KUNSTGESCHICHTE KUNSTTECHNOLOGIE UND RESTAURIERUNG

Neue Perspektiven der Zusammenarbeit

A MATTER OF TEAMWORK

ART HISTORY CONSERVATION AND CONSERVATION SCIENCE

New perspectives for cooperation

Reimer

IN MEMORIAM
JILLEEN NADOLNY

KUNSTGESCHICHTE, KUNSTTECHNOLOGIE UND RESTAURIERUNG:
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Eine Einführung

ART HISTORY, CONSERVATION AND CONSERVATION SCIENCE:
New Perspectives for Cooperation
An Introduction

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Translation from German by Katharine Schmidt

Introduction

Since 1988, art historians and conservators have collaborated on studies of the paintings of the Old Masters Collection of the Städel Museum, in order to compile the museum's scholarly catalogues. The publication in 1993 of the volume entitled *Niederländische Gemälde im Städel Museum 1400–1550*[1] set the standard for this endeavor; the early Netherlandish paintings in the collection of the Städel Museum are of particular importance due to their quality. One of the outstanding works in this group is without a doubt the *Lucca Madonna*, painted around 1437 by Jan van Eyck (c. 1390–1441) (**fig. 1**). The art historical (→art history, →*Kunstwissenschaft, Bildwissenschaft*) significance of this panel painting is also evident in its extensive history of art technological (→art technology) research (**fig. 2**). As early as 1938, Christian Wolters created an X-ray image of the Virgin and Child, for a study of Van Eyck's use of lead white.[2] In 1958, Jules Desneux was the first to use infrared photography to analyze the underdrawing.[3] Following further technological examinations (X-ray images and infrared reflectography, hereafter referred to as IRR) published in the scholarly catalogue of 1993, the painting was once again analyzed both by Noëlle L.W. Streeton[4] and in the context of the project *Van Eyck Research in OpeN Access* (VERONA) of the Koninklijk Instituut voor het Kunstpatrimonium/Institut Royal du Patrimoine artistique (KIK/IRPA).[5]

The technological analyses of the painting performed during the preparation of the 1993 scholarly catalog not only provided a detailed insight into the painting technique used to create the artwork, but additionally, they afforded a surprising glimpse into the genesis of the *Lucca Madonna*. Initially, the painting was conceived as a self-contained space into which viewers would look, as if into a dollhouse; with a few modifications in the painting process (→working process), however, Jan van Eyck succeeded in opening the boundary between representation and reality. As a result, the room depicted in the painting now appears to seamlessly extend into the space around the viewer: Not only the carpet, but also the windows and the niches in the side walls, as well as the cross-ribbed vaulted

ceiling are depicted only partially, thus suggesting their continuation on the viewer's side of the picture plane.[6]

In preparation for a new edition of the scholarly catalog of Netherlandish paintings from 1450 to 1500, the painting has now been the subject of in-depth analyses, with a focus on macro X-ray fluorescence analysis (MA-XRF).[7] MA-XRF analysis is based on the excitation of matter with high-energy X-rays, which evokes fluorescence radiation specific to each chemical element.[8] Thus, MA-XRF analysis allows for the non-destructive identification of chemical elements, and the visualization of their distribution throughout a painting. Hence, it enables insights not only into the → materials and pigments used but also into the underlying layers, providing a direct glimpse into the process of a painting's creation.

The objective of the new analysis was to gain a deeper understanding of the production process of one of the showpieces in the Early Netherlandish collection. For this purpose, more detailed knowledge of Jan van Eyck's concrete painting technique – in particular, the composition of pigments and their use, as well as the sequence of paint layers – was to be obtained in order to better comprehend the individual steps and changes undertaken in the process of creating the painting, along with the associated artistic decision-making. Deciphering the creative process is of interdisciplinary significance, as it enables insights into the work of Jan van Eyck, one of the most important and influential artists of the fifteenth century. Therefore, the results of the art technological investigations were discussed and contextualized after their evaluation within the framework of the interdisciplinary project *MA-XRF Research at the Städel Museum*. Although the painting has frequently been subjected to art technological studies, unexpected findings have emerged in the course of the new analyses, providing a novel perspective on Jan van Eyck's work.

New Art Technological Analyses Methodology

As part of the new analysis, three macro X-ray fluorescence scans (MA-XRF),[9] several X-ray fluorescence point measurements (XRF),[10] and a digital X-ray image (XRR)[11] were taken of the *Lucca Madonna*. The evaluation of MA-XRF datasets incorporated previous results[12] and was accompanied by microscopic examinations.[13] This step-by-step process allows for the reconstruction of the artistic process of the *Lucca Madonna*, which will be described below in chronological order.

The Ground Layer

The white priming layer contains calcium, as strong calcium signals (Ca) can be detected alongside the edges of the panel, in the craquelure and in the areas covered with only a thin layer of paint (**fig. 3**, Ca). The use of an aqueously bound chalk ground was common in the fifteenth century in the Netherlands and has been identified in numerous works by Jan van Eyck.[14]

Moreover, lead signals (Pb) detectable across the surface and in the uniform absorption of X-rays in XRR indicate the presence of an isolation layer ("primuersel"[15]) applied with broad vertical brushstrokes over the entire pictorial ground (**fig. 4**). However, the analysis cannot unambiguously determine whether this layer is located above or below the underdrawing.[16]

The Underdrawing

Already in 1993, extensive underdrawings, particularly under the Virgin's red garment, were visualized using a Hamamatsu IRR Vidicon system (**fig. 2a**).[17] The IRR conducted by the Koninklijk Instituut voor het Kunstpatrimonium/Institut Royal du Patrimoine artistique (KIK/IRPA) shows the underdrawing in greater detail (**fig. 2b**).[18] Due to the absorption of a broad wavelength range in the infrared, a carbon-based material, which seems to have been the most common medium for underdrawings in early Netherlandish painting, can be assumed.[19] A re-evaluation of the high-resolution IRR now indicates an additional underdrawing phase in the creation of the *Lucca Madonna*, executed with a metalpoint.[20] In some areas of the Virgin's garment, next to the previously described meticulous brush drawing, fine lines with a homogenous line width can be seen in IRR, that roughly indicate the fall of the drapery (**fig. 5b**). In the lower right area of the red garment these lines are visible through the thinly applied paint layer as consistently wide, gray lines (**fig. 5a**).[21] While a metalpoint can be presumed based on the characteristics found, the exact material cannot be identified.[22] It is likely that this metalpoint drawing was used during one of the initial stages of the composition, which the artist subsequently retraced with black ink and brush, refining it with more details and sporadic hatchings. The use of metalpoints in underdrawings in early Netherlandish paintings has been repeatedly mentioned in art technological research since the 1970s.[23] Recent studies have now provided evidence of metalpoints whose material composition could not be further identified, for (under-)drawings on primed wood panels in works by the Van Eyck brothers, such as the exposed drawing of the painting entitled *Saint Barbara* (1437, Antwerp, Royal Museum of Fine Arts),[24] or in the *Ghent Altarpiece* (1432, Ghent, St. Bavo's Cathedral).[25]

The Paint Layers
Pigments and Fillers

MA-XRF analysis primarily allows for the identification of inorganic pigments. Lead white was used as a white pigment (**fig. 3**, Pb). Various iron-containing earth pigments, such as yellow, red, and brown ocher, are visible in the iron distribution. The presence of various blue and green copper-based pigments can be presumed based on the co-occurrence of varying ratios of copper and zinc (**fig. 3**, Cu, Zn). Copper blue, for instance, is found in the brocade fabric, in the glass vial on the right-hand edge, and in small blue details of the ornaments on

the Virgin's garment; copper green can be found in the green brocade decoration (**fig. 6**).[26] Ultramarine (K) was used for the Virgin's blue undergarment as well as for depicting vibrant blue details in the brocade ornamentation, the beads on the seam of the garment, and on the blue tiles.[27] Vermilion (HgS) was employed for the extensive application of paint in the Virgin's garment, and for vibrant red brocade and fabric embellishments on the throne and in the carpet (**fig. 3**, Hg). For bright light-yellow details and highlights, lead-tin yellow partly mixed with yellow ocher was used, as seen in the light-yellow brocade patterning of the carpet.

By identifying filler materials and substrates related to the creation of organic lake pigments, as well as the admixture of color modifiers, it is also possible to deduce the use of organic lake pigments through MA-XRF analysis.[28] The meticulous elaboration of the *Lucca Madonna* is also based on the use of these lake pigments, which are evident in the distribution of both calcium and potassium. The latter is often associated with translucent, deep-red glazes used for shading the depths of the garments and brocade, and in some places also contains manganese.[29] Moreover, strong calcium signals are also present in brown and black tones, such as the initial depiction of the ceiling.[30]

Of particular interest are the extensive zinc signals, appearing both in paint applied over large areas and fine details (**fig. 3**, Zn). Zinc is detectable in reddish-brown areas of the picture, such as the wood and the brass bowl on the right-hand edge of the artwork, as well as in the dark-brown-to-black contouring of the brocade pattern and the figures of the Christ Child and the Virgin Mary (**fig. 6b**). Furthermore, zinc can be found in light-yellow (up to brown) brocade ornaments on the baldachin. Jana Sanyova et al. were also able to identify zinc in the original painting of the *Ghent Altarpiece*, where it often co-occurs with potassium and manganese.[31] In both the *Lucca Madonna* and the *Ghent Altarpiece*, zinc is found together with copper in the shadowy areas of the room. Sanyova et al. attribute this to the admixture of various drying modificators to slow-drying paint. Thus, red paint layers contain glass and zinc-based materials, while copper-based salts like verdigris and blue vitriol are found in dark areas.[32]

The Genesis of the Work

The first application of paint meant to initially divide the pictorial ground, and was therefore executed with broad, quickly applied brushstrokes. An initial light-gray indication of the interior space has already been described by Streeton,[33] based on microscopic examinations, and can also be seen over a wide area both in the X-ray image and in the lead distribution of the MA-XRF analysis (**fig. 3**, Pb).[34] The application of this initial layer traces the depiction of the room by leaving the borders of individual pictorial elements exposed.[35] The MA-XRF lead distribution clearly indicates that the artist applied the paint in these individual areas at a fast pace. Besides the light-gray underpainting of the room, the Virgin's red garment is underpainted with vermilion in a thin application. The purpose of this layer is clearly evident in the brushstroke, which does not follow the folds of the garment, but quickly covers the area in various directions (**fig. 3**, Hg). The area

of the brocade fabric was likewise colored in a first step with a copper-based blue or green paint, applied in a horizontal or meandering manner around the figures depicted (**fig. 3**, Cu). Unlike the light-gray underpainting of the interior architecture, observed by Streeton,[36] these copper- and mercury-containing intermediate layers do not adhere to the borders of the depiction, but serve solely as coloring.

Within the first application of paint, the light-gray underpainting was likely used to depict the initial interior architecture, as it includes a step in the front of the floor that was later rejected in favor of the wooden throne platform located on the tiled floor seen today (**fig. 3**, Pb), which is nowadays covered by the copper-based underpainting of the subsequently conceived carpet. In this first coloring of the richly embellished carpet, the only area left unpainted is an initially more generously designed fold in the Virgin's red garment on the lower left side, which in turn was also left uncovered by the vermilion-red underpainting of the Virgin's garment (**fig. 7**, Cu). Thus, the following layer sequence for the build-up of the painting emerges: 1. light-gray toning of the architectural background with lead white and ochers; 2. blue and/or green underpainting of the throne, the carpet, and the green landscape on the left in the window; 3. red underpainting of the Virgin's garment.

The painting of the image was subsequently executed on top of the underpaintings by incorporating these first layers of paint. The interior architecture, for instance, is painted above the light-gray intermediate layer, and indicated only by bright and shaded areas.[37] Several symbolic elements,[38] such as the washbowl and the two lions on the front ends of the armrests on the throne, were left unpainted in the lead-containing layer from the beginning onward, and thus, were already envisioned in the initial composition. Others, such as the lion figures on the rear throne posts, the pieces of fruit on the left windowsill, and the candle holder and glass carafe in the niche on the right edge, were executed above the application of the light-gray intermediate paint layer used to depict the room. In the case of the first three details, this underpainting is completely covered by the application of opaque paint. In the depiction of the carafe, however, the underlying layer is skillfully integrated through the use of glazes and a few selectively applied opaque light reflexes.

The extensive revision of the interior architecture during the painting process has already been described in detail.[39] While only minor details were changed in the group of figures consisting of the Virgin and Child, the depiction of the room was fundamentally altered through a few painterly interventions.[40] The initially planned flat ceiling was already dark-colored, with a paint layer containing ocher (Fe) and calcium. Only afterward did the artist execute the Gothic arches, the elevated height of the room's vault, and the oculi above the window and niche, using a mixture of lead-, copper-, and iron-based pigments (**fig. 3**, Fe; see **fig. 2b**). In the left area of the painting, the left wall and the ceiling were shaded together, while the distinct border between the illuminated wall and the discarded dark ceiling on the right side of the painting was integrated as a shadow of the throne in today's image. The Gothic architecture, localized in the corners of the room, was created in a sketch-like →manner. Beside the individual brushstrokes that give form to the pillars and the cross-rib vaults, translucent shadings and fine light reflexes were applied only in certain areas. Between them, the underlying paint layer is exposed. The canopy of the throne was also enlarged and adjusted to fit the

Abb. 1 Jan van Eyck, *Lucca-Madonna*, ca. 1437, 65,7 × 49,6 × 0,8 cm, Mischtechnik auf Eichenholz, Inv.-Nr. 944, Frankfurt, Städel Museum. // **Fig. 1** Jan van Eyck, *Lucca Madonna*, c. 1437, 65.7 × 49.6 × 0.8 cm, mixed technique on oak, inv. no. 944, Frankfurt, Städel Museum.

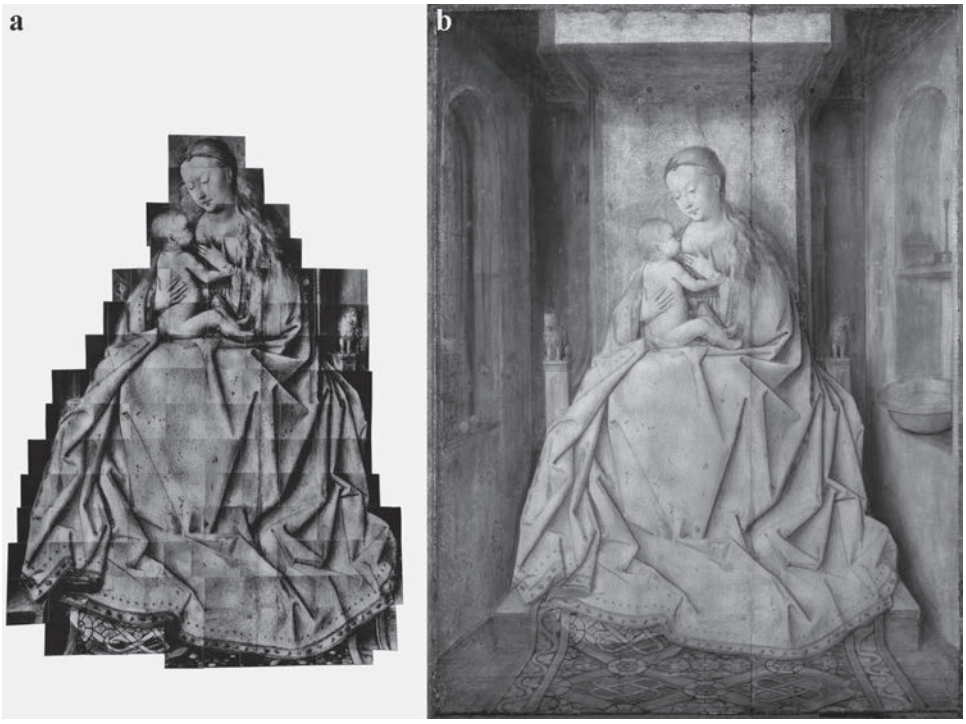

Abb. 2 Die Weiterentwicklung der Infrarotreflektografie (IRR) 1993–2015 am Beispiel der *Lucca-Madonna*. (a) IRR-Assemblage mit der Vidicon (Hamamatsu), (b) Hochaufgelöste IRR (Osiris). // **Fig. 2** The evolution in the development of infrared reflectography (IRR) from 1993 to 2015, taking as an example the *Lucca Madonna*. (a) IRR assemblage made with vidicon (Haamatsu), (b) high-resolution IRR (Osiris).

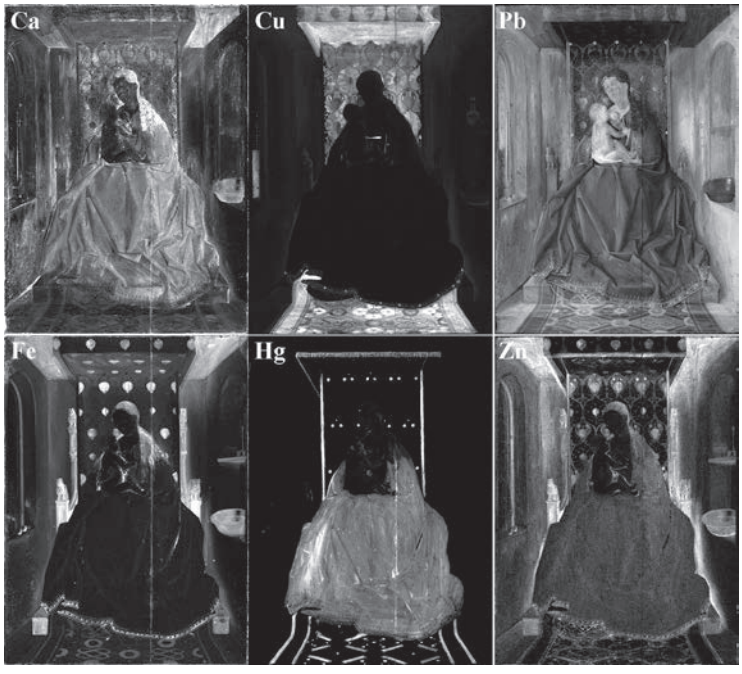

Abb. 3 MA-XRF-Element-Verteilung von Calcium (Ca-K), Kupfer (Cu-K), Eisen (Fe-K), Quecksilber (Hg-L), Blei (Pb-L) und Zink (Zn-K). Je heller ein Bereich ist, desto mehr ist von dem jeweiligen Element vorhanden. // **Fig. 3** MA-XRF element distribution for calcium (Ca-K), copper (Cu-K), iron (Fe-K), quicksilver (Hg-L), lead (Pb-L), and zinc (Zn-K). The lighter the area appears, the more of the respective element it contains.

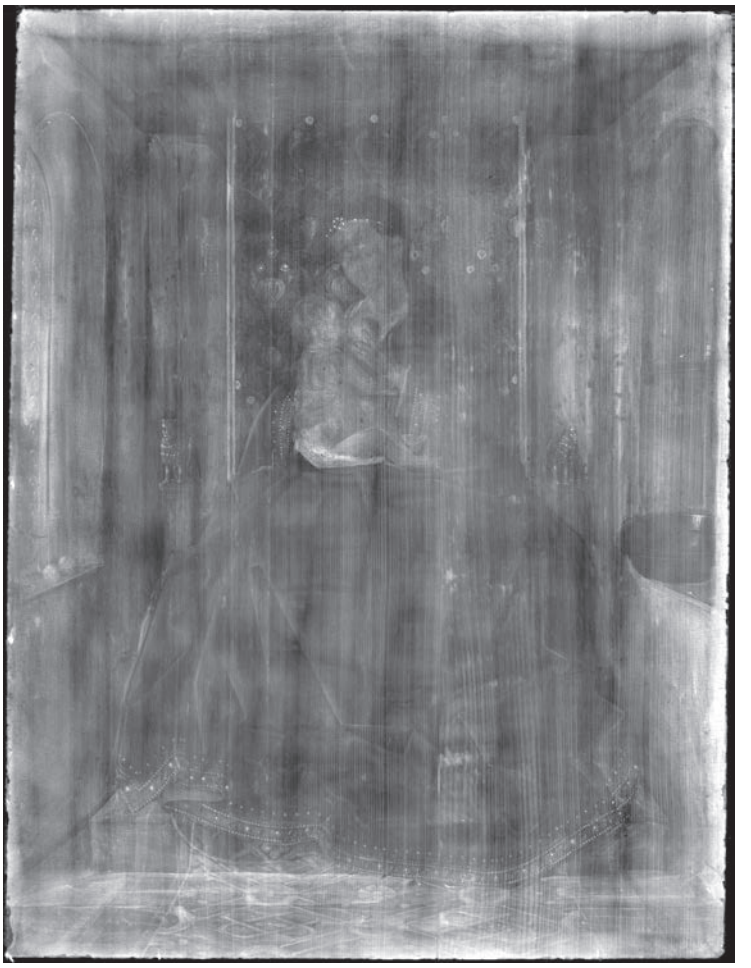

Abb. 4 Digitale Röntgenaufnahme (XRR). // **Fig. 4** Digital X-ray image (XRR).

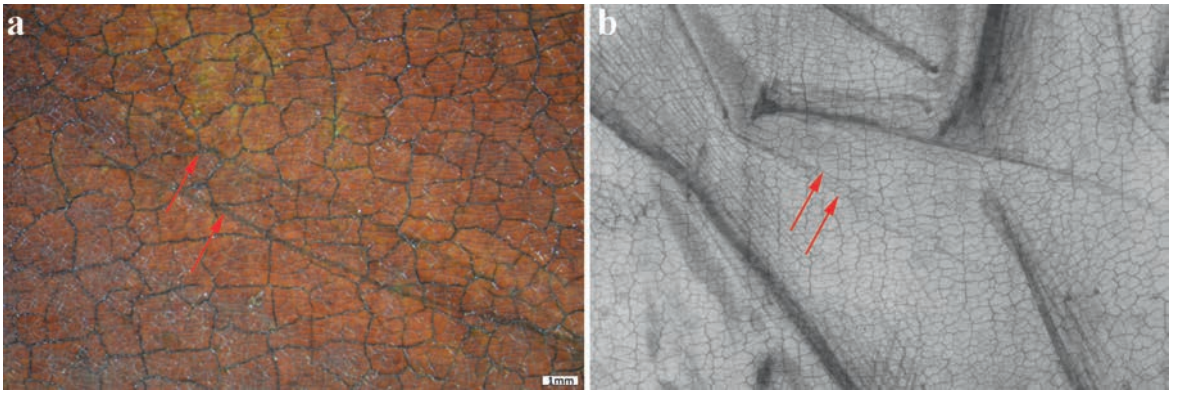

Abb. 5 Metallstift-Unterzeichnung im roten Gewand (a) unter dem Mikroskop und (b) in der IRR. // **Fig. 5** Metal-stylus underdrawing in red garment (a) under the microscope and (b) in IRR.

Abb. 6 Detail der Malerei im (a) sichtbaren Licht und (b) MA-XRF-Korrelation der Cu-K- und Zn-K-Signale. Die Korrelations-Kartierung desselben Bereiches zeigt die Präsenz verschiedener zink- und kupferbasierter Pigmente und Additive. // **Fig. 6** Detail from the painting in (a) visible light and (b) MA-XRF correlation of the Cu-K and Zn-K signals. The correlation mapping of this area shows the presence of different zinc- and copper-based pigments and additives.

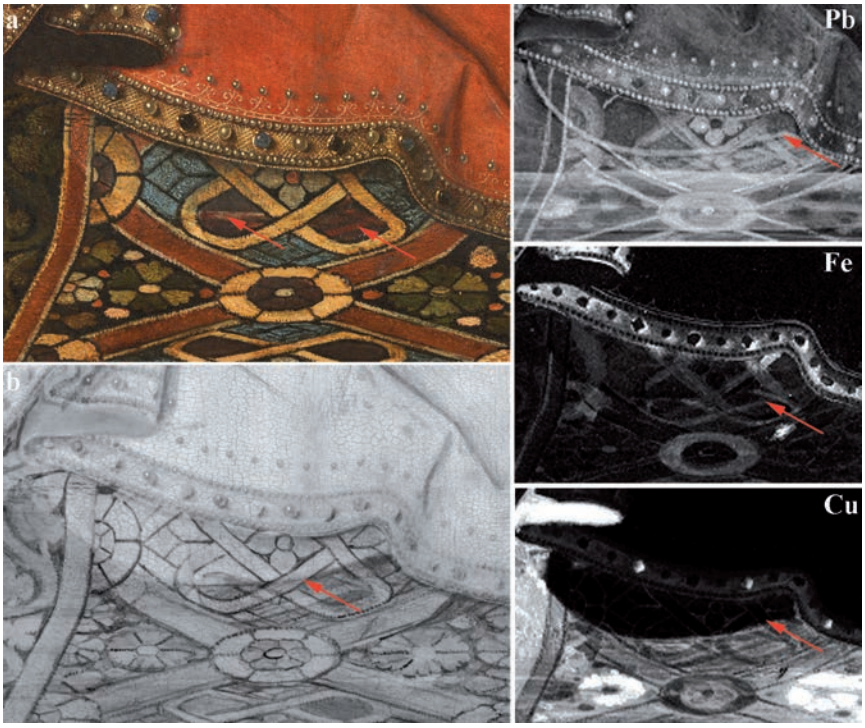

Abb. 7 Pentiment im Teppich im (a) sichtbaren Licht und (b) unter infraroter Strahlung. MA-XRF-Element-Verteilung von Blei (Pb-L), Eisen (Fe-K) und Kupfer (Cu-K). Die vielschichtigen Veränderungen dieses Bereiches können verschiedenen Phasen der Werkgenese zugeordnet werden. // **Fig. 7** Pentimento in the carpet in (a) visible light and (b) under infrared radiation. MA-XRF element distribution of lead (Pb-L), iron (Fe-K), and copper (Cu-K). The multi-layered changes in this area can be categorized as belonging to different phases of the genesis of the work.

perspective of the image (**fig. 3**, Ca, Fe, Pb). The figure of a young, bearded man, described by Hugh Hudson,[41] which was discarded during the painting process, was until recently visible only in IR photography[42] and in the first IRR (Vidicon).[43] It was now possible to prove, by means of MA-XRF analysis, that the figure was executed with an iron-based earth pigment. A similar figure – presumably representing a prophet, as a reference to the Old Testament – on the right side of the throne would be consistent, but it has not been possible to identify such a figure, neither by means of IRR nor in the elemental distribution of the MA-XRF analysis. In the context of the discarded figure, it is also worth mentioning that only the two lower lions – in a clear allusion to the throne of King Solomon in the Old Testament – were omitted in the original application of paint.[44] The lions visible today on the rear throne-posts, on the other hand, were painted directly on top of the finalized paint layers of the background.

As described by Jeltje Dijkstra in 2005, the production process in early Netherlandish painting, which entailed working from light, opaque layers to dark, translucent layers, gives these paintings their unique luminosity.[45] The drapery folds in the Virgin's red gown are based on the intermediate vermilion layer that was covered in the depths of the garment with a red and/or brown ocher (Fe, Mn), and in bright areas with a light red tone based on the admixture of lead white, as well as on the partial application of a red glaze. Blue areas containing expensive ultramarine pigments were commonly underpainted with azurite, to cut costs. An underpainting with azurite such as this cannot, however, be detected in the Virgin's blue garment (**fig. 3**, Cu), although potassium signals clearly point to the use of ultramarine.[46] The modification of the composition continued during the painting process. Thus, in the area of the above-mentioned pentimento in the copper-blue underpainting of the carpet in the lower left, changes in the carpet patterning are visible (**fig. 7b**, Cu). The rejected garment fold was outlined with a bright ribbon visible not only in the distribution of lead (**fig. 7**, Pb), but also to an extent with the naked eye, since it shines through translucent areas of paint (**fig. 7a**). Furthermore, the yellow quatrefoil pattern was at first executed with the same perspective foreshortening as the other two yellow decorative elements (**fig. 7**, Fe). Since the carpet runs over the edge of the podium, its shape was altered during the painting process. The final subtle details, such as the opulent beadwork of the garments and the elaborate brocade fabric of the carpet, stand out due to the meticulous application of paint and the shading of individual elements. The Virgin's bead-embroidered seam was underlaid with an ocher, on which the depicted gold threads were executed with lead-tin-yellow, while the gems and pearls were painted with lead white, ultramarine, and copper pigments.

The Interdisciplinary Perspective on the Technological Results

What conclusions can be drawn from an art technological study with such a specific focus? In the present case, the results of the MA-XRF analysis illustrate the spectrum of variation in Jan van Eyck's painting technique, ranging from the broad and rapid application of paint in different areas to the meticulous individual

brushstrokes executed to render fine details. The skillful integration of initial intermediate paint layers into the final image, the changes adeptly made during the painting process, the finely executed details and the evidence regarding the admixture of paint modifiers all attest to the artist's deep understanding of painting techniques, and to his craftsmanship. The extensive revision of the background is a distinctive feature of the *Lucca Madonna*, which stands out not only for its technical execution but also for its refined aesthetic effect, which seemingly blurs the boundary between the pictorial space and the space inhabited by the viewer. The results of the XRF scans now make the sequence of these partial revisions more comprehensible, by means of material analysis and the overlapping of elemental distributions.

The newly gained knowledge on the materials and genesis of the *Lucca Madonna* illuminates two points. First, repeated analysis may contribute to a deeper understanding of an object. Furthermore, in the context of interdisciplinary exchange, results that might otherwise have remained undiscovered can be deciphered and interpreted in a sound manner. In the present case, the new findings can advance the current state of research by deepening knowledge on the creation of the work as described by Jochen Sander back in 1993, through the identification of the materials used and the clarification of the sequence of complex working steps.[47] This can be seen in the discarded male figure on the throne, described by Hudson,[48] which can be interpreted as a prophet figure analogous to numerous comparable figures in paintings by Jan van Eyck. Previously attributed to the underdrawing, this figure can now be more precisely located within the painting process. The rejection of this figure during the stage of painting hence suggests that Jan van Eyck's artistic approach retained a certain spontaneity throughout the entire creative process.

This case study demonstrates the potential of modern non-destructive examination methods: MA-XRF analysis is just as suitable for interdisciplinary collaboration and discussion as IRR,[49] since on the one hand, each of the 700,000 measurement points generated by scanning the *Lucca Madonna* contains materials-science data, and on the other hand, the results can be presented as easily accessible visible images. Thus, the visual results of the element distributions, which enable researchers to look into the depths of a painting, can in particular be used for interdisciplinary discussions or public relations in a museum context (→art mediation, art education), such as in public tours. However, there are also limitations. As with any examination, questions remain; to answer them, further analysis that might require sampling would be needed to achieve a deeper understanding of the stratigraphy and →materiality of the painting. Taking as an example the pentimenti on the throne, it is currently not possible to determine non-invasively whether a second prophet figure was originally envisioned on the right side of the throne.

What is the benefit of interdisciplinary collaboration? This can be clearly demonstrated, using once again the example of the prophet figure on the Virgin's throne. An asymmetrical throne decoration can be ruled out from an art-historical perspective, while the art-technological examination demonstrated that the figure was already partially executed in paint; taken together, this evidence indicates

a symmetrical composition of the figures within the underdrawing stage. On the basis of the interlinked expertise employed here, it can be presumed that Jan van Eyck initially intended to depict a second figure. Whether this is actually the case is a question to be answered in the future.

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