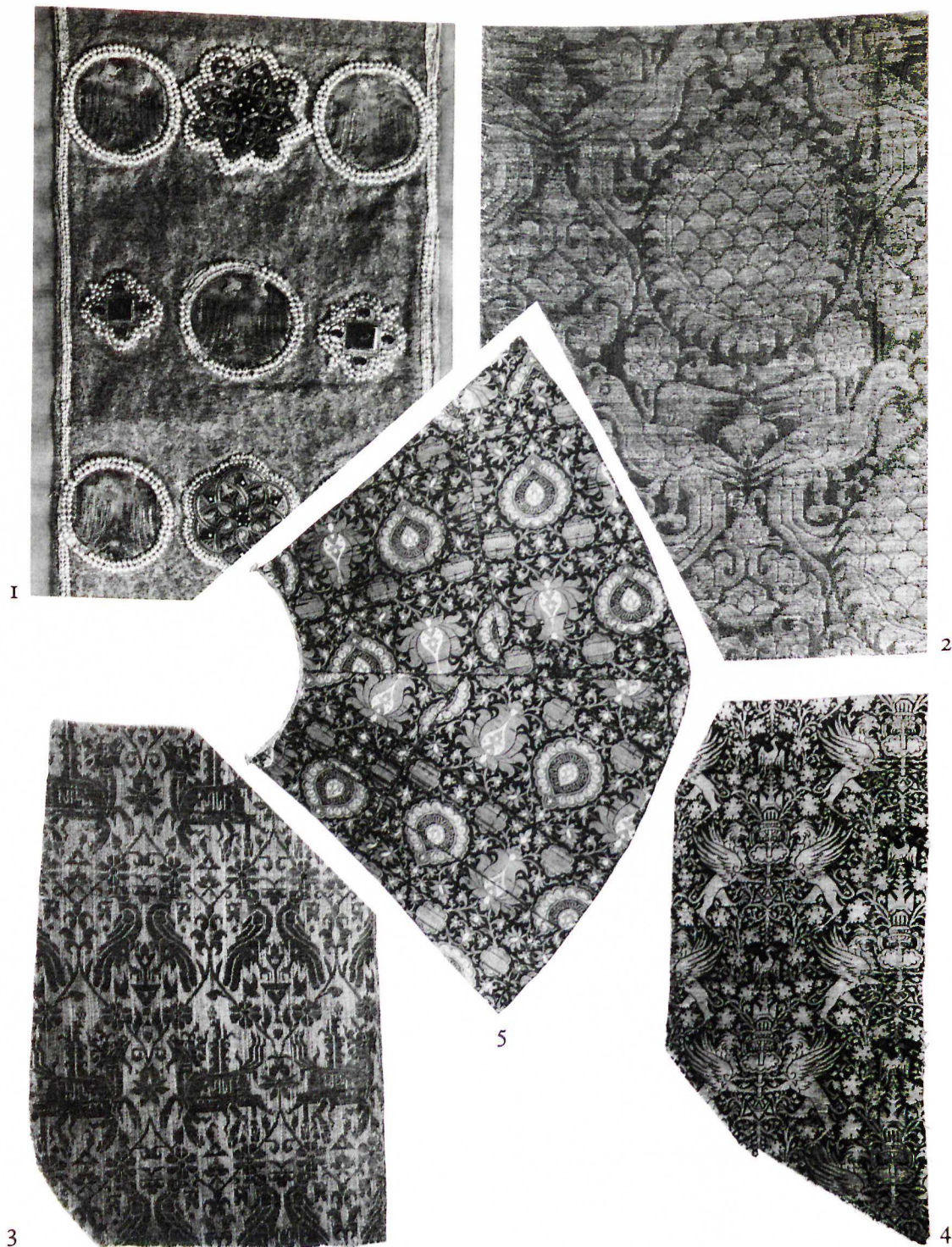


FIG. 1. TEXTILES FROM WHICH SAMPLES WERE TAKEN
(Accession numbers correspond to Table I.)

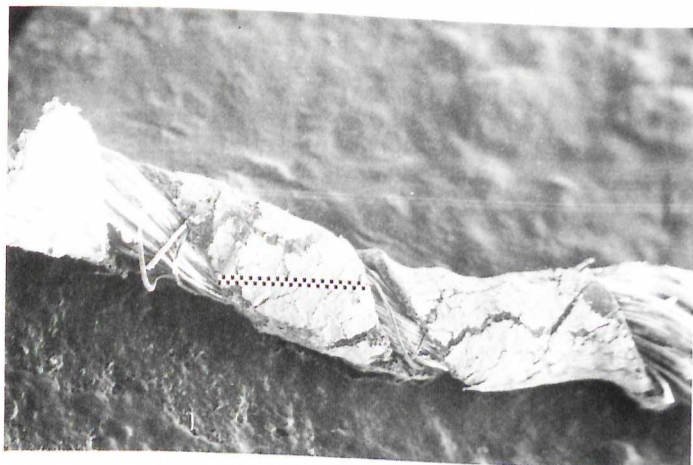
TABLE I: TEXTILES FROM WHICH SAMPLES WERE TAKEN

Acc. No.	Brief Description	References*
¹ CMA 39.40	Egypt or Syria, 14th C.	11, fig. 116; 12, pl. 66, no. 291
CMA 19.28	Egypt/Syria, 13-14th C.	12, no. 29; [13], pl. 42
CMA 19.29	Italy, 14th C.	12, pl. 25, no. 96
² Stola	Italy, 14th C.	14, fig. 11
CMA 28.649	Italy, 14th C.	15, fig. 103; 16, pl. 40; 17, no. 104; 18, no. 28; 19, fig. 5; 20, fig. 31
CMA 31.61	Italy, 14th C.	19, fig. 21; 21, no. 206
CMA 27.380	Spain, 13th C.	12, pl. 32, no. 116; 15, fig. 51; 21, no. 78; 22, no. 124.
CMA 28.650	Spain, 13th C.	12, pl. 33, no. 118; 21, no. 77
CMA 32, 137	Spain, 13th C.	12, pl. 34, no. 123; 15, fig. 91; 21, no. 75; 23, fig. 183
CMA 42.1077	Spain, 13th C.	12, pl. 33, no. 117; 15, fig. 47; 21, no. 80
CMA 48.498	Spain, 13th C. (half silk)	unpublished
CMA 39.42	Spain, 14th C.	15, fig. 88; 24, fig. 27
CMA 39.48	Spain, 15th C.	21, no. 95
CMA 18.30a	Near East, 14th C.?	[15], fig. 146-47; [25], no. 99, 100
CMA 39.44	Near East, 14th C.	15, fig. 95; 18, pl. 21; 21, no. 180; 26, fig. 295; 27, fig. 48; 28 no. 98
CMA 18.292	Near East, 14th C.	25, no. 27; 29, pl. iv
CMA 45.14	Near East, 14th C.	30, pl. 116a
³ KR 06109	Near East, 14th C.	30, pl. 110; 31, fig. 11; 32, pl. 59
CMA 85.4	W. Turkestan, 14th C.	33, pl. 998B
CMA 29.905	Near East, 14th C.	16, pl. 32; [25], no. 64b
CMA 45.34	Near East, 14th C.	12, pl. 25; 18, pl. 26; 34, pl. 46, III
CMA 26.509	Near East, 14th C.	12, no. 91; 21, no. 191; 28, cat. 99
KR 00135	Near East, 14th C.	35, no. 32
⁴ CH 02-I-273	Near East, 14th C.	[25], fig. 92a; 36, III, 43
CH 02-I-285	Near East, 14th C.	[25], no. 71
⁵ CAI 1961.1196	Near East, 14th C.	16, pl. 34

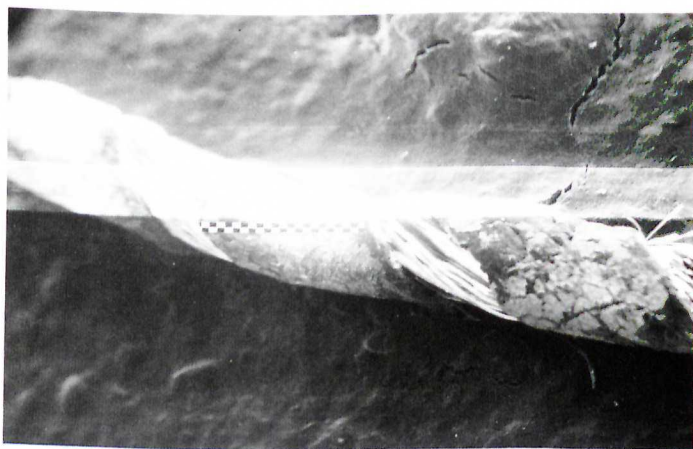
*[Brackets] indicate closely related, but not identical fabrics. See also appendix.

1. CMA = Cleveland Museum of Art
2. Kunsthistorische Museum, Vienna
3. Krefeld, Deutsches Textilmuseum
4. Cooper-Hewitt Museum, New York
5. Chicago Art Institute

Metal Wrappings from Medieval Textiles



a.



b.



c.

FIG. 2.

descriptive features may be lost. For example a single specimen cannot reveal that some wrapping is S twist and some Z twist (CMA 39.44). Sometimes in the handling of the specimen the twist of the core disappears or the tightness of twist (of core and wrapping) becomes difficult to judge. Such descriptive details are better judged by examination of the textile itself. In general, it is important to examine the textile as a whole in addition to single specimens for adequate descriptions.

RESULTS AND DISCUSSION

Table 2 shows results of examination by light and electron microscopy. An attempt is made to describe: 1. Condition of the specimen. 2. Overall structure of the specimen (tightness of wrapping, direction of twist, etc). 3. Identity of materials of core and wrapping, and 4. Colour of core and wrapping. Identification of 'gold' or 'silver' in this table reflects visual observations only. Sometimes the gold or silver actually present is detected by EDS and not with the light microscope (cf. CMA 28.650 and CMA 48.498).

Table 3 shows EDS results indicating elemental composition of the wrapping and core (elements above atomic no. 10). Presence and absence of gold, silver, and other significant elements is indicated, including approximate percentages for the wrapping surface. Elemental analysis of the wrapping surface reflects the fact that some metal surface has been lost. The presence of calcium, silicon, and sulphur in the analysis of the metal surface indicates that substrate and/or ground for the metallic layer is interacting with the electron beam. The values obtained for gold and silver are therefore probably low in an absolute sense as an indicator of the original metal surface composition. The presence or absence of copper may be significant in indicating the purity of the metals employed, although in some cases, copper was observed (<10%) as part of the wrapping material but *not* part of the metal surface, suggesting that it might have been part of the adhesive material for the metal surface (CMA 32.137, CMA 48.498). Sulphur was observed in all analyses for wrapping and core fibres; aluminium and iron were frequently found in both wrapping and core materials. Silver was usually found in core fibres when silver was present on the surface, but gold was not found in the cores, suggesting that the more easily corrodable silver migrated. The percent compositions obtained for gold and silver therefore probably reflect a certain amount of 'surface enrichment' similar to that encountered in gold alloy objects in which baser metals have been displaced through chemical processes that do not affect gold. In one case (CMA 19.28, see Figure 2C), an area showing pure gold, occurs at the overlapping of two leaf layers, but the surrounding areas show only about 93% gold. The other trace elements encountering electrons are from the broken metallic surface and arise from the

FIG. 2. SCANNING ELECTRON MICROGRAPHS OF SAMPLES

- a. Scanning Electron micrograph (20KV x60) of Sample from CMA 39.42, Showing Twist of Core (Silk) and Wrapping (Silver/Gold on Leather). Cursor indicates width of wrapping in microns.
- b. Scanning Electron Micrograph (20KV x55) of Sample from CMA 39.48, Showing Twist of Core (Silk) and Wrapping (Silver/Gold on Leather). Cursor indicates width of wrapping in microns.
- c. Scanning Electron Micrograph (20KV x650) of Wrapping Surface (Gold) Showing Overlapping of Metal Leaf. CMA 19.28. Leather wrapping not shown.

Metal Wrappings from Medieval Textiles

TABLE 2: SAMPLES EXAMINED (LIGHT MICROSCOPE AND SEM MICROGRAPHS)

Acc. No.	Description of Specimens
CMA 39.40	Core: undyed Silk, Z twist. Wrapping: Z twist, flattened metal, loosely but evenly wrapped. Corroded. Gold/silver appearance.
A	Outer surface. Metallic area.
B	Outer surface. Metallic area.
C	Core fibres.
D	Core fibres.
CMA 19.28	Core: undyed silk, Z twist. Wrapping: S twist, leather, loose but even spacing, core visible, silvery gold appearance, loss of metal.
A	Metal surface.
B	Wrapping.
C	Metal surface (double thickness of gold).
D	Core fibres.
CMA 19.29	Core: red silk, no twist. Wrapping: S twist, flattened metal, silvery gold, loosely wrapped.
A	Wrapping.
B	Core fibres.
Stola	Core: Lt. yellow or white silk, S twist. Wrapping: S twist flat metal, gold exterior, silver interior.
A	Exterior.
B	Interior.
CMA 28.649	Core: undyed linen, 2-ply S. Wrapping: S-twist parchment or membrane, closely wrapped, tarnished silver, some gold. Wrapping translucent (not brown).
A	Metal surface.
B	Wrapping.
C	Core fibres.
CMA 31.61	Core: undyed linen, 2-ply S. Wrapping: S twist, parchment or membrane, closely wrapped, only traces of tarnished silver visible on brown surface.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CMA 27.380	Core: lt. yel. silk, sl. Z twist. Wrapping: Z twist, membrane or parchment, brown ground. Evenly spaced about exposed core. Gold and silver; loss of metal.
A	Metal surface.
B	Wrapping.
C	Core fibres.

TABLE 2: SAMPLES EXAMINED (LIGHT MICROSCOPE AND SEM MICROGRAPHS) — (continued)

Acc. No.	Description of Specimens
CMA 28.650	Core: red & pik silk, sl. Z twist. Wrapping: Z-twist, loosely wrapped, dk. brown ground on membrane or parchment, sl. loss of metal, very bright gold.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CMA 32.137	Core: lt. yellow silk, Z twist. Wrapping: Z twist, reddish ground on membrane or parchment, loosely wrapped. Gold and silver; loss of metal.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CMA 42.1077	Core: lt. yel. Silk, sl. Z twist. Wrapping: Z twist, membrane or leather, tightly wrapped. Gold, silver on brownish ground visible. Loss of metal.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CMA 48.498	Core: v. white linen, 2 ply S. Wrapping: S twist, leather, closely wrapped, tarnished silver, loss of metal, brownish ground.
A	Metal surface.
B	Wrapping.
CMA 39.42	Core: yel. silk, Z twist. Wrapping: Z twist, leather, loosely wrapped, loss of metal, dark ground. Silvery gold.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CMA 39.48	Core: yel. silk, Z twist. Wrapping: Z twist, leather or membrane, loosely wrapped, core visible, inner surface of wrapping dk. Brown. Silvery gold.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CMA 18.30a	Core: yellow silk Z twist. Wrapping: Z twist, parchment, tightly wrapped. Bright gold on surface.
A	Wrapping.
B	Core fibres.

Metal Wrappings from Medieval Textiles

TABLE 2: SAMPLES EXAMINED (LIGHT MICROSCOPE AND SEM MICROGRAPHS) — (continued)

Acc. No.	Description of Specimens
CMA 39.44	Core: Undyed linen, 2 ply Z & S. Wrapping: Z & S twists, leather, tightly wrapped. Gold. Corroded.
A	Wrapping, metal absent.
B	Wrapping, metal present.
C	Core fibres.
D	Core fibres.
CMA 18.292	Core: lt. yel. silk, Z twist. Wrapping: Z twist, membrane or parchment, gold, tightly wrapped.
A	Wrapping.
B	Core fibres.
CMA 45.14	Core: undyed cotton, 2 ply Z. Wrapping: Z twist, leather, silver, tightly wrapped.
A	Wrapping.
B	Core fibres.
KR 06109	Core: lt. yel. silk, Z twist. Wrapping: Z twist, leather, gold, loosely wrapped.
A	Wrapping.
B	Core fibres.
CMA 85.4	Core: white & yel. Cotton, 2 ply Z. Wrapping: Z-twist, brownish, leather, v. tightly wrapped, brittle. Silvery gold.
A	Metal Surface.
B	Wrapping.
C	Core fibres.
CMA 29.905	Core: Undyed linen, 2 ply S. Wrapping: S twist, membrane or leather, mottled gold, br. leathery wrapping with blackish ground, closely wrapped.
A	Metal Surface.
B	Wrapping.
C	Core fibres.
CMA 45.34	Core: Undyed linen, 4 ply S. Wrapping: S twist, br., leathery wrapping. Not tightly wrapped. Gold.
A	Metal Surface.
B	Wrapping.
C	Core fibres.
CMA 26.509	Core: Undyed linen, 4 ply S. Wrapping: S twist, gold on dark brown leather or membrane (areas of transparency), loosely wrapped.
A	Metal surface.
B	Wrapping.
C	Core fibres.

TABLE 2: SAMPLES EXAMINED (LIGHT MICROSCOPE AND SEM MICROGRAPHS) — (continued)

Acc. No.	Description of Specimens
KR 00135	Core: tan (undyed?) cotton >1 ply Z. Wrapping: Z-twist, gold on brown ground attached to leather or membrane. Loosely wrapped.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CH 02-I-273	Core: tan (undyed?) silk, Z twist. Wrapping: S twist mottled gold on brown/black leather or membrane. Loose, regular wrapping.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CH 02-I-285-G	Core: undyed white linen, 3 ply S. Wrapping: S twist lustrous gold attached to membrane (translucent) through brown ground. Loose, regular wrapping.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CH 02-I-285-S	Core: undyed white linen, 3 ply S. Wrapping: S twist tarnished silver on lt. brown/orange ground attached to tan membrane or leather. Loosely wrapped.
A	Metal surface.
B	Wrapping.
C	Core fibres.
CAI 1961.1196	Core: undyed white cotton, >1 ply Z. Wrapping: Z-twist silvery surface on lt. Brown membrane or leather. Closely wrapped.
A	Metal surface.
B	Wrapping.
C	Core fibres.

adhesive material and the substrate to which the metal leaf is attached. None of the other metal surfaces examined were entirely free of substrate or adhesive material (except CMA 39.40 and CMA 19.29 which were flattened metal wound directly about core fibres). When low (~50%) values of gold and/or silver (e.g. CMA 39.44, CMA 45.14, CMA 29.905) were found the presence of other elements suggests wear, corrosion, or non-uniform application of the metal surface rather than impurity in the applied metals.

Table 4 shows a summary of all results including approximate widths of the wrapping materials, read directly from cursors on SEM micrographs. Finally, Table 5 focuses on the gold and silver contents in the samples tested. All the European examples examined contained both silver and gold in substantial quantities. The Italian examples always had more silver than gold. Among the Spanish textiles one group had more gold than silver; one group had more silver than gold. Among the Near Eastern specimens gold or silver but not

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TABLE 3: EDS RESULTS

Acc. No.		Elements Observed
CMA 39.40	A, B C, D	Ag(>75%), Au (<10%), Cu(<10%), S, other tr. elem. Al, Ca, S, traces of Ag and other elements.
CMA 19.28	A B C D	Au (~95%), other trace elements, no Ag. Ca, Fe, Si, Al, S, other elements. Au (~100%). Ca, Fe, Si, Al, S.
CMA 19.29	A B	Ag (~70%), Au (~15%), Cu (~10%), other tr. elem. Al, Ca, other trace elements.
Stola	A B	Ag (>70%), Au (~20%), Cu (~4.5%), other tr. elem. Ag (>90%), Au (none), Cu (~7%).
CMA 28.649	A B C	Ag (>85%), Au (>10%), other elements. Ag, Ca, S, Si. Ag, Ca, S, Si, Al, Fe.
CMA 31.61	A B C	Ag (>50%), Au (>30%), other elements. Ag, Au, Ca, S, Si, Al, Fe, other elements. Ag, Ca, S, Si, Al, F, other elements, no Au.
CMA 27.380	A B, C	Ag (>20%), Au (>75%), other trace elements. Ca, Al, Si, S, other elements.
CMA 28.650	A B C	Ag (~10%), Au (~80%), other trace elements. Ca, Al, Si, S, Fe, other elements, Au. Ca, Al, Si, S, Fe, other elements, no Au.
CMA 32.137	A B C	Ag (~6%), Au (~90%), other trace elements. Ag, Au, Ca, Si, Al, Fe, Cu, other trace elements. Ca, S, Al, Si, other elements.
CMA 42.1077	A B C	Ag (>10%), Au (~67%), other trace elements. Ag, Ca, S, Si, Al, Fe, other elements. Ca, S, Al, Si, other elements.
CMA 48.498	A B	Ag (~40%), Au (~5%), other elements. Ag, S, Si, Al, Fe, other elements.
CMA 39.42	A B C	Ag (~70%), Au (~20%), other elements. Ag, Au, Ca, Si, Al, Fe, S, other elements. Ag, Ca, S, Fe, Al, Si, other elements.
CMA 39.48	A B, C	Ag (>45%), Au (>35%), other elements. Ag, S, Ca, Al, Fe, other elements.

TABLE 3: EDS RESULTS — (continued)

Acc. No.		Elements Observed
CMA 18.30a	A	Au, no Ag, other trace elements.
	B	Al, S, other trace elements, including Fe.
CMA 39.44	A	Fe, Al, Ca, Au (~15%).
	B	Au (>50%), other trace elements, no Ag or Cu.
	C, D	Al, S, other elements, no Fe, Ag, Au.
CM 18.292	A	Au (>85%), other trace elements, no Ag.
	B	Al, S, Ca, Fe, other trace elements.
CMA 45.14	A	Ag (~60%), no Au, other trace elements.
	B	S, Ca, other trace elements, incl. Ag.
KR 06109	A	Au (>85%), no Ag, other trace elements.
	B	Al, S, Fe, other trace elements.
CMA 85.4	A	Ag (>80%), Au (~5%), Ca, S, other trace elements.
	B	Ag (~50%), Au (~5%), Ca, S, Si, Na, other tr. elem.
	C	Na, Cl, Ca, K, S, other tr. Elements. No Ag or Au.
CMA 29.905	A	Au (~50%), no Ag, other elements.
	B, C	No Au or Ag; Ca, S, Si, Al, Mg, other tr. elem.
CMA 45.34	A	Au (>90%), Ca, no Ag.
	B	No Au, no Ag; Ca, S, Al, other trace elements.
	C	Au (trace), other elements, as in B.
CMA 26.509	A	Au (>90%), Ag (trace), other trace elements.
	B	Au (tr.), Ag (none); Ca, Si, Al, S, other tr. elem.
	C	No Au, no Ag; Ca, Si, S, Al, Na, other tr. elem.
KR 00135	A	Au (>95%), no Ag; Ca.
	B	Au, Ca, Si, Al, S, other trace elements.
	C	No Au; Ca, Al, Ag, other elements.
CH 02-I-273	A	Au (>90%), no Ag; Ca, Si, other trace elements.
	B	Au, Ca, S, Fe, other trace elements.
	C	No Au; Ca, Al, S, K, Cl, Fe, other tr. elements.
CH 02-I-285-G	A	Au (>85%), no Ag; Ca, Si, other tr. elem. incl. Fe.
	B	No Au; Ca, Si, Al, S, other tr. elem. incl. Fe, Cu.
	C	No Au, Ca, Al, Si, S, other tr. elem. incl. Fe.
CH 02-I-285-S	A	Ag (>75%), no Au; S, Mg, other trace elements.
	B	Ag, Ca, Si, Al, Na, S, other trace elements.
	C	No Ag; Ca, S, Si, Al, other tr. elem. incl. Fe.
CAI 1961.1196	A	Ag (~75%), no Au; other trace elements.
	B	Ag (~40%), Ca, Si, Al, S, other tr. elem. incl. Fe.
	C	No Ag; Ca, K, Cl, S, other trace elements.

Metal Wrappings from Medieval Textiles

TABLE 4: SUMMARY OF FINDINGS

Acc. No.	Description of Specimens
CMA 39.40	Single wrapped undyed silk, Z twist. Z twist wrapping of loosely wrapped flattened metal. Ag:Au:Cu ~7.5:1:1. Wrapping width: ~234 microns (0.23 mm).
CMA 19.28	Single wrapped undyed silk, Z twist. S twist wrapping of leather loosely wrapped to which is attached nearly pure gold leaf. Au ~100%. Wrapping width: ~594 microns (0.59 mm).
CMA 19.29	Single wrapped red silk, no twist. S twist wrapping of loosely wrapped flattened metal. Ag:Au:Cu ~7:1.5:1. Wrapping width: ~240 microns (0.24 mm).
Stola	Single wrapped, lt. yellow silk, S twist. S twist metal wrapping. Outer surface composition; Ag:Au:Cu ~7:2:0.5. Inner surface composition; Ag:Au:Cu ~9.3:0:0.7. Wrapping width: ~370 microns (0.37 mm).
CMA 28.649	Single wrapped undyed linen, 2-ply S. S twist wrapping of parchment or membrane closely wrapped to which is attached metallic surface. Ag:Au ~8.5:1. Wrapping width: ~870 microns (0.87 mm).
CMA 31.61	Single wrapped undyed linen, 2 ply S. S twist wrapping of parchment or membrane closely wrapped to which is attached metallic surface. Ag:Au ~5:3. Wrapping width: ~540 microns (0.54 mm).
CMA 27.380	Single wrapped lt. yellow silk, sl. Z twist. Z twist wrapping of parchment or membrane loosely wrapped to which is attached metallic surface. Ag:Au ~2:7.5. Wrapping width: ~468 microns (0.47 mm).
CMA 28.650	Single wrapped red & pink silk, sl. Z twist. Z twist wrapping of dk. brown ground on membrane or parchment loosely wrapped to which is attached metallic surface. Ag:Au ~1:8. Wrapping width: ~744 microns (0.74 mm).
CMA 32.137	Single wrapped lt. yellow silk, sl. Z twist. Z twist wrapping of parchment or membrane loosely wrapped to which is attached metallic surface. Ag:Au ~1:18. Wrapping width: ~1040 microns (1.04 mm).
CMA 42.1077	Single wrapped lt. yellow silk, sl. Z twist. Z twist wrapping of leather or membrane tightly wrapped to which is attached metallic surface. Ag:Au ~1:6.7. Wrapping width: ~540 microns (0.54 mm).
CMA 48.498	Single wrapped white linen, 2 ply S. S twist wrapping of leather closely wrapped to which is attached metallic surface. Ag:Au ~8:1. Wrapping width: ~480 microns (0.48 mm).
CMA 39.42	Single wrapped yellow silk, Z twist. Z twist wrapping of leather loosely wrapped to which is attached metallic surface. Ag:Au ~7:2. Wrapping width: ~394 microns (0.39 mm).
CMA 39.48	Single wrapped yellow silk, Z twist. Z twist wrapping of leather or membrane loosely wrapped to which is attached metallic surface. Ag:Au ~9:7. Wrapping width: ~520 microns (0.52 mm).

TABLE 4: SUMMARY OF FINDINGS — (continued)

CMA 18.30a	Single wrapped yellow silk, Z twist. Z twist wrapping of parchment, tightly wrapped to which is attached gold. No silver. Wrapping width: ~970 microns (0.97 mm).
CMA 39.44	Single wrapped undyed linen, 2 ply Z & S. Z & S twist tightly wrapped leather to which is attached gold; no silver or copper. Wrapping width: ~340 microns (0.34 mm).
CMA 18.292	Single wrapped lt. yellow silk, Z twist. Z twist wrapping of membrane or parchment tightly wrapped to which is attached gold; no silver or copper. Wrapping width: uncertain (SEM image did not permit measurement).
CMA 45.14	Single wrapped undyed cotton, Z twist. Z twist wrapping of leather tightly wrapped to which is attached silver; no gold or copper. Wrapping width: ~765 microns (0.76 mm).
KR 06109	Single wrapped lt. yel. silk, Z twist. Z twist wrapping of leather loosely wrapped to which is attached gold; no silver or copper. Wrapping width: ~700 microns (0.70 mm).
CMA 85.4	Single and double wrapped undyed cotton, 2 ply Z. Z twist wrapping of membrane or leather tightly wrapped to which is attached tarnished metal. Ag: Au ~17:1 Wrapping width: ~540 microns (0.54 mm).
CMA 29.905	Single wrapped undyed linen, 2 ply S. S twist wrapping of brown membrane or leather closely wrapped to which is attached, on a blackish ground, mottled gold. No silver or copper. Wrapping width: ~420 microns (0.42 mm).
CMA 45.34	Single wrapped undyed linen, 4 ply S. S twist wrapping of brown membrane or leather loosely wrapped to which is attached gold. No silver or copper. Wrapping width: ~550 microns (0.55 mm).
CMA 26.509	Single wrapped undyed linen, 4 ply S. S twist wrapping of brown membrane to which is attached gold (tr. of silver). Wrapping width: ~550 microns (0.55 mm).
KR 00135	Single wrapped tan (undyed?) cotton, 2 ply Z. Z twist wrapping of leather or membrane loosely wrapped to which is attached gold on a brown ground. No silver. Wrapping width: ~510 microns (0.51 mm).
CH 02-1-273	Single wrapped tan (undyed?) silk, Z twist. S twist wrapping of leather or membrane (brown/black) loose, regular, to which is attached mottled gold. No silver. Wrapping width: ~450 microns (0.45 mm).
CH 02-1-285-G	Single wrapped undyed linen, 3 ply S. S twist wrapping of translucent membrane loosely wrapped through brown ground to which is attached lustrous gold. No silver. Wrapping width: ~720 microns (0.72 mm).
CH 02-1-285-S	Single wrapped undyed linen, 3 ply S. S twist wrapping of tan membrane or leather loosely wrapped to which is attached tarnished silver through lt. brown/orange ground. No gold. Wrapping width: ~450 microns (0.45 mm).
CAI 1961.1196	Single wrapped undyed cotton, 2 ply Z. Z twist wrapping of lt. brown membrane or leather loosely wrapped to which is attached gold. No silver. Wrapping width: ~600 microns (0.60 mm).

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TABLE 5: GOLD/SILVER CONTENT

CMA 39.40 19.28	Egypt-Syria	Ag > Au Au
19.29 Stola 28.649 31.61	Italy	Ag > Au Ag > Au Ag > Au Ag > Au
27.380 28.650 32.137 42.1077 48.498 39.42 39.48	Spain	Ag < Au Ag < Au Ag < Au Ag > Au Ag > Au Ag > Au Ag > Au
18.30a 39.44 18.292 45.15 KR 06109 85.4 29.905 45.34 26.509 KR 00135 CH 02-1-273 CH 02-1-285 CAI 1961.1196	Near East	Au Au Au Ag Au Ag (5% Au) Au Au Au (Ag trace) Au Au Au or Ag Ag

both was found, except for CMA 26.509 in which a trace of the minor element was found. In the textile attributable to Central Asia, CMA 85.4, the quantity of the minor element found was more than that in CMA 26.509, but less than that found in the Spanish and Italian samples. The two Mamluk examples do not permit generalization: one had silver in excess of gold (CMA 39.40) — flattened metal wound directly about silk core; one was gold only (CMA 19.28) — gold leaf on leather wound about silk core. Since metal wrapped yarns are readily transportable and an easy medium of trade it is possible that the gold/silver ratios may indicate manufacturing sites for the wrapped yarns without indicating sites of the weaving centres. A tentative European assignment may be made for the mixed metal; a Middle Eastern assignment may be made for the specimens containing gold *or* silver in the absence of the other.

A study focusing particularly on Central Asian and Near Eastern silks of the late Mongol early Timurid period is in preparation; comparative observations will be made as well on Italian, Spanish, and Mamluk silks of the fourteenth century underscoring the distinguishing technical peculiarities of each.

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- ³ Bibliography, items 11-36.

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APPENDIX. BIBLIOGRAPHY OF TEXTILES STUDIED AND RELATED PIECES

Textile	References	Collections* with Related Pieces and Accession Numbers
CMA 39.40	11, 12, 37-41	_____
119.28	13	_____
19.29	12	_____
Stola	14	_____
28.649	15-20, 25, 30, 42-46	C.H., N.Y., 02.1.353; M.H.T., Lyon; V. & A., London, 49-1894; C.A.I., Chicago, 47.330; M.A., Barcelona, 23.887; M.E., Vich, 2528; M.C., Brussels; D.T., Krefeld, 02191; Kgm., Berlin; A.S., Riggisberg; M.F.A., Boston, 96.610; L.A.C.M.A., Los Angeles; M.M.A., N.Y., 12.55.2.
31.61	12, 19, 21, 25, 30, 43, 47-53	G.M., Nürnberg, 533; K.I., Vienna; Kgm., Berlin, 81.963; M.C., Brussels; V. & A., London, 8309; M.N., Florence; M.F.A., Boston; L.A.C.M.A., Los Angeles, 55.57.10
27.380	12, 15, 16, 21, 22, 54, 55	I.V.D.J., Madrid, 8; T.M., Wash, D.C., 84.25; M.M.A., N.Y., 46.156.3; A.S., Riggisberg, nos. 6, 16 M.H.T., Lyon, 30411, 29731; M.A., Barcelona; M.T.B., Tarrasa, V22 A.I.C., Chicago, 16.379; M.F.A., Boston; 28.326 C. H., N.Y. 1943-20-1 & 1944-21-1 (with border); Formerly Barcelona, private collection — large piece with selvage; present location unk. M.A., Barcelona, pieces still attached to San Valero vestments, 27958.

APPENDIX. BIBLIOGRAPHY OF TEXTILES STUDIED AND RELATED PIECES — (*continued*)

Textile	References	Collections* with Related Pieces and Accession Numbers
28.650	12, 21, 47, 55-57	I.V.D.J., Madrid, 52.
32.137	12, 15, 16, 21 23, 47, 58-61	I.V.D.J., Madrid, 9a, 9b; A.I.C., Chicago, 50.1; T. M., Wash. D.C., 84.27; M.M.A., N.Y., 28.194.
42.1077	12, 15, 16, 21, 47, 51, 55, 62, 63	M.A., Barcelona, 5202, 5203; M.M.A., N.Y., 46.156.4; Loewi; A.I.C., Chicago, 45.167; M.A., Barcelona, 32897; I.V.D.J., Madrid, 48.
48.498	— Unpublished —	
39.42	12, 15, 24, 36, 38, 47, 75	I.V.D.J., Madrid, 19; I.V.D.J., Lazaro Col., Madrid. 5722, 1604; M.A., Barcelona; M.H.T., Lyon, 694; Rijks., Amsterdam, 12157; C.H., N.Y., 1902-1-311.
39.48	12, 21, 30, 38	A.S., Riggisberg, 681; M.A., Barcelona; M.H.T., Lyon.
18.30a	15, 25, 64-66 73	M.C., Brussels; M.A.D., Paris, [in book of samples: Album EE 7, vol. 1]; M.N., Florence; M.H.T., Lyon; H.S., N.Y.
39.44	15, 18, 21, 25-28, 30, 36 38, 43, 67-69, 73	Kgm., Berlin; M.C., Brussels; M.C., Paris; V. & A., London, 772-1894; M.A.D., Paris, 7557; M.M.A., N.Y., 15.126.2; C.H., N.Y., 02-1-262; C.S., Milan, 228T; Rijks., Amsterdam; M.M.F.A., Montreal, 49.50DT5; A.S., Riggisberg, 214; U.P., Phila.
18.292	25, 29, 73	M.C., Brussels.
45.14	30, 73	Kgm., Berlin.

APPENDIX. BIBLIOGRAPHY OF TEXTILES STUDIED AND RELATED PIECES — (continued)

Textile	References	Collections* with Related Pieces and Accession Numbers
KRo6109	30-32, 73, 76-78	Kgm., Berlin; Rijks., Amsterdam.
85.4	33, 73	Kgm., Berlin; D. T., Krefeld 88790; M.H.T., Lyon, 27238.
29.905	16, 25, 73	M.C., Brussels, 402; V & A, London, T86-1910; C.A.I., Chicago, 52.1252; M.A., Barcelona, 23.780; M.E., Vich.
45.34	12, 18, 25, 26, 30, 34, 52, 73	Kgm., Berlin, 97.70; M.H.T., Lyon, 25496; V. & A., London, 782-1893; M.C., Brussels; M.A.D., Paris, 14660; C.H., N.Y. 02-1-220; G.M., Nürnberg, 512.
26.509	12, 21, 28, 73	M.H.T., Lyon, 28.340; C.H., N.Y., 02-1-292; M.F.A., Boston, 39.542.
KR 00135	35, 74, 77	Marienkirche, Lübeck.
CH 02-1-273	25, 26, 36 73, 77	M.C., Brussels, 458; Kgm., Berlin, 97.71; M.A.D., Paris, 16351; D.T., Krefeld, 01288.
Ch 02-1-285	25, 26, 43, 70, 73	M.C., Brussels, 458; V. & A., London, 779-1893.
CAI 1961.1196	16, 25, 26, 30, 71-74	M.C., Brussels; Kgm., Berlin; M.H.T., Lyon.

ABBREVIATIONS USED IN APPENDIX

A.S. = Abegg Stiftung	M.C. = Musée cinquantenaire d'arte et d'histoire (Brussels)
C.A.I. = The Art Institute of Chicago	M.C. = Musée Cluny (Paris)
C.H. = Cooper Hewitt Museum	M.E. = Museo Episcopale
C.S. = Castello Sforzesco	M.F.A. = Museum of Fine Arts
D.T. = Deutsches Textilmuseum	M.H.T. = Musée historique des tissus
G.M. = Germanisches National Museum	M.M.A. = Metropolitan Museum of Art
H.S. = Hispanic Society	M.M.F.A. = Montreal Museum of Fine Arts
I.V.D.J. = Instituto de Valencia den Don Juan	M.N. = Museo Nazionale
K.I. = Kunst & Industrie (now Museum für Angewandte Kunst)	M.T.B. = Museo Textile Biosca
Kgm. = Kunstgewerbemuseum	Rijks. = Rijksmuseum
L.A.C.M.A. = Los Angeles County Museum of Art	T.M. = Textile Museum
Loewi = Loewi Collection, Los Angeles, CA	U.P. = University of Pennsylvania Museum (now Philadelphia Museum of Art)
M.A. = Museo des Arte	V. & A. = Victoria and Albert Museum
M.A.D. = Musée des arts décoratifs	