METROPOLITAN MUSEUM JOURNAL 57

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VOLUME 57 / 2022

THE MET

The Metropolitan Museum of Art

NEW YORK

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This publication is made possible by a gift from Assunta Sommella Peluso, Ada Peluso, and Romano I. Peluso, in memory of Ignazio Peluso.

The *Metropolitan Museum Journal* is published annually by The Metropolitan Museum of Art.
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Manuscripts submitted for the *Journal* and all correspondence concerning them should be sent to journalsubmissions@metmuseum.org. Guidelines for contributors are given on p. 6.

Published in association with the University of Chicago Press. Individual and institutional subscriptions are available worldwide. Please direct all subscription inquiries, back issue requests, and address changes to: University of Chicago Press, Journals Division, P. O. Box 37005, Chicago, IL 60637-0005, USA. Phone: (877) 705-1878 (U.S. and Canada) or (773) 753-3347 (international), fax: (877) 705-1879 (U.S. and Canada) or (773) 753-0811 (international), email: subscriptions@press.uchicago.edu, website: www.journals.uchicago.edu

ISBN 978-0-226-82464-2
(University of Chicago Press)

ISSN 0077-8958 (print)
ISSN 2169-3072 (online)

Library of Congress
Catalog Card Number 68-28799

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The authors are grateful to the peer reviewers of the *Metropolitan Museum Journal* for their suggestions and assistance.

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Typefaces: Calibre, Lyon, and Harriet
Printed on Arctic Matt, 150 gsm
Separations by Professional Graphics, Inc., Rockford, Illinois
Printed and bound by Ofset Yapımevi, Istanbul

Front cover illustration: Jacob Lawrence, *The Shoemaker*, 1945–46. See fig. 1, p. 107.
Back cover Illustration: Matȟó Nážiŋ (Standing Bear; Mnikhówožu Lakȟóta), *The Battle of the Little Bighorn*, ca. 1920. See fig. 1, p. 86.

Illustration on p. 2: José Manuel de la Cerda. Tray (*batea*) with Turnus provoked into war by Aeneas, ca. 1764. See fig. 1, p. 41

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Manuscripts are reviewed by the *Journal* Editorial Board, composed of members of the curatorial, conservation, and scientific departments, as well as scholars from the broader academic community.

To be considered for the following year's volume, the complete manuscript must be submitted by September 15.

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ABBREVIATIONS

MMA The Metropolitan Museum of Art
MMAB The Metropolitan Museum of Art Bulletin
MMJ Metropolitan Museum Journal

Height precedes width and then depth in dimensions cited.

METROPOLITAN MUSEUM JOURNAL 57

A Monumental-Scale Crimson Velvet Cloth of Gold in The Met: Historical, Technical, and Materials Analysis

GIULIA CHIOSTRINI, ELIZABETH CLELAND, NOBUKO SHIBAYAMA, FEDERICO CARÒ

Brilliant with kingly pomp, . . . The walls are everywhere cloaked with golden hangings, . . . With cloth of silk in lattice work, interspersed with golden rivets, the inner chambers of the English palace are magnificent.

Thus, the French humanist and poet Jacques Dubois described the temporary palace of Henry VIII erected at the massive, northern French site of the diplomatic meeting between the English king and Francis I in June 1520.[1] Memorably coined by contemporaries as the "Field of the Cloth of Gold" in recognition of the copious amounts of velvet fabrics on view in both royal enclosures, this moniker is just one reminder of the preeminent role of expensive, sumptuous textiles as conspicuous, competitive signifiers of royal pomp and splendor in Renaissance Europe.

The exhibition "The Tudors: Art and Majesty in Renaissance England," organized by The Metropolitan Museum of Art (2022–23), explores the interplay

fig. 1 Furnishing textile of crimson velvet cloth of gold. Attributed to Florence, late 15th–mid-16th century. Silk and gilt silver-metal-wrapped thread, 10 ft. 5½ in. × 5 ft. 8 in. (318.8 × 172.7 cm). The Metropolitan Museum of Art, Bequest of Susan Dwight Bliss, 1966 (67.55.101)

Metropolitan Museum Journal, volume 57, 2022. Published by The Metropolitan Museum of Art in association with the University of Chicago Press. https://doi.org/10.1086/723660. © 2022 The Metropolitan Museum of Art.

between the decorative and the visual arts at the English royal courts during the long sixteenth century. Although posterity lingers on the material extravagances of Henry VIII, it was his father, Henry VII, founder of the Tudor monarchy, who first realized the extent to which visual majesty could bolster the family's tenuous claims to the crown. Certainly, despite the posthumous reputation of Henry VII for fiscal sobriety, account books reveal his prodigious spending on Italian luxury velvets. The court of Henry VII was copiously furnished with textiles to create awe-inspiring displays of regal magnificence, surpassing any acquisitions in this field practiced by the usurped preceding Yorkist dynasty.[2] In one year, Henry VII spent well over £1,300 only on black, purple, and crimson velvets from Lucchese and Florentine merchants.[3] Most evocative of all is the Henry VII Cope (formerly known as the Stonyhurst Cope), now in the collection of the Jesuits in Britain, part of a set of more than thirty-two such vestments and accompanying hangings commissioned by Henry VII for use in Westminster Abbey, for which he paid about £100,000.[4] The velvets were designed from scratch, featuring Tudor roses and Lancastrian double Ss, with the portcullis of his mother's family, the Beauforts. Using the agency of merchants Antonio Corsi and Lorenzo and Ieronimo Buonvisi, the customized velvets were woven to shape simultaneously in two esteemed weaving centers, Lucca and Florence. Henry VIII shared his father's taste for Italian velvet, and likewise appreciated its regal exclusivity. This conviction was codified in the Acts of Apparel, sumptuary laws restricting the wearing of "cloth of gold of tissue" (the most expensive cloth of gold, distinguished by its gold loops) to the royal family and their close circle. Such was Henry VIII's interest that he requested his lord high chancellor, Cardinal Thomas Wolsey, to provide him with a draft of the 1515 statutes and an abstract to annotate before they were passed.[5]

fig. 2 Detail of furnishing textile of crimson velvet cloth of gold shown in fig. 1

fig. 3 Patched panel of crimson velvet cloth of gold. Attributed to Florence, late 15th- to mid-16th century. Silk and gilt silver-metal-wrapped thread, 60½ in. × 46½ in. (153.7 × 118.1 cm). The Metropolitan Museum of Art, Gift of Samuel H. Kress, 1946 (46.109.26)

Seen through the lens of today's different hierarchies of worth, it can be difficult to grasp exactly why the Tudors, like the Valois, the Habsburgs, and the Ottomans, valued these velvets so much, prepared to spend outrageously on them, and attempted to monopolize their use. Such is the depleted state of surviving textiles that verbal eyewitness descriptions like that of Dubois, quoted above, are almost invariably the most effective means to envision the material splendor of royal interiors in the fifteenth and sixteenth centuries. We must engage our imaginations to match surviving fragments with painted evocations by the likes of Mantegna, Jan van Eyck, and Piero della Francesca.[6] The Met is fortunate to own a rare survival: a furnishing textile of crimson velvet cloth of gold of near-unique scale (fig. 1).[7]

This velvet hanging is, in comparison with most of the surviving record, enormous. It spans three loom widths; the selvages (sealing the edges of each of these loom widths) are intact; and the hanging is so tall that it accommodates three vertical repeats of its distinctive, asymmetrical pattern. As such, this velvet's size enables us to experience the phenomenon of the floor-to-ceiling cloths of gold that so awed Dubois and his contemporaries. Designed to make an impact and be legible from a distance, it is clearly a furnishing velvet, its pattern bolder and motifs bulkier than finer, more minutely detailed dress velvets. Thickly sinuous

fig. 4 Cope. Italian, late 15th-century velvet with early 17th-century orphrey, assembled after ca. 1625. Silk and metal-wrapped thread, W. 52½ in. (133.4 cm). The Metropolitan Museum of Art, Brooklyn Museum Costume Collection at The Metropolitan Museum of Art, Gift of the Brooklyn Museum, 2009; Gift of The Rembrandt Club, 1911 (2009.300.3409)

vertical golden branches meander above and below large, stylized golden pomegranates. Particular to this design, the branches bend to the right about halfway between the pomegranate motifs to accommodate a pattern of tumbling rosebuds (fig. 2). Two of these roses in each repeat are fully opened: five-petaled, bipartite roses with red centers and "plain" gold outer petals, separated by pointed aristate leaf tips.

Like other luxury early modern textiles, not least tapestries, a talented designer would have conceived the pattern represented on this velvet; his or her design would have been shared with the weavers via an annotated drawn model on paper. Since the twelfth century, the Tuscan town of Lucca and the Adriatic port of Venice had dominated European silk weaving, which subsequently spread to Genoa, Florence, and Milan. Spanish silk weavers, long established at Granada and Valencia, were by the 1500s emulating their Italian counterparts. Raw silk, imported predominantly from Jordan, Syria, and the Balkans or increasingly cultivated locally in Calabria, Lombardy, and Piedmont, was spun, dyed, spooled, and woven within family workshops under the patronage of wealthy, sometimes noble, silk manufacturers. Production in most cities was strictly regulated by guilds. Gradually, Florence and Genoa came to dominate the market for the gold-woven deep-pile velvet silks so coveted by European and Levantine royalty.[8] The drawn model could be copied, adapted, and transported between rival weaving centers (although there were civic measures in place to try to prevent this). They might be used and reused as long as market fashions, available raw materials, and, of course, weaving talent allowed. It is apparent that this pomegranate and rose design must have been much admired, its model emulated across multiple different workshops over a period of decades. Another surviving velvet with the same design, for example, had been imported into England by 1516, when a single loom width of it was used in the Fayrey family's pall cloth.[9] Other surviving scraps are in The Met's collection: smaller, cut, and patched (fig. 3) or later repurposed (fig. 4).[10] In addition to The Met's three-width furnishing hanging, the most spectacular survival of this velvet design is in the church of Santa Maria nella Badia Fiorentina in Florence (fig. 5).[11] Some of the Badia Fiorentina examples date from 1470 (alongside later, matching pieces woven in the seventeenth century). Though the designs are so similar, it is very difficult to gauge by eye alone how closely these velvets' techniques correspond, and whether or not they might have been woven in the same weaving center, let alone the same workshop.

Although a hanging like the large one in The Met is so evocative of Renaissance material sumptuousness, and proven so important an expenditure according to the documentary record, these extraordinary velvets

tend to be sidelined in art historical surveys, either summarily glossed over or ignored altogether. This, despite compelling contributions to the field of textile studies by scholars such as Lisa Monnas.[12] Apparently unaware of the Badia Fiorentina velvets (dating to 1470), misinformed historians have identified the bicolored five-petaled rose in the repeat of The Met's velvet (fig. 2) as evidence that Henry VII (who seized the throne in 1485) specially commissioned this design, incorporating what would subsequently become his distinctive heraldic device of the Tudor rose (fig. 6).[13] Instead, it is worth considering that it was a glimpse of this stock motif prevalent in the velvets he so admired that gave Henry VII the idea to superimpose his family's red Lancastrian rose with his wife's white Yorkist rose to create the Tudor rose. This stroke of genius branding after thirty years' civil war would unite the two antagonistic symbols. The physical challenges of velvets like these—their poor survival rate; inaccessibility and infrequent public display; technical intricacies; replicated designs across broad geographies and decades of production—might explain why their publication is limited, and largely siloed within a narrow field of textile scholarship.

A major conservation project prepared The Met's furnishing velvet for display in the opening gallery of "The Tudors" exhibition. This intervention provided an unprecedented opportunity for Met colleagues to explore this important velvet as a physical object, engaging head-on some of the following challenges: to chart the intricacies of its technique; to identify and help source its dyes; and to analyze the composition and structure of its metal-wrapped threads. The study is part of an ongoing, collaborative technical investigation of weaving features, material, metal thread technology, and dyes in early modern Florentine velvet production underway between conservators and scientists from The Met and the Opificio delle Pietre Dure in Florence. This article seeks to provide a model for future scholarship by contributing to a database of comparative material for such surviving early modern velvets.[14] E.C.

fig. 5 Hanging of crimson velvet cloth of gold. Florence, 1470. Silk and gilt silver-metal-wrapped thread, 90 × 24 in. (228 × 61.4 cm). Church of Santa Maria nella Badia Fiorentina, Florence

fig. 6 Two Tudor roses (left) and two Lancastrian roses (right). Detail of stained glass, ca. 1500, in the rose window, south transept, York Minster

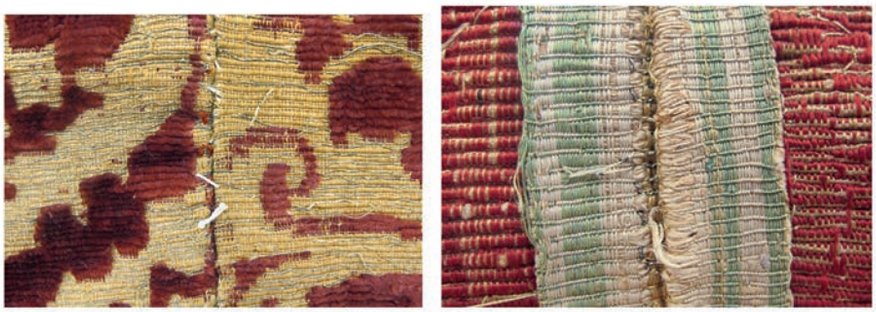


fig. 7 Detail of the obverse (left) and reverse (right) of the joint seams between two of the velvet panels. Stitches in mercerized cotton were used in correspondence to the folded selvages retained on the reverse of each panel. Once the whole panel was reassembled, the conservation treatment allowed for the repositioning of the selvages in the same way, and the external selvages were left open and accessible to the public for a better appreciation of weaving details.

fig. 8 Detail of the obverse (left) and reverse (right) of one of the three panels positioned on the conservation worktable. Once the selvages were unfolded, the panel was reversed, and narrow strips of cotton were stitched along both sides to strengthen these fragile areas.

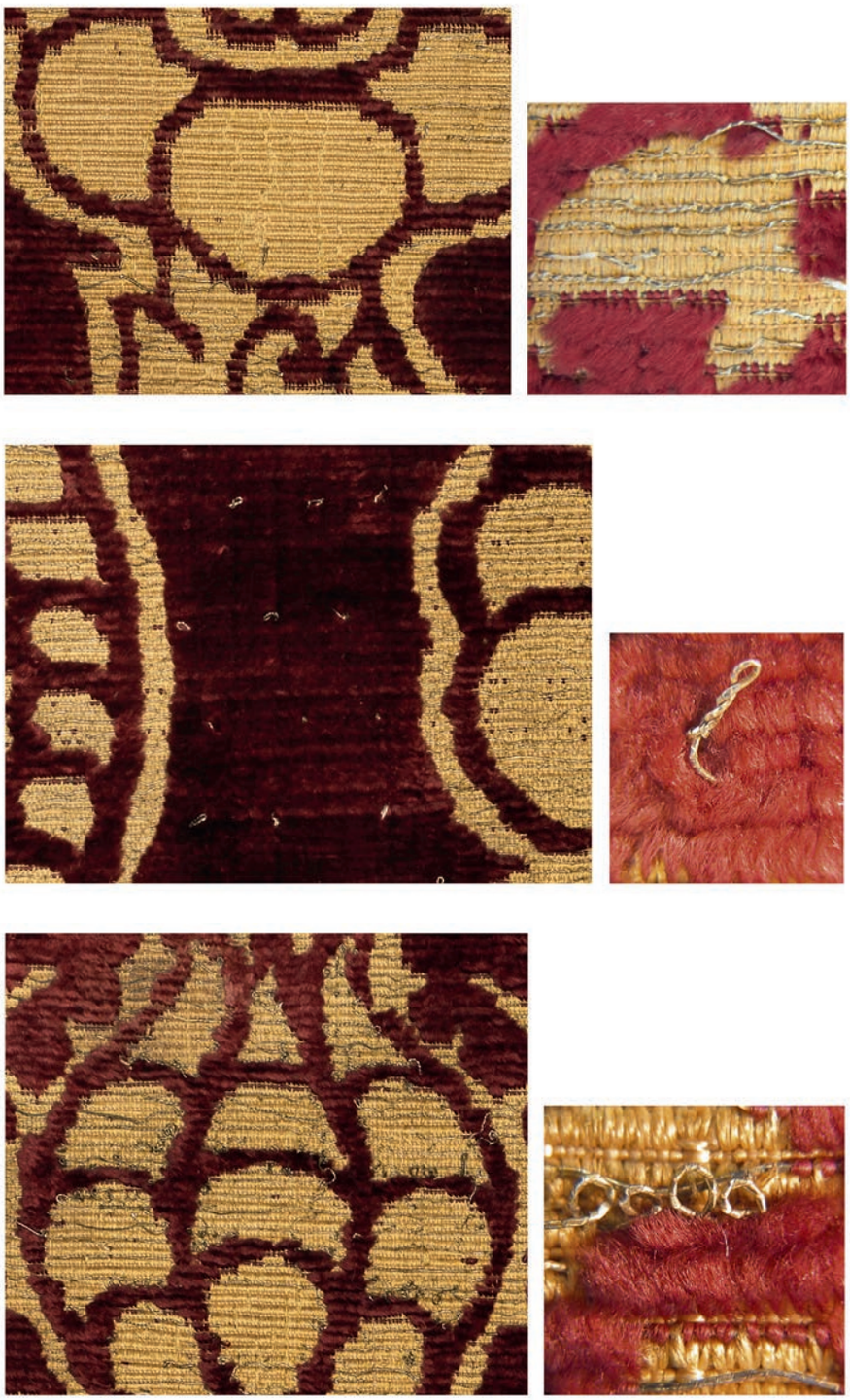
fig. 9 Detail of before (left) and after treatment (right) showing one of the whole panel corners after unfolding the ease of velvet weaving. Cleaning the surface from soil deposits made accessible details of the *allucciolato* features that were not visible prior to the conservation treatment. Stabilization of the damaged areas with conservation stitches in mercerized cotton allowed for the loose weft threads' realignment and the unfolded selvage stabilization.

TREATMENT: CONSOLIDATION AND PREPARATION FOR DISPLAY IN "THE TUDORS" EXHIBITION

Assessment of the cloth of gold in 2019 by The Met's textile conservators proved the high quality of its weave and supported its significance to the study of late fifteenth- and early sixteenth-century velvet production. Deciding how to prepare the velvet for display, curators and conservators agreed on a treatment that allowed the velvet to be hung as a wall covering, its original function.[15] This style of installation required stabilization and consolidation. Though the cloth of gold's weave structure remained strong and well preserved, this luxurious textile's appearance was affected by the loss of main warp threads and small lacunae spread on the three loom widths' surface. Consolidation along the seams between the three panels provided additional support to degraded areas of the weave structure that could otherwise potentially affect the stability of the hanging during its display period.

A complete visual examination confirmed that no original joint seams remained, and disassembly could proceed. Supporting this decision was evidence of modern mercerized cotton threads in white and red used for the current stitches and creating unnecessary tension (fig. 7).[16] Disassembly of the whole hanging allowed for successful stabilization of each single panel and facilitated the maneuver of the large textiles during the treatment without further damaging the piece.

Once disassembled, the conservation treatment began. Each velvet length was placed on a worktable, allowing for the cleaning of the pieces with low-suction vacuum. Following photographic documentation, the tension-creating previous restoration stitches were removed from the foundation fabric. Humidification flattened folds in the selvages through a process that rehydrated the fibers and improved their structural condition. Once the selvages were open, narrow strips of cotton fabric were applied with conservation stitches along the reverse of both sides of each panel. Small tears and original weft threads were realigned and stabilized before proceeding with the reassemblage of the three panels (fig. 8). Adjustments of the hanging length over the centuries had resulted in an abundance of folded velvet along the top and bottom edges. These areas were unfolded to return the panel to its original length (fig. 9). In the final stage of the conservation process, the cloth of gold was prepared for hanging with the application of segments of Velcro along the top edge. For display, the velvet is supported within an exhibition case made of a wooden stretcher wrapped in neutral color-tested fabric, with a Plexiglas bonnet protecting the textile from external environmental factors.[17] G.C.



TECHNICAL OBSERVATIONS

Prior to its display as part of the exhibition, the textile underwent microscopy analysis of the weaving technique, fiber identification, and a visual examination of the obverse and reverse of the piece. Woven in crimson silk pile, the panel is constructed of three identical loom widths of cut and voided silk velvet enhanced by silver-gilt-wrapped silk threads.[18] Just as the velvet's asymmetrical design suggests attribution to Florence, bolstered by its resemblance to the well-documented Badia Fiorentina velvets (see fig. 5), technical analysis reveals that the textile's physical construction correlates strongly with Florentine manufacture. Each loom width, of which all selvages are still well preserved, measures approximately 22½ inches. This figure neatly corresponds with the breadth of the standard measurement in Florence, the 23-inch braccio.[19] In addition, the selvages edging The Met's three loom widths are ⅝ inch (1.5 cm) wide; they are woven in plain weave with alternating green and white threads (a detail normally hidden from view). In both width and coloration, the selvages correspond to those recorded on the Badia Fiorentina velvets, as well as other velvets documented as Florentine production.[20]

Skillful weavers made the most of their costly materials in the creation of this velvet. The foundation fabric is composed of a taffeta *doublé*, in which parallel rows of thick, undyed silk wefts are covered by a fine yellow silk warp (fig. 10).[21] An even finer narrow additional weft, called a covering weft, conceals the pile warp in the voided areas, which are those areas of the textile not covered with the deep crimson pile. This crimson pile on the surface of the velvet articulates the design's contours, while the yellow-gold color of the flatter, voided areas conveys the pomegranates, roses, and foliage. By dyeing the warp and the covering weft yellow, they complement and accentuate the glow of the actual silver-gilt-wrapped silk thread. These golden threads are *filé*, meaning that they are continuous, covering the whole loom width, running from selvage to selvage. They are visible in some areas, but hidden beneath the pile in others.[22] The weavers used the *filé* of silver-gilt-wrapped silk thread to best advantage, manipulating rods during weaving to create tall loops of metal thread where the weft could not be pulled down tightly into the weave but instead rose up above the finished surface once the rods were removed. Tiny *allucciolato* effects, only used in the crimson pile areas, are characterized by a single, taller loop that twists up around itself (fig. 11). Creating subtle, golden sparkles within the crimson areas, this technique evocatively

fig. 10 Detail of the foundation fabric in taffeta *doublé* (left) and microphotograph 20x (right) of its weave structure showing a count of 30 fine yellow silk warp and 36 thick silk weft threads, Z-twisted, per centimeter; 8 covering wefts per centimeter in yellow silk fine thread conceal the voided crimson silk pile warps; 8 *filé* of silver-gilt-wrapped silk thread per centimeter is tied adjacent to the covering weft by a ½ twill binding warp in yellow silk thread.

fig. 11 Detail of the *allucciolato* feature (left) and microphotograph 20x (right) of a single loop. *Allucciolato*, a term derived from the Italian word *lucciola* (firefly), is distinguished by individual loops of the *filé* metal-wrapped threads twisted and spread in the pile area. The feature is achieved through the addition of a row into the weaving that lifts the metal-wrapped thread to form the loop.

fig. 12 Detail of the bouclé feature (left) and microphotograph 20x (right). The bouclé feature is achieved in the same way described above for the *allucciolato* effect, but it forms a rod of loops of the *filé* metal-wrapped thread instead of a single loop.

takes its name from *lucciola*, the Italian for "firefly." In the effect called bouclé, short rows of "loop-the-loop" rings of gold appear across the yellow-gold voided areas (fig. 12). (This type of golden loop was the distinguishing feature of the most expensive "cloth of gold of tissue" singled out in Henry VIII's Acts of Apparel cited above.) The harmonious combination of these technical features with the well-preserved red and yellow dyes enhances the entire design.[23] The early Badia textiles share a significantly similar weaving structure, also composed of a taffeta *doublé* in *filaticcio*, with comparable technical features of the looped precious-metal wrapped threads.[24]

Technical clues support the theory that the velvet is an example of the portable furnishing textiles purchased by the likes of Henry VII and Henry VIII from the Florentine market to decorate the interiors of their permanent and temporary palaces. The whole panel has a structurally strong weave, the thickness of which might initially strike one as heavy-handed compared with the more delicate construction of dress velvets. However, this very strength of the textile would render it physically hardy enough to withstand the constant handling, installation and deinstallation, and general wear and tear of a functional wall hanging. Combining costly materials with such a dense weave, the weavers skillfully achieved a wall covering of sumptuous appearance. The large dimensions of the depicted pattern are enriched by an abundance of precious material to magnify the reception of this magnificent decorative textile from up close or far away. Furthermore, the extent of the preserved length of the three loom widths supports the hypothesis that the whole velvet functioned as a hanging textile from its genesis. While it is not unusual to observe velvet panels of these dimensions in museum collections, most are cleverly assembled modern composites of similar and contemporary textile fragments.[25] This rare, full-length textile shows the full design composition and original splendor of the cloth of gold. G.C.

ANALYSIS OF DYES

To help understand the provenance of the velvet, dyes used on the samples of red pile and yellow weft yarn from the velvet were analyzed by high performance liquid chromatography with photodiode array detector (HPLC-PDA). Small yarn samples were taken from the velvet and their dyes extracted for analysis.[26]

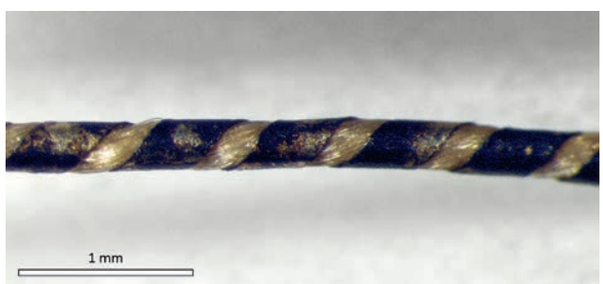
The dye used on the red yarn sample suggests cochineal, an insect dye from either South or Central America (*Dactylopius coccus* Costa) or from Armenia (*Porphyrophora hamelii* Brandt).[27] Carminic acid, a dominant colorant of those dyes, was detected as a main colorant in the red sample. Cochineal from America is reported to have been imported by Spain in the early half of the sixteenth century for the first time. Armenian cochineal had been used in Europe prior to American cochineal; however, when the latter became popular it eventually replaced the use of Armenian cochineal.[28] Using the insect dye cochineal, which was expensive, indicates the high quality of this velvet textile.[29]

The dye used on the yellow yarn sample suggests a combination of weld (*Reseda luteola* L.) and young fustic (*Cotinus coggygria* Scop.). Luteolin 7-O glucoside, luteolin, and agigenin, which are main colorants of weld, and sulfretin, a main colorant of young fustic, which adds an orangey tone to the yellow yarn, were detected from the yellow sample.[30] Weld was the representative yellow natural dye in Europe and in the Mediterranean because of its beautiful color, availability, and lightfastness.[31] Young fustic mainly grows in southern and Central Europe. It is known to be less lightfast than weld, and as a result perhaps regarded as less salient than weld. However, young fustic was the only yellow dye in the medieval silk-dyeing recipes of Florence and Venice, which differs from the recipes of silk yellow dyeing in France or Spain where weld was used as the main yellow dye.[32] In addition, weld appears to have been used as a supplement in an early fifteenth-century Florence treatise, where it is recommended to nuance the yellow of young fustic to less of a russet shade.[33] The main production area of young fustic was the Veneto and Provence.[34] The yellow yarn sample from a Florentine border showed the presence of young fustic and weld by dye analysis, proving the recipe in the Florence treatise.[35] In addition, yellow yarns from other velvets attributed to Florence are found to be dyed with a mixture of weld and young fustic.[36]

Although the types of dyes that were indicated as having been used in The Met's velvet were widely used in Europe and parts of Western Asia, historical records indicate that the use of young fustic with weld in the yellow yarn sample is suggestive of Italian origin. However, to narrow attribution to Florence on the basis of its dyes, more Florentine velvets need to be studied to understand the relationship between the dyes and the attribution. The combination of the two dyes young fustic and weld, for example, was also found in a yellow silk yarn sample from a textile that was probably made in Granada, Spain, in the late fifteenth century and a yellow silk core yarn of metal thread from a

seventeenth-century Ottoman velvet.[37] In those instances, the dyed yarns could have been exported from Italy to those places or there might have been a similar dyeing recipe in use.

The red silk appears to be weighted with tannins,[38] or tannins were used as an auxiliary agent.[39] Ellagic acid, derived from ellagitannins under hydrolytic conditions,[40] was detected from the red yarn sample in addition to colorants of cochineal. Ellagitannins are one of two subdivisions of hydrolysable tannins along with gallotannins. The technique of weighting silk with tannins had been used in the medieval period or earlier, and gall was a typical source plant.[41] Ellagic acid is found often in historical red silk yarn samples dyed with carminic acid, a main colorant of cochineal, in Europe and the Middle East.[42] N.S.



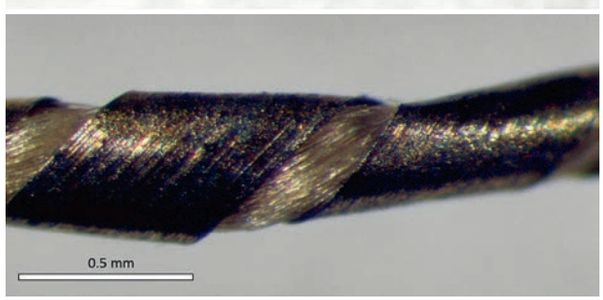


fig. 13 The metal thread is seen here under visible light at the binocular microscope. Longitudinal marks along the entire length of the strip are visible in the bottom image.

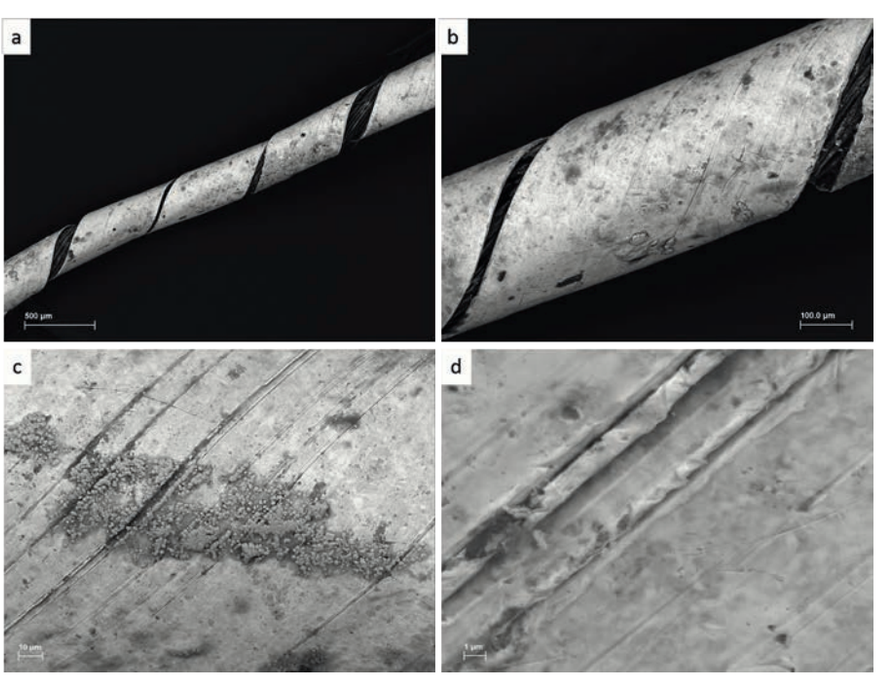


fig. 14 Backscattered electron (BSE) images of the metal thread, showing the thread's overall surface (a and b), and details of the die marks and corrosion products at the surface of the metal strip (c and d)

ANALYSIS OF METAL THREADS

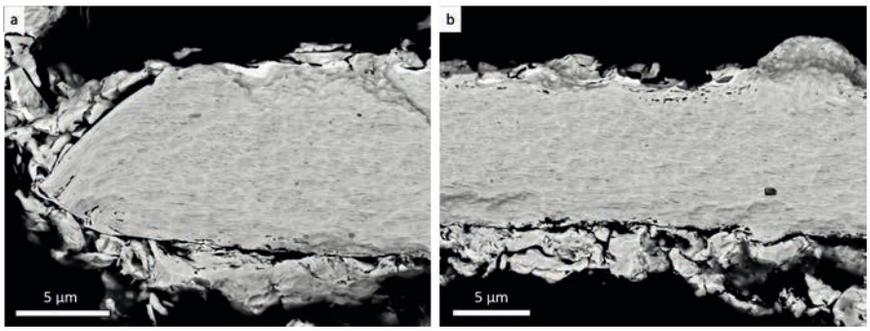
One sample of metal thread was collected and examined by optical microscopy (OM) and scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS).[43] Characteristic measurements of the whole sample were taken under high magnification, such as the thread width, the metal strip width, the distance between coils, and the coil angles. A small portion of the metal strip was embedded in epoxy resin and cross-sectioned in order to investigate its composition, thickness, and the type and thickness of metal coating. Together, the data help to reconstruct the technology used to manufacture the metal-wrapped threads, and ultimately place this production within the broad context of technological practices at the service of European textile makers.

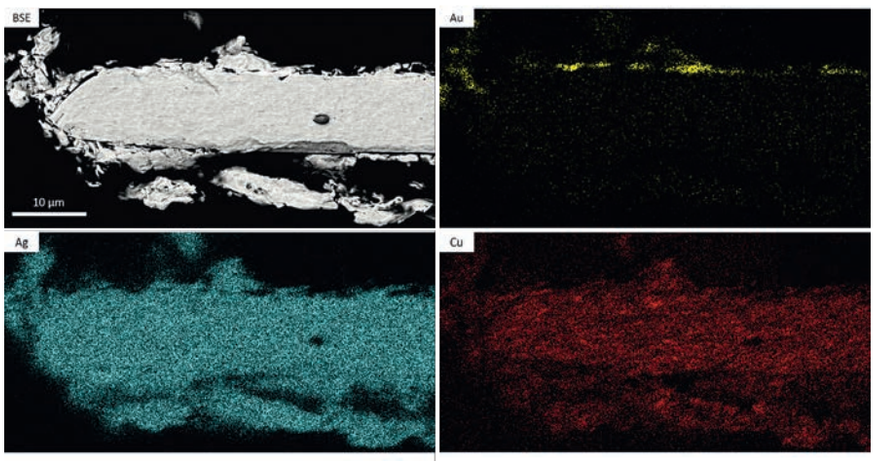
The thread consists of S-type metal coil wrapped around a yellow-dyed core yarn (figs. 11, 12). The thread has a total diameter of about 300 μm. The metal strip has an average width of 400 μm, and is about 10 μm thick. The coils are tightly and evenly spaced by a gap 10–50 μm wide, and wrapped with an angle of about 50°. The metal strip is a binary Ag-Cu alloy with an average composition of 82.6 ± 0.4 wt% silver (Ag) and 17.1 ± 0.4 wt% copper (Cu). Lead (Pb) is present in trace amounts of about 0.3 ± 0.1 wt%.

The surface of the metal strip bears traces of straight and rather deep die marks that run along the entire length of the strip, and that are more pronounced on the gilt side (figs. 13, 14). In places, these die marks expose the silver core underneath the gilding. Straight die marks indicate that the strip was likely rolled or drawn sometime after gilding.

The silver strip is gilt on one side with a highly discontinuous gold layer (fig. 15) that varies in thickness from about 80 nm to about 150 nm, suggesting that a bar of metal was first gilt on one of its sides, and then flattened and reduced to a thin strip.

In cross section, the texture of the metal strip is typical of a highly worked alloy, where the cast structure has been deformed and flattened. The edges of the strip are asymmetrical, with strong bending and folding of the metal toward the ungilt side of the strip (figs. 15, 16). This indicates that the strip was cut using a directional shear pressure applied predominantly from the gilt side of the strip. The strip is also characterized by the presence of abundant fines of metal,





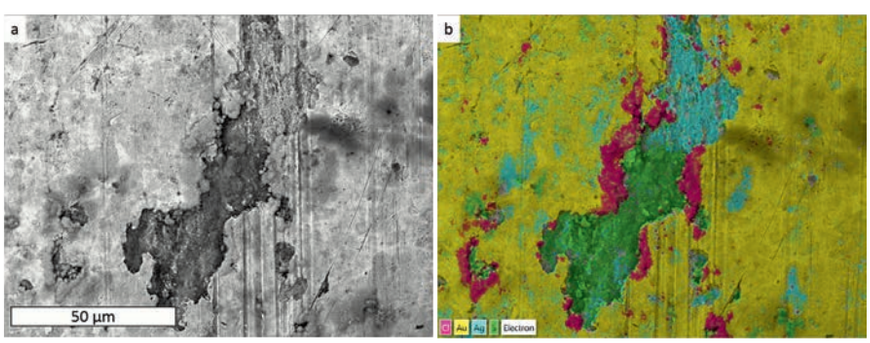


fig. 15 Cross section of the metal thread seen in BSE, showing the heavily worked metal structure (a and b), asymmetrical edges (a), and abundant metal fines (a and b). Gold is visible on one side of the thread (top) as a bright, discontinuous layer (a and b).

fig. 16 BSE image of the metal thread cross section, and distribution maps of gold (Au), silver (Ag) and copper (Cu). The elemental maps show the gold layer on one side only (in yellow), and the deformed Cu-rich phase (in red).

fig. 17 BSE image of a highly corroded thread surface with loss of gilding (a), and a composite elemental map (b) showing the distribution of silver chlorides (red, Cl), silver sulfides (green, S), and of the silver substrate (blue, Ag) and gilding layer (yellow, Au).

sometimes carrying gilding, and adhered to the strip surfaces (fig. 15).

The formation of corrosion products is especially developed and diffused as silver sulfides and chlorides built up on top of the strip surfaces. These corrosion products often concentrate along the grooves and are responsible for the loss of portions of the gilding (fig. 17).

The presence of die marks running along the strip length, combined with a single gilt side, cut edges, and metal fines, suggests that the strip might not have been manufactured using the "beaten-and-cut" method or the "drawn-and-rolled" method described in the literature,[44] but rather by a combination of the two. Threads with similar characteristics have been previously identified on a mid-sixteenth-century tapestry belonging to the Fables of Ovid series, woven in Brussels by Willem de Pannemaker and purchased in 1556 by Philip II of Spain.[45]

Reconstructing the exact technology employed in the production of this metal thread is challenging, as several combinations of manufacturing and spinning processes could have led to the microstructures seen in the studied sample. Among the possible manufacturing techniques, it is suggested that the strip was obtained from a gilt bar that was beaten and flattened mechanically, and then rolled and cut through cutting rollers. It is also possible that the straight marks were left during the stretching of a "beaten-and-cut" strip, by friction against the portion of the strip that was rolled onto the stretcher. In this case, however, fines containing traces of gold should have been detected on the underside of the metal strip as well, an occurrence that was not confirmed by this analysis. Ultimately, these findings indicate that the presence of longitudinal die marks on the metal threads' surface does not necessarily imply that the strip was produced by rolling a drawn gilt wire, and that a thorough characterization of these materials requires the study of both their surfaces and cross sections.

It is very likely that other ways to produce long, narrow, and gilt metal strips existed in addition to the traditionally recognized "beaten-and-cut" and "drawn-and-rolled" methods, at least in sixteenth-century Europe. These manufacturing techniques, possibly bridging and combining characteristics from both the well-known methods, need further investigation to be fully understood. F.C.

CONCLUSION

The size and excellent condition of the rare textile of crimson velvet cloth of gold in The Met capture the appeal of large-scale luxury furnishing velvets for their

original patrons, not least the fledgling Tudor dynasty. The velvet's stylistic attribution to Florence is bolstered by the historical record that Florence was one of the two centers patronized by the Tudors. Likewise supporting the attribution to Florence is the loom width's concordance with the Florentine braccio, and the green and white selvages. The use of young fustic dye, with its orangey color, is reported to be more characteristic of medieval Italian silk recipes in contrast to those of Spain and France, with the weld-young fustic combination documented to Florence. However, to confirm this attribution, the results will need to be compared with future analyses of velvets that securely document the place of production.

Beyond this contributing evidence to the regional attribution of the velvet, the technical data on weave, dyes, and threads shared here more broadly enhances our knowledge of Italian velvet weaving in the fifteenth and sixteenth centuries. Materials and technical analysis trace the hands of this velvet's makers, revealing otherwise indiscernible trade secrets. The velvet, for example, has a strong, thick weave, designed to survive the handling and weight for use as a hanging. Gilt bars were flattened and cut by rollers to create the metal strips, a sophisticated technology that would have allowed the fabrication of large quantities of golden threads at efficient and cost-effective rates. Such a manufacturing process might be more common than previously documented, and its identification in two different fifteenth- and sixteenth-century textiles, one woven in Brussels and one in Florence, raises questions about movements of materials and technologies. The technical study of further comparative material will help determine whether this technology was specific to specialized and possibly regional workshops, or the result of the spread of technological innovations to various production centers of Europe. The silk cores to these metal-wrapped threads were dyed yellow to enhance their glittering effects. The weavers used *allucciolato*, random loops of gold, in the crimson velvet pile to accentuate the sparkle of the hanging. The skill and work of the weavers, dyers, *battilori* (gold beaters), and *filatrici* (assemblers of the metal threads) become more readily appreciable. The technical and physical analysis of the three velvet loom widths provides important evidence that such velvets not only served as dress fabrics but could also be designed and constructed as luxury interior furnishings, a documented function until now recognized mainly through representations in paintings.

The present case study is intended to help create a core body of knowledge that, analyzed in tandem with growing comparable data of velvets with complete provenance, might shed light on questions of regional attribution, perhaps even associations with specific family workshops, and continue to sharpen scholars' focus on the materials and manufacturing techniques in the decorative arts.

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NOTES

1 Published with translation by Bamforth and Dupèbe 1991, 71.
2 Discussed in detail in Cleland and Eaker 2022.
3 See Hayward 2020, 117–19.
4 The documents pertaining to Henry VII's commission of the vestments for Westminster Abbey are published and discussed by Monnas 1989; see also Condon 2003, 68, and Cleland and Eaker 2022, no. 7.
5 Passed between 1509 and 1533, these Acts of Apparel are published by Baldwin 1926, 140–62, and discussed in detail by Monnas 2008, 2, and Hayward 2009.
6 See studies by Monnas 2008 and Duits 2008.
7 See Giulia Chiostrini in Cleland and Eaker 2022, no. 15.
8 For a detailed account of the context of early modern European silk weaving and an accompanying bibliography, see Monnas 2008, 1–65.
9 For the context producing "countless variations of only a few pattern types on the market," see Peter 2020, 20. The *Fayrey Family Funeral Pall*, ca. 1516 (St. Peter's Church, Dunstable, Bedfordshire, on loan to the Victoria and Albert Museum, London), is made of Florentine velvet cloth of gold, crimson silk cut and uncut pile, and silver-gilt weft loops, with side panels of violet velvet, applied embroideries of silver-gilt, silver, and colored silks on linen. Monnas in Marks and Williamson 2003, no. 349, pl. 31.
10 The Met's patched panel of crimson velvet cloth of gold (fig. 3) is a modern composite of multiple small, irregular fragments of velvet. Other smaller examples of velvet with this design (in addition to figs. 3 and 4), are in the Victoria and Albert Museum, London, inv. 81-1892, see Monnas in Marks and Williamson 2003, no. 201; the Abegg-Stiftung, Riggisberg, inv. 2478, see Peter 2020, 20; the Antonio Ratti Foundation, Como, inv. 146, see Buss 1996, 23; and the Costume Gallery, Pitti Palace, Florence, inv. Tessuti Antichi no. 614, see Orsi Landini 2020, 68–69. Two magnificent examples that have survived with dimensions comparable to the one in The Met belong to the Comunità Ebraica, Pisa, inv. 09-00500741, and the Museo Ebraico di Roma, inv. 675; see Liscia Bemporad and Melasecchi 2019, nos. 30, 31. A considerably later but splendid example, with deep blue pile, combining four loom widths, each with three repeats, is the Pall Cloth made for Pope Leo XI (d. 1605) in the Victoria and Albert Museum, inv. 142-1869.
11 For the Badia Fiorentina velvets, see Liscia Bemporad and Guidotti 1981; Buss, Butazzi, and Pertegato 1983; and Paolo Peri in Dal Prà, Carmignani, and Peri 2019, no. 10.
12 In particular, Monnas 1989, 2008, 2012.
13 Chiara Buss (1996, 22) describes these as "Tudor roses" in reference to a small fragment of velvet woven to the same design, preserved in the Antonio Ratti Foundation, Como. Thomas P. Campbell (2007, 145) illustrates The Met's hanging in his discussion of the "Field of the Cloth of Gold," having raised the suggestion of a Tudor commission (verbal communication to E. Cleland, January 25, 2006).
14 We acknowledge the trailblazing approach of the Lombardy-based Progetto PSL (La produzione Serica in Lombardia), headed by Chiara Buss (see Buss 2009 and 2011). Monnas 2008, 16; Buss 2009, 15; and Adelson 2013, 975, call for increased publication of data from scientific analysis of specific textiles. Corinna Kienzler (2020) presents targeted case studies in this mode; Monnas (2012) includes thread, dye, and weave structure analyses in entries in her Victoria and Albert Museum highlights catalogue.
15 We are grateful to Janina Poskrobko, Conservator in Charge of the Department of Textile Conservation at The Met, for her support of this project.
16 Traces of old thick threads in the form of knots located on the surface of the folded selvages were found on the reverse of the panels. They were documented and left in place. Further investigation is needed to verify their contemporaneity to the velvet weaving.
17 All the material in contact with the art for temporary or permanent use was Oddy-tested and approved by the Department of Scientific Research, The Met.
18 Silver-gilt-wrapped thread is a thin layer of gold applied on a silver metal strip wrapped around a silk core. See the discussion and analysis of metallic threads below.
19 The Florentine measure called *braccio* for this type of velvet manufactured between the thirteenth and sixteenth centuries corresponded to 23 inches [58.362 cm], excluding the selvages. See Monnas 2008, 320–21.
20 For existing analysis of similar textiles of Florentine production, see Orsi Landini 2017, 37–44; Liscia Bemporad and Melasecchi 2019, 158–59; and Monnas 2012, 98–101, nos. 24, 25. A collaborative technical investigation of Renaissance Florentine velvet production is underway among conservators and scientists from The Met and the Opificio delle Pietre Dure in Florence. The research is ongoing, but is currently focused on a comparison study of weaving features, material, metal threads technology, and dyes implied in the construction of The Met's furnishing textile of crimson velvet cloth of gold (fig. 1) and the fifteenth-century Badia church velvets.
21 Taffetta *doublé* is an extended tabby weave in which the warp threads pass over a great number of weft threads. For a helpful description of this type of foundation fabric in velvet weaving, see Orsi Landini 2020, 63–80.
22 *Filé* is a continuous metal weft thread that creates a selvage-to-selvage pattern. In contrast, a "brocaded" weft indicates a discontinuous weft thread inserted into a weaving only in correspondence of a design pattern.
23 See the dye analysis below.
24 *Filaticcio* is an Italian term taken to mean "raw silk." For a detailed description, including technical analysis of the tissues, see Liscia Bemporad and Guidotti 1981. The study suggests that the 1470 Badia velvet panels were commissioned to decorate the interiors of the Florentine church.
25 For instance, we can observe velvet panel MMA 46.109.26 (fig. 3) (60½ in. × 46½ in.), which resembles the hanging under discussion both from a design and a technical perspective. However, the textile is made of four small fragments of velvet that have been joined along their perimeters sometime in their more recent history with the intention to construct a certain length. Many examples of important Renaissance velvets in museum collections are fragmentary, often with evidence of previous folding suggesting that they were originally part of vestments rather than hangings.
26 The experimental method was as follows:

Small yarn samples were taken from the velvet, and each sample (approx. 5 mm) was extracted using 40 µl of a mixture of 0.01 M aqueous oxalic acid, pyridine, and methanol (3/3/4, v/v/v) in a small test tube. The yarn sample was left for half an hour at room temperature, subsequently heated at 55–60°C for 20 minutes. The extract was then removed to an insert, and the tube was rinsed with 20 µl of methanol; the rinsing solution was

also added to the insert. Then, 80 µl of the new mixture mentioned above was added to the test tube again and heated at 90–100°C for 10 minutes; this extract was then moved to the same insert. The tube was rinsed with 20 µl of methanol, and the rinsing solution was also added to the insert. The extract in the insert was dried in a vacuum desiccator using an aspirator. The residue was mixed with 2 µl of dimethylformamide at 60°C for 5 minutes, next, 6 µl of methanol was added to vortex, and then 4 µl of 1% aqueous formic acid (v/v). The solution was centrifuged for 10 minutes at 3500g; the supernatant was injected into the HPLC system. The extraction method was slightly modified from the method developed by Mouri and Laursen 2011.

The chemicals used here are analytical or HPLC grade and a high pure water was made by Milli-Q water purification system.

The analytical system used consisted of a 1525µ binary HPLC pump, 2996 PDA detector, 1500 series column heater, in-line degasser and a Rheodyne 7725i manual injector with 20 µl loop (Waters Corporation, Milford, MA). An XBridge BEH Shield RP_{18} reversed-phase column (3.5 µm-particle, 2.1 mm I.D. × 150.0 mm, Waters Corporation, Milford, MA) was used with a guard column (XBridge BEH Shield RP_{18} 3.5 µm-particle, 2.0 mm I.D. × 10.0 mm, Waters Corporation, Milford, MA) with a flow rate of 0.2 mL/min. The column pre-filter (Upchurch ultra-low Volume pre-column filter with 0.5 µm stainless steel frit, Sigma-Aldrich, St. Louis, MO) was attached in front of the guard column. Column temperature was 40°C.

The mobile phase was eluted in a gradient mode of 1% formic acid in high purity water (v/v) (A) and a mixture of methanol and acetonitrile (1/1, v/v) (B). The gradient system was 90% (A) for 3 min → to 60% (A) in 7 minutes in a linear slope → to 0% (A) in 24 minutes in a linear slope, and then to 90% (A) in 1 minute and held at 90% (A) for 10 minutes.

27 Several studies using statistics to differentiate species of cochineal that contain the same colorants with a different ratio have been done (Wouters and Verhecken 1989; Serrano et al. 2015). However, in this study, the differentiation is not performed.
28 Cardon 2007, 630; Phipps 2010, 26–27.
29 Monnas 2012, 23.
30 Cardon 2007, 171, 192.
31 Ibid., 168.
32 Ibid., 172.
33 Ibid., 192.
34 Ibid., 195.
35 Wouters 1995.
36 Monnas 2012, 99, 111.
37 MMA 2011.480 and 1970.65.9. Unpublished internal documents, 2005 and 2011, Department of Scientific Research, The Met.
38 Hacke 2008.
39 Serrano et al. 2015.
40 Haslam 1966, 91.
41 Bogle 1979.
42 Monnas 2012, 158; Shibayama, Wypyski, and Gagliardi-Mangilli 2015.
43 Analysis was performed with a FE-SEM Zeiss Σigma HD, equipped with an Oxford Instrument X-MaxN 80 SDD detector. Backscattered images (BSE), energy dispersive x-ray spectroscopy (EDS) analysis and X-ray mapping were realized at 20kV. One fragment of metal thread was mounted on a carbon stub with carbon tape and analyzed by SEM-EDS in low vacuum. One fragment of metal strip was embedded in epoxy resin, cross-sectioned, polished by means of an ion milling system (Hitachi IM4000), and carbon coated (carbon thickness of 12 µm) before being studied by SEM-EDS in high vacuum.
44 Brenni 1930; Montegut et al. 1992; and Járó, Gondar, and Toth 1993.
45 Hacke et al. 2009. For the tapestry series, see Cecilia Paredes in Cleland 2014, 294–301.

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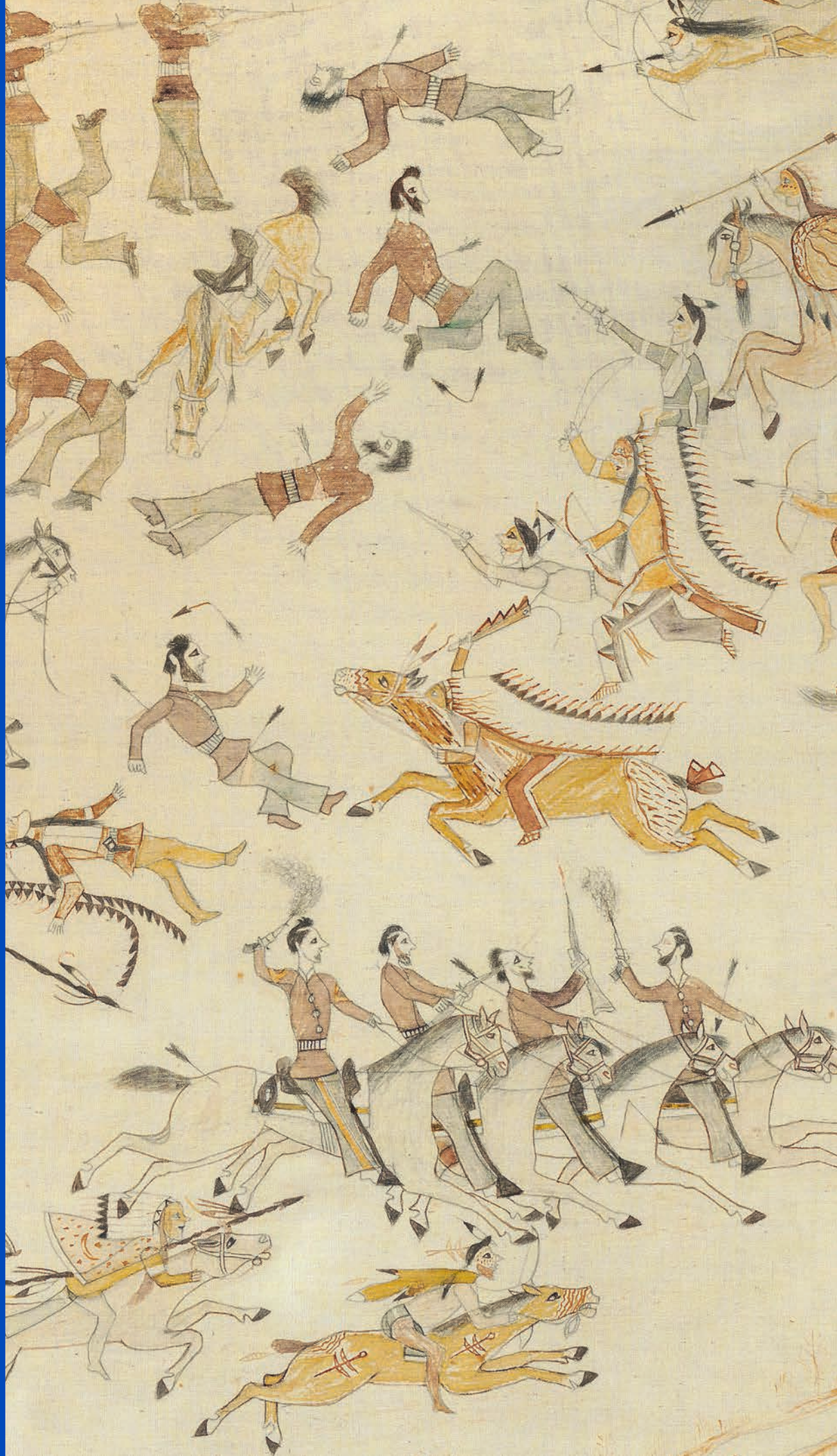

ISBN-13: 978-0-226-82464-2
ISBN-10: 0-226-82464-0
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9 780226 824642
PRINTED IN TURKEY