A Double-Headed Eagle Embroidery: Analysis and Conservation

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The double-headed eagle embroidery came to my attention during preparations at The Metropolitan Museum of Art for the 2004 exhibition of Byzantine art (Figure 1). Following research by curators into the embroidery’s Greek inscription, it appeared that the textile was not originally intended for use as a military banner—notwithstanding its presentation as such at the time of its acquisition by the Department of Arms and Armor in 1912. When translated, the inscription suggested that the embroidery had served an ecclesiastical use. A detailed study of the construction of this rare textile, one of the few surviving Byzantine embroideries made before the fifteenth century, was undertaken. An early date for the embroidery was confirmed, and a technique of manufacture was revealed that differed from that commonly practiced in Western Europe at the time. Originally, the embroidery, while rather coarse, would have been imposing—and even regal—with its shimmering metallic threads set against a bold red field.

Research also provided insights into how the work should be conserved and subsequently exhibited. The embroidery was detached from its nineteenth-century mounting by cutting and removing the stitches holding it in place. The mounting had deteriorated and no longer provided sufficient support. Removal of the embroidery uncovered the reverse of the textile, further facilitating study. The fragility of the textile limited options for conservation. It was decided to remount the embroidery on a neutral-colored support fabric to focus attention on the eagle itself, an iconic symbol of Byzantium. The gilding of the metallic threads has dulled and the silver has tarnished. While the embroidery is still striking, age has softened—or muted—its visual impact. Also, while its purported ecclesiastical function now seems likely, its context is not known. For example, were there other elements on the red backing, and what was its size? How and where was the textile originally displayed? Was it an altar cloth? Or did the embroidery adorn a banner, one carried not in battle but in church processions? Could the embroidery have been used as a totem shield, placed next to a tomb?

Construction of the Embroidery

The large double-headed eagle, measuring 148.6 centimeters (58 3/8 inches) in height and 129.9 centimeters (51 3/16 inches) in width, was embroidered with metallic and colored silk thread on a linen and paper support. The breast of the eagle bears an embroidered inscription in metallic thread, surrounded by a blue-silk embroidered background (Figure 2). The crowned heads (Figure 3), the necks, the center medallion, and the tail are delicately defined in red, yellow, blue, brown, and white silk embroidery, in addition to the now-blackened metallic thread.

A tightly woven, plain-weave fabric of undyed white linen and a layer of paper (to increase strength) served as the grounds for the embroidery. The warp and weft yarns of the ground fabric are single spun into a Z direction. The thread count of the warp is eighteen to nineteen yarns per centimeter and the thread count of the weft is sixteen to seventeen yarns per centimeter.

Two pieces of linen were stitched together along their selvages to accommodate the size of the eagle. The join was whipstitched using undyed white linen thread (two yarns with a slight Z-twist plied into an S direction). Seen from the obverse, the join, covered with metallic and silk embroidery threads, left a barely visible, uneven vertical line through the center of the eagle; from the reverse, the join is revealed where the paper backing is damaged. All other edges are cut.

The eagle embroidery was made by stretching the support materials on a frame, providing a taut surface allowing the embroiderer to use both hands and to maintain better control. Traces of brown and red underdrawing are visible to the naked eye where embroidery is missing, indicating that, prior to stitching, design elements were drawn onto the linen ground.
Figure 1. Double-headed eagle embroidery. Byzantine (possibly Greece or Constantinople), ca. 1366–84. Metallic and silk thread embroidered on a linen and paper support, 175.3 x 139.7 cm. The Metropolitan Museum of Art, Rogers Fund, 1912 (12.104.1). The embroidery formed part of a banner when it was acquired in 1912.
Figure 2. Detail of Figure 1, showing inscribed medallion. The background of the inscription was embroidered in blue silk in a satin stitch, overlaid with stitches in a netlike pattern. The linen ground is exposed where the silk embroidery is now missing. The thick linen cords beneath the metallic thread contribute to the embroidery’s three-dimensional effect.

Figure 3. The left crowned head of the eagle in Figure 1. The cord beneath the metallic thread outlines the head, eyes, and details in the neck. The jewels in the crown and the beak are embroidered with colored silk yarn, over layers of paper.
Most likely, the eagle motif was worked from the center outward. First, thick, undyed linen cords were stitched with undyed white linen thread (two yarns with a slight Z-twist plied into an S direction) to the linen and paper backing. These cords delineated those design elements that were raised, such as the outline of the eagle’s body, its crowned heads, the wings, legs, and talons, and the medallion with its inscription. Only at a later stage would these linen cords be embroidered over and the surrounding areas filled in with a pattern by couching down the metallic threads. This technique was commonly employed when delicate threads—such as these—were to be attached to a support. If threaded through a needle and passed through the ground of an embroidery, the metallic threads would have been damaged by the friction created. The embroiderer economized by limiting the precious materials to the surface.

Metallic threads were laid in parallel to each other on the linen ground and couched into place in pairs with a thinner thread of vivid yellow silk (two yarns with no visible twist plied into an S direction). Yellow was chosen to blend with what was once the shiny gold metallic thread. The yellow couching thread has faded to beige on the obverse, but is still well preserved on the back. Since the taut fabric made it impossible to pass a needle through the grounds in one motion, the needle was kept in a vertical position at all times, threaded with the yellow silk, with one of the embroiderer’s hands above and the other below the frame.

The metallic threads at the edges of the embroidery are continuous, simply doubled over. At each turning point the threads are couched down in pairs—evidence that the embroidery is complete. The couching threads unite the linen ground, paper backing, and the metallic threads. The couching thread was stitched with regularity, pulled just enough to hold the metallic threads down and, depending on its placement, different patterns were created. This method enabled the embroiderer to model each element of the eagle, giving the design a liveliness and even a three-dimensional effect.

The now heavily corroded metal thread was analyzed. It appears to be gilded membrane thread. The discovery that gold was a component of the metallic thread was anticipated in view of the choice of a yellow couching thread. White couching thread was commonly used when silver metallic thread was employed. The metallic thread consists of a cut strip of gilded membrane, or animal gut, wound in an S direction, around an undyed linen core, spun in an S-twist, which it almost completely covers. The membrane—thin, and with a smooth surface and an opaque appearance—serves as the substrate to which the metal gilding adhered.

The composition of the gilded membrane was analyzed in 2004 by Mark Wypyski, Research Scientist in the Department of Scientific Research at The Metropolitan Museum of Art. Scanning electron microscopy and energy-dispersive X-ray spectrometry (SEM-EDS) elemental analysis revealed that the metallic components on the surface of the membrane consist of silver and gold, in approximately a six to one ratio by weight—evidence that the coating on the membrane is gilded silver. In addition to considerable corrosion, much loss of metal can be observed: the silver now appears as a black sulfide layer over the gilding. No mercury was detected in the analysis, ruling out the possibility that the silver was originally mercury gilded.

Gilded membrane thread had several advantages over the earlier metallic thread made of pure gold or gold alloy: production was less expensive, the thread was lightweight and flexible—when employed both in weaving cloth or, more rarely, embroidery—and the finished textile itself weighed less. On the other hand, it was not as lustrous as pure gold thread and the gilding rubbed off easily, exposing the silver layer below.
and making it vulnerable to corrosion, which explains
the dull appearance of many surviving textiles.

Membrane thread was most likely introduced into
Europe from Byzantium or Cyprus as early as the
eleventh or twelfth century, and was first used in
Spain and Sicily. By the thirteenth century, it was
employed in the production of cloth in such impor-
tant weaving centers as Venice, Lucca, and Cologne,
and from the thirteenth to the fourteenth century, it
was also made in Europe. European embroideries
in which membrane thread has been identified usually
date to after the mid-fourteenth century. While in
Germany and other European countries membrane
thread prevailed until the beginning of the sixteenth
century, after the middle of the fourteenth century, in
Northern Italy, gilded-silver thread already had replaced
membrane thread as a less-expensive alternative.

The embroidery is also impressive because of the
relieflike quality of the double-headed eagle, achieved
through the technique of the stump work: to enhance
the jewels in the crowns (Figure 4) and beaks, and in
the center of the flower (part of the tail), layers of
paper were cut in the desired shape, sewn with silk
thread (two yarns with no visible twist plied into an S
direction) through the embroidery’s linen and paper
grounds, and embroidered over with colored silk
thread. It is difficult to reconstruct precisely how these
paper layers were prepared, but in the jeweled crowns,
for example, it appears that, rather than being cut,
paper was fashioned into the desired shape, imitating
the facet of a precious stone, whereas in the beak the
paper layers are flat and fewer in number.

A sample of fibers from the paper backing below
the inscription was examined and analyzed in 2005
by Andrew W. Mellon Conservation Fellow Denise
Stockman of the Sherman Fairchild Center for Works
on Paper and Photograph Conservation at The Metro-
politan Museum of Art. Light brown and of a soft
texture, these fibers resembled hemp. A sample taken
from one of the jewels in the left crowned head of the
eagle revealed that the paper there was white,
smoother in texture, and brittle, its fibers resembling
linen; starch also was detected, presumably used as a
sizing material.

Paper was not manufactured in fourteenth-century
Byzantium, but was imported from Spain or Italy. It was
made from worn linen cloth, to which remnants of
ropes made of hemp sometimes were added. In
Spain, starch was employed as a sizing material, as
opposed to gelatin in Italy. Stockman concluded that
both papers used in the eagle embroidery most likely
were made from linen fibers (obtained from worn
cloth, with hemp added to the light brown paper sam-
ple), and were imported from Europe, possibly Spain.

To adorn the double-headed eagle further, details
of the crowned heads, the neck, the center medallion,
and the tail were delicately defined with red, yellow,
blue, brown, and white silk embroidery. Untwisted col-
ored silk was chosen, resulting in a clean, shiny sur-
face instead of the matte effect that occurs when
twisted threads are used. Different embroidery
stitches were employed. Satin stitch, in dark blue,
light blue, red, yellow, white, and brown thread, can
be identified in the jewels in both crowns, and in the
beaks, the collar, the background of the inscription,
the flower petals, and the talons. The eyes were
embroidered with dark brown, white, yellow, and red
silk thread in delicate split stitches (Figure 5). The
background of the inscription was embroidered in dark
blue, in a satin stitch, which was overlaid with an open,
filling stitch, in a netlike pattern, of the same blue silk.

Nobuko Shibayama, Associate Research Scientist in
the Department of Scientific Research at The Metro-
politan Museum of Art, attempted in 2004 to identify
the dyes used in the manufacture of the colored silk
thread by means of visual examination under ultravio-
et light and magnification, measuring color with a

![Figure 5. Detail of the head of the eagle in Figure 3. The eyes were delicately defined with embroidery in dark brown, white, yellow, and red silk yarn.](image-url)
Minolia cm2002 spectrophotometer, and High Performance Liquid Chromatography (HPLC) with a photodiode array (PDA) detector. Samples were taken of the light and dark yellow couching thread; the yellow, blue, and red embroidery yarn; and the red sewing thread. The white (it is safe to assume that it is undyed) and brown embroidery yarn, as well as the yellow sewing thread, however, had deteriorated too much to permit sampling.

Shibayama concluded that weld was used to dye the dark yellow couching thread and the yellow embroidery thread, and she tentatively identified weld as the dye employed to color the light couching thread as well. The blue yarn was dyed with an indigotin containing a dye such as woad; the red sewing thread was believed to have been colored with a combination of a kermes and a madder-type dye. The red dye of the embroidery yarn was tentatively identified as orchil, which is extracted from lichens and is said to have originated on Crete and on other Greek Islands. The dyestuffs employed in the manufacture of the colored yarns were in use at the time the eagle embroidery was produced, and are consistent with Early Byzantine textiles; however, only the blue and one of the two red yarns would retain their initial brilliance and rich color.

After the embroidery of the eagle was complete, it was cut out and applied to a secondary fabric. A margin of .3 to 1.5 centimeters (¼ to ⅜ inches) of the linen foundation was turned backward and secured to the reverse, whipstitched with undyed linen thread (two yarns with a slight Z-twist plied into an S direction). A knot was made when beginning a new thread.

Analysis suggests that the eagle was embroidered onto a linen ground backed with a layer of paper, and then onto a fine, dyed-silk ground. It is likely that a lining of a heavier fabric would have been added, for strength. Traces of red silk stitches (two yarns with no visible twist plied into an S direction) along the perimeter of the embroidery—some still conserved in their original holes and some with a knotted end—imply that this background was possibly a red silk fabric (the same sewing thread was found scattered over the reverse). Also, along the perimeter of the embroidery are pinkish brown linen threads (two yarns with a slight Z-twist plied into an S direction). At some point in its history, the delicate silk background must have been in such poor condition that the eagle embroidery was separated from it, and sewn onto a new fabric backing—a practice that was not uncommon. At this point, however, the original meaning behind the eagle embroidery and the purpose for which it was made were lost.

To help date the embroidery, a small sample was taken from the linen ground and a carbon-14 test was performed by a private firm in Miami, Beta Analytic, Inc. Results suggested that the embroidery was made between A.D. 1270 and 1400, a time period consistent with the findings of the other analyses.

**Nineteenth-Century Restoration of the Embroidery**

In the nineteenth century, the double-headed eagle embroidery was mounted as a banner, applied onto a thin, yellow satin-weave silk and a coarsely woven linen fabric support. A natural, undyed cotton cord was stitched around all four sides with beige cotton thread. Red silk thread, in an overcast stitch, was used to sew the cord through the silk and linen fabrics, creating a solid red border about .7 centimeter (about ⅛ inch) in width. Yellow silk satin served as the undecorated back of the banner, and tassels composed of a wooden core decorated with metallic and cotton thread were sewn onto the lower corners. A sleeve along the top edge was added to enable a rod to be inserted in order to hang the textile, and a cord made of metallic thread was attached along the top edge.

Missing metallic thread from the embroidery itself was replaced with beige and brown cotton thread, imitating the original technique. Fragile and missing silk was restored with silk thread that matched the faded color rather than the original: for example, areas once embroidered in light blue now faded to beige were filled in with beige silk thread. Missing paper was replaced (one jewel in the right crown and one in the circle of the flower). The completed banner measured 175.3 centimeters (69 inches) in height and 139.7 centimeters (55 inches) in width, with the eagle embroidery placed at the center.

**Condition of the Embroidery**

The embroidery is structurally strong, but shows signs of wear. The metallic thread is in poor condition: it has blackened, and is brittle and worn. In places, the membrane substrate of the metallic thread and the beige linen core is exposed, as is the linen cord and the embroidery ground. Areas embroidered in silk are fragile.

The most notable fading occurred in the yellow silk thread used to couch the metallic thread, and in the pale blue silk embroidery thread that has become beige.
Due to the iron mordant employed to fix the color during the dyeing process, the brown silk has deteriorated, exposing the thick linen cords (Figure 6), except in the area of the talons along their perimeter.

The most fragile parts of the embroidery are the crowned heads, the beaks, and the talons. Layers of paper are exposed where the silk embroidery has worn away. Around the edges of the embroidery, the original red silk and linen sewing thread is visible, as are scattered red silk threads on the reverse. The paper backing underneath the linen embroidery ground has broken into pieces. There are also small wax stains.

Conservation of the Embroidery at The Metropolitan Museum of Art

The fragility of the embroidery limited options for its conservation. Since it was to be prepared for exhibition, and displayed vertically, it was decided to stitch the eagle embroidery onto a new support, as its nineteenth-century assemblage had severely deteriorated. The obverse and reverse of the embroidery were then treated with a low-suction vacuum cleaner. Any additional cleaning, whether with chemicals or water, could not be undertaken without further damaging the deteriorated materials—above all, the corroded
Figure 7. The double-headed eagle embroidery after conservation in 2004. See also Colorplate 3.
membrane threads (moisture causes membrane threads to twist), whose brilliance, unfortunately, could not be reinstated.

A washed, medium-weight muslin fabric was stretched over a frame. Pima cotton in a neutral tone was stretched over the muslin and secured to the back of the frame. The embroidery was attached at the center, with a two-ply cotton thread in a zigzag stitch, and the frame was positioned between two tables. Crossbars that could be moved, depending on the area that was being worked on, helped prevent the frame from warping. Stitching began from the center outward, with one person passing the threaded needle to a second individual positioned below the frame. Each stitch covered two metallic threads.

During treatment, the heavy embroidery had to be carefully manipulated. Once the textile was attached to the support fabric, the crossbars were replaced with a solid support, which was screwed from the inside to the outer frame. The mounted embroidery (Figure 7, Colorplate 3), which measures 159.4 x 141.6 x 5.4 centimeters (62 1/8 x 55 1/8 x 2 1/8 inches), was covered with a Plexiglas box, allowing a one-inch space between the box and the surface of the embroidery. The embroidery can be displayed in a vertical position, but is stored flat. Materials from the nineteenth-century restoration were documented and are being kept separately.

NOTES

Helpful comments on earlier drafts were offered by Peter Barnet, Herbert Broderick, Helen C. Evans, Mechthild Flury-Lemberg, and Florica Zaharia.

3. It was not uncommon in the Middle Ages to use paper as a support material for textiles, as, for example, for the hoods of cope and for miters. See Mechthild Flury-Lemberg, Textilkonservierung: Im Dienste der Forschung (Bern, 1988), pp. 206–13.
4. The direction in which a thread is spun, twisted, or plied is described by the diagonals of the letter S for the left and Z for the right direction. See Dorothy K. Burgham, Warp and Weft: A Textile Terminology (Toronto, 1980), p. 161.
6. The cord is made of undyed white linen, and consists of six yarns with a loose Z-twist, plied into three pairs of threads each twisted in an S direction, which are, in turn, twisted in an S direction, resulting in a hard, wiry cord.
7. For a definition of the stitch, see Mary Thomas’s Dictionary of Embroidery Stitches (New York, 1935), pp. 54–55.
8. Beginning in the twelfth century, threads were couched in pairs instead of singly. See Marie Schulte and Sigrid Müller Christensen, Das Stichereiwerk (Tübingen, 1935), p. 12.
11. Ibid.
16. For a definition of the stitches, see Mary Thomas’s Dictionary of Embroidery Stitches, pp. 179, 186.
18. Ibid.